Alaska SeaLife Center®

windows to the sea

Guide to Marine Life

For Visitors, Staff, and all Marine Life Enthusiasts

Sea Grant
Alaska

John M. Uscian
with contributions on Seagrasses
and Algae by Gayle I. Hansen

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This Book is Dedicated to

Howard M. Feder,

my mentor in the study of invertebrates

Above: Dr. Howard M. Feder, seen here as a young Arctic biologist, emerging from an igloo (circa 1960)

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Diane and Don Coleman provided a photograph of the hairy lithoid crab, (*Hapalogaster mertensii*).

Dr. Dave Cowles, who maintains the website http://rosario.wwc.edu/inverts, provided excellent photographic material for the following species (Dr. Cowles' website [http://www.wwc.edu/academics/departments/biology/rosario.htm] is literally full of great

information and photographs on Pacific marine species; this resource is most highly recommended for further information): giant plumose anemone (*Metridium giganteum*), green anemone (*Anthopleura xanthogrammica*), yellow zoanthid (*Epizoanthus scotinus*), aggregating anemone (*Anthopleura elegantissima*), sea pen (*Ptilosarcus gurneyi*), flatworm (*Kaburakia excelsa*), sandworm (*Nereis vexillosa*), northern staghorn bryozoan (*Heteroptera magna*), whitecap limpet (*Acmaea mitra*), keyhole limpet (*Diodora aspera*), shield limpet (*Lottia pelta*), plate limpet (*Tectura scutum*), purple ring topsnail (*Calliostoma annulatum*), leafy hornmouth (*Ceratostoma foliatum*), frilled dogwinkle (*Nucella lamellosa*), channeled dogwinkle (*Nucella canaliculata*), checkered periwinkle (*Littorina scutulata*), hairy triton (*Fusitriton oregonensis*), black katy chiton (*Katharina tunicata*), mossy chiton (*Mopalia mucosa*), cockle (*Clinocardium nottallii*), spiny pink scallop (*Chlamys hastate*), smooth pink scallop (*Chlamys rubida*), rock scallop (*Crassadoma gigantean*), rock jingle (*Pododesmus cepio*), red octopus (*Octopus rubescens*), brooding star (*Leptasterias hexactis*), six armed star (*Leptasterias epichlora*), bat star (*Patiria miniata*), sand star (*Lulia foliolata*), white sea cucumber (*Eupentacta quinquesemita*), common acorn barnacle (*Balanus glandula*), little brown barnacle (*Chthamalus dalli*), graceful kelp crab (*Pugettia gracilis*), bluespine hermit (*Pagurus kennerlyi*), bering hermit crab (*Pagurus beringanus*), Steven's hermit crab (*Pagurus stevensae*), blackeyed hermit crab (*Pagurus armatus*), umbrella crab (*Cryptolithodes sitchensis*), scaled crab (*Placetron wosnessenskii*), rhinoceros crab (*Rhinolithodes wosnessinskii*), Pacific lyre crab (*Hyas lyratus*), graceful decorator crad, (*Oregonia gracilis*), pygmy rock crab (*Cancer oregonensis*), and red rock crab (*Cancer productus*).

Dr. Peter Dyrnyda provided photographs of the following organisms: breadcrumb sponge (*Halichondria panicea*) and yellow boring sponge (*Cliona celata*).

Dr. Jerry Filipski of the University of Alberta Canada provided a photograph of the coastrange sculpin, *Cottus aleuticus*.

Fishbase (http://www.fishbase.org/), widely recognized as a superb internet resource for virtually all fish species, provided images of the following species: Alaskan plaice (*Pleuronectes quadritubercula*tus), leister sculpin (*Enophrys lucasi*), roughspine sculpin (*Triglops macellus*),

spotted snailfish (*Liparis callyodon*), and the tadpole sculpin (*Psychrolutes paradoxus*).

Fishpix (fishpix.kahaku.go.gp.jp/fishimage-e/search) provided an image of the Arctic shanny (*Stichaeus punctatus*).

Bill Frank, who maintains the excellent website (www.jaxshells.corg) of shells from all about the United States and elsewhere provided photographs of the margarite snail (Margarites papillosus), Kennicott's whelk (*Beringius kennicottii*), red veiled-chiton (*Placiphorella rufa*), Greenland Cockle (*Serripes groenlandicus*), the polar star (*Leptasterias polaris*) the gunpowder star (*Gephyreaster swifti*) and the ridged blood star (*Henricia aspera*).

Fujimura and Okukajika (members.jcom.home.ne.jp/05124338801fujimura/okukajika.htm) provided an image of the plain sculpin (*Myoxocephalus jaok*).

Dr. Michael Guiry, who oversees the Algaebase website, provided one picture for each of the following seaweed species (the website, www.algaebase.com, is most highly recommended as an outstanding on-line resource to anyone wishing to undertake a study of marine algae): eelgrass (*Zostera marina*), sea lettuce (*Ulva* spp.), little nori (*Smithora naiadum*), nori (*Porphyra* spp.), nailbrush (*Endocladia muricata*), rusty rock (*Hildenbrandia* sp.), coral leaf (*Bossiella* spp.), tidepool coralline seaweed (*Corallina officinalis* var. *chilensis*), bleached brunette (*Cryptosiphonia woodii*), mermaid's cup (*Constantinea simplex*), Turkish washcloth (*Mastocarpus papillatus*), iridescent blade (*Mazzaella splendens*), polly drawing (*Polysiphonia* spp.), black pine (*Neorhodomela larix*), bulb seaweed/oyster thief (*Colpomenia peregrina*), false kelp (*Petalonia fascia*), acid weed (*Desmarestia ligulata*), tangle (*Laminaria setchellii*), bull kelp (*Nereocystis luetkeana*), five mid-ribbed kelp (*Costaria costata*), ribbon kelp (*Alaria* spp.), sea spatula (*Pleurophycus gardneri*), walking kelp (*Pterygophora californica*), and rockweed (*Fucus gardneri*).

Dr. Daniel Guthrie of the MW Keck Science Center in California provided the following seaweed images (Dr. Guthrie's excellent images of marine algaes form the Aleutian Islands can be accessed online as part of the MW Keck Science Center website; I highly recommend this

resource): Pacific dulse (*Palmaria mollis*).

Jason Hall of the University of Washington – Tacoma provided an image of the Breadcrumb Sponge/Gunpowder Sponge (*Halichondria panacea*).

Dr. Gayle Hansen, who authored the alga and seagrasses chapters, provided 1-2 pictures of each of the following species: sea lettuce (*Ulva* spp.). dead man's fingers (*Codium fragile*), little nori (*Smithora naiadum*), nori (*Porphyra* spp.), pacific dulse (*Palmaria mollis*), bleached brunette (*Cryptosiphonia woodii*), mermaid's cup (*Constantinea simplex*), Turkish washcloth (*Mastocarpus papillatus*), iridescent blade (*Mazzaella splendens*), red feather (*Ptilota filicina*), winged rib (*Delesseria decipiens*), polly (*Polysiphonia* spp.), black tassel (*Pterosiphonia bipinnata*), cocklebur alga (*Odonthalia floccosa*), common sea felt (*Pylaiella littoralis*), false kelp (*Petalonia fascia*), soda straws (*Scytosiphon lomentaria*), studded sea balloon (*Soranthera ulvoidea*), acid weed (*Desmarestia ligulata*), sugar kelp (*Saccharina latissima*), tangle (*Laminaria setchellii*), three mid-ribbed kelp (*Cymathaere triplicata*), five-ribbed kelp (*Costaria costata*), shotgun kelp (*Agarum clathratum*), ribbon kelp/winged kelp (*Alaria* spp.), dragon kelp (*Alaria fistulosa*), walking kelp (*Pterygophora californica*), northern bladder chain kelp (*Cystoseira geminata*), and wireweed (*Sargassum muticum*). She also provided the life history diagrams for the flowering plants, green algae, red algae, and brown algae.

Kevin Heard provided a photograph of a white spot anemone (*Utricina lofotensis*).

Keith Hiscock (Published on MarinLin website) provided a photograph of the fat henricia star, *Henricia sanguibolenta*.

Kristin Hultgren who maintains the website 'Stanchowicz Lab,' University of Calkifornia – Davis (http://www-eve.ucdavis.edu/stachowicz/hultgren.shtml), provided an image of the northern kelp crab (*Pugettia producta*).

Theresa Jewell provided a photographic image of Hal's colus (*Colus hali*).

Debbie Karimoto provided a photograph of the hairy crab (*Hapalogaster cavicauda*).

Diver Owen Lloyd contributed the following photographs for this book (Mr. Lloyd maintains an excellent website [www.owenlloyd.com] with many fine photographs of marine organisms and I highly recommend this superb online resource): lion's mane jellyfish (*Cyanea capillata*), Pacific wingfoot snail (*Gastropecteron pacificum*), yellow edged cadlina nudibranch (*Cadlina luteomarginata*), gold dirona (*Dirona aurantia*), sea lemon (*Anisodoris nobilis*), giant white dorid (*Archidoris odhneri*), shaggy mouse nudibranch (*Aeolidia papillosa*), orange peel nudibranch (*Tochuina tetraquetra*), leather star (*Dermasterias imbricata*), blood star (*Henricia leviuscula*), ochre star/purple star (*Pisaster ochraceus*), mottled star/true star (*Evasterias troschelii*), red banded star /long-armed star (*Orthasterias koehleri*), sunflower star (*Pycnopodia halianthoides*), fish-eating star (*Stylasteria forreri*), cushion star (*Pteraster tesselatus*), cookie star (*Ceramaster patagonicus*), morning sun star (*Solaster dawsoni*), Stimpson's sun star (*Solaster stimpsoni*), gray brittle star (*Ophiura lutkeni*), purple sea urchin (*Strongylocentrotus purpuratus*), California sea cucumber (*Parastichopus californicus*), orange sea cucmber/red sea cucmber (*Cucumaria miniata*), feather star (*Florometra serratissima*), giant acorn barnacle (*Balanus nubilus*), spot shrimp (*Pandalus platyceros*), coon-stripe shrimp (*Pandalus danae*), northern kelp crab (*Pugettia producta*), Dungeness crab (*Cancer magister*), widehand hermit crab (*Elassochirus tenuimanus*), spiny lithoid crab (*Acantholithoides hispidus*), butterfly crab (*Cryptolithodes typicus*), helmet crab (*Telmessus cheiragonus*), sailfin sculpin (*Nautichthys oculofasciatus*), scalyhead sculpin (*Artedius harringtoni*), longfin sculpin (*Jordania zonope*), buffalo sculpin (*Enophrys bison*), red Irish lord (*Hemilepidotus hemilepidotus*), cabezon (*Scorpaenichthys marmoratus*), copper rockfish (*Sebastes caurinus*), yellowtail rockfish (*Sebastes flavidus*), black rockfish (*Sebastes malanops*), China rockfish (*Sebastes nebulosus*), quillback rockfish (*Sebastes maliger*), sturgeon poacher (*Podothecus acipenserinus*), kelp greenling (*Hexagrammos decagrammus*), whiespotted greenling (*Hexagrammos stelleri*), northern ronquil (*Ronquilis jordani*), decorated warbonnet (*Chirolophis decoratus*), mosshead warbonnet (*Chirolophis nugator*), snake prickleback (*Lumpenus sagitta*), crescent gunnel (*Pholis laeta*), walleye pollock (*Theragra chalcogramma*), starry flounder (*Platichthys stellatus*), and the bay pipefish (*Syngnathus leptorhynchus*).

Mr. William Leonard, who maintains the excellent website 'CalPhotos' (http://calphotos.berkeley.edu/browse_imgs/invertebrate_com_26.html) provided an image of the Pacific red hermit crab (*Elassochirus gilli*) and the smooth pink scallop (*Chlamys rubida*).

Dr. Milton Love, who maintains the website "The Fish Pics Database" (an excellent and highly recommended source for information on and photographs of northern Pacific fish species), provided photographs of the following species: smoothhead sculpin (*Artedius lateralis*), black prickleback (*Xiphister atropurpureus*), high cockscomb (*Anoplarchus purpurescens*), and the Pacific sanddab (*Citharichthys sordidus*).

Dr. Richard Mooi, of the California Academy of Sciences San Francisco Bay 2K Project, donated an image of the stout costal shrimp/shortspine shrimp, *Heptacarpus brevirostris*.

Janna Nichols "Janna Nichols provided the following excellent, high quality images from her superb 'REEF Critterwatchers' marine life website (http://www.pnwscuba.com/critterwatchers/critterofthemonth.htm), which I recommend to anyone desiring to see the beauty of northern Pacific marine species (her photographs are especially sharp and colorful): white spotted anemone (*Urticina lofotensis*), moon jelly (*Aurelia labiata*), sunflower star (*Pycnopodia helianthoides*), eccentric sand dollar (*Dendraster excentricus*), northern kelp crab (*Pugettia producta*), graceful crab (*Cancer gracilis*), wold eel (*Anarrhichthys ocellatus*), grunt sculpin (*Rhamphocottus richardsoni*), sailfin sculpin (*Nautichthys oculofasciatus*), longfin sculpin (*Jordania zonope*), buffalo sculpin (*Enophrys bison*), padded sculpin (*Artedius fenestralis*), Pacific staghorn sculpin (*Leptocottus armatus*), great sculpin (*Myoxocephalus polyacanthocephalus*), red Irish lord (*Hemilepidotus hemilepidotus*), black rockfish (*Sebastes melanops*), canary rockfish (*Sebastes pinniger*), copper rockfish (*Sebastes caurinus*), China rockfish (*Sebastes nebulosus*), lingcod (*Ophiodon elongates*), kelp greenling (*Hexagrammos decagrammus*), mosshead warbonnet (*Chirolophis lugator*), northern ronquil (*Ronquilis jordani*), crescent gunnel (*Pholis laeta*), and starry flounder (*Platichthys stellatus*).

Dr. Emilien Pelletier of the Institut des sciences de la mer de Rimouski (ISMER) provided an

image of the polar star (*Leptasterias polaris*).

Drs. Warren E. Savary and Luis A. Soloranzo provided images of the little brown barnacle (*Chthamalus dalli*).

Dr. David Scheel contributed photographs of the Arctic moon snail (*Natica aleutica*) and Kennerley's venus (*Humilaria kennerleyi*).

Dr. Paul C. Silva and the regents of the University of California granted permission to use the drawing of the split blade kelp (*Saccharina subsimplex*).

Dr. A. J. Silverside of the University of Paisley provided the photograph of *Calothrix* sp.

Adam P. Summers contributed a photograph of the spinyhead sculpin (*Dasycottus setiger*).

Ms. Lacy Taylor provided a photograph of the fluted bryozoan (*Hippodiplosia insculpta*).

Dr. Yves Terryn, scientific associate of both MNHN, Paris, France and RBINS, Brussels, Belgium, provided photographs of the wrinkled dove snail (*Amphissa Columbiana*) and Kennicott's whelk (*Beringius kennicottii*). He oversees an excellent website, www.naturalart.be, and I recommend this to anyone interested in marine species images and information ranging from seaweeds to fishes (has many excellent photographs).

Dr. Kerry Werry supplied photographs of the red gilled aeolid (*Flabellina fusca*) and the red-veiled chiton (*Placiphorella rufa*). Please note that this photograph, like all others in this manual, is copyrighted by the contributor (which in this case of these two photographs is Dr. Werry).

The Alaska Fish and Wildlife Service provided an image of the harlequin duck, Histronicus histronicus. All FWS photographic images displayed on the internet are in the public domain and are accessible at images.fws.gov.

Alaska SeaLife Center interns/workers, including Richard Hocking, Mandy Keogh, Rachael Murton, Nicole L. Sperbeck, Darin and Deanna Trobaugh, and volunteer John M. Uscian each provided at least several of the following photographs: hermit crab sponge (*Halichondria suberea*), burrowing green anemone (*Anthopleura elegantissima*), short plumose anemone (*Metridium senile*), crimson anemone (*Cribrinopsis fernaldi*), Christmas anemone (*Utricina crassicornis*), sea pen (*Halipteris willimoesi*), moon jelly (*Aurelia labiata*), purple encrusting bryozoan (*Disporella separata*), lined chiton (*Tonicella lineata*), bay mussel/blue mussel (*Mytilus trossulus*), robust clubhook squid (= Pacific giant squid) (*Moroteuthis robustus*), giant Pacific octopus (*Enteroctopus dofleini*), vermillion star (*Mediaster aequalis*), Arctic cookie star (*Ceramaster arcticus*), daisy brittle star *Ophiopholis aculeata*), basket star (*Gorgonocephalus caryi* (= *G. eucnemis*), green sea urchin (*Strongylocentrotus drobachiensis*), red sea urchin (*Strongylocentrotus franciscanus*), eccentric sand dollar (*Dendraster excentricus*), thatched barnacle (*Semibalanus cariosus*), rough patch shrimp (*Pandalus stenolepis*), Alaskan hermit crab (*Pagurus ochotensis*), Pacific red hermit crab (*Elassochirus gilli*), heart crab (*Phyllolithodes papillosus*), longhorn decorator crab (*Chorilia longipes*), grunt sculpin (*Rhamphocottus richardsoni*), bigmouth sculpin (*Hemitripterus bolini*), Pacific staghorn sculpin (*Leptocottus armatus*), plain sculpin (*Myoxocephalus jaok*), great sculpin (*Myoxocephalus polyacanthocephalus*), yellow Irish lord (*Hemilepidotus jordani*), rougheye rockfish (*Sebastes aleutianus*), silergray rockfish (*Sebastes brevispinus*), atka mackerel (*Pleurogrammus monopterygius*), sablefish (*Anoplopoma fimbria*), rock greenling (*Hexagrammos lagocephalus*), masked greenling (*Hexagrammos octogrammus*), Pacific cod (*Gadus macrocephalus*), Arctic grayling (*Thymallus arcticus*), horned puffin (*Fratercula corniculata*), tufted puffin (*Lunda cirrhata*), pigeon guillemot (*Cepphus columba*), common murre (*Uria aalge*), black oyster catcher (*Haematopis bachmani*), red-legged kittiwake (*Rissa brevirostris*), long tailed duck (*Clangula hyemalis*), harlequin duck (*Histronicus histronicus*), spectacled eider (*Somateria fischeri*), the Pacific common eider (*Somateria mollissima*), and the Pacific eider (*Somateria mollissima*).

Beach Watchers, an extension service of Washington State University (www.beachwatchers.wsu.edu), provided images of the black katy chiton (*Katharina tunicata*), the red sea cucmber (*Cucumaria miniata*), Graceful Kelp Crab (*Pugettia gracilis*), the Bering

hermit crab (*Pagurus beringanus*), and Pygmy Rock Crab (*Cancer oregonensis*).

BioMEDIA ASSOCIATES (http://www.ebiomedia.com) provided an image of the Pacific Wingfoot Snail **(**Gastropteron pacificum).

CalPhotos (http://calphotos.berkeley.edu/browse_imgs/invertebrate_sci_42.html) provided an image of the whitespot anemone (*Urticina lofotensis*).

The Cobble Beach at Snug Harbor (website: http://depts.washington.edu/fhl/zoo432/snugharbor/common.html) provided an image of the Spiny pink scallop (*Chlamys hastata*).

The Coral farm (www.CoralFarm.co.uk) provided a photograph of the margarite snail (*Margarites pupillus*).

The Duxbury Reef website (http://www.gatetrails.com/exhibits/duxburyreef.html) provided an image of the aggregating anemone (*Anthopleura elegantissima*).

Evergreen University (website: http://academic.evergreen.edu/t/thuesene/animalia/arthropoda/crustacea/decapoda/cancridae/productus.html) provided an image of the Red Rock Crab (*Cancer productus*).

Fishbase (website: http://www.fishbase.org/summary/Speciessummary.php?id=2693) provided images of the great sculpin (*Myoxocephalus polyacanthocephalus*) and the Arctic grayling (*Thymallus arcticus*).

Guiamarina Photos (website: http://www.guiamarina.com/gallery/v/kamchatka/01+Marine+Animals/06+Echinodermata/Holothuroidea/Cucumaria+vegae.jpg.html) provided an image of the black sea cucmber (*Cucumaria vegae*).

The Humbolt State University Natural History Museum website (http://www.humboldt.edu/~natmus/newsletter/Tidepools/molluscs.html) provided an image of the gumboot chiton (*Cryptochiton stelleri*).

The Institute for Watershed Studies of the University of Washington provided a photograph of the Sitka periwinkle (*Littorina sitkana*).

The National Oceanic and Atmospheric Coalition (NOAA) of the U.S. Department of Commerce, through maintaining on-line images that are in the public domain, was utilized in obtaining the following photographs (NOAA is an excellent and highly recommended source for information pertaining to virtually all aspects of marine biology/oceanography): sea sawdust (*Trichodesmium erythraeum.*), surfgrass (*Phyllospadix serrulatus.*), sea whip (*Balticina sp.*), sinous/lyre whelk (*Buccinum plectrum*), ridged whelk/northwest Neptune/lyre whelk (*Neptunea lyrata*), Pacific weathervane scallop (*Patinopecten caurinus*), she shaggy mouse nudibranch, (*Aeolidia papillosa*) Sand Star (*Luidia foliolata*), black spined star (*Lethasterias nanimensis*), mud star (*Ctenodiscus crispatus*), the fish-eating star (*Stylasterias ferreri*), purple sun star/smooth sun star (*Solaster endeca*), common sand star (*Echinarachnius parma*), sea football (*Cucumaria frondosa*), black sea cucmber (*Cucumaria vegae*), bay shrimp (*Crangon stylirostris*), golden king crab/brown king crab (*Lithodes aequispinus*), Puget Sound king crab (*Lopholithodes mandtii*), tanner crab and snow crab (*Chinoecetes bairdi* and *Chinoecetes opilio*), the butterfly crab (*Cryptolithodes typicus*), Pacific Lyre Crab **(***Hyas lyratus***),** Hairy Lithoid Crab (*Hapalogaster mertensii*), sea peach (*Halocynthia aurantium*), Alaska skate (*Bathyraja parmifera*), Pacific herring (*Clupea harengus pallasi*), three-spined stickleback (*Gasterosteus aculeatus*), tidepool sculpin (*Oligocottus masculosus*), spinyhead scuplin (*Dasycottus setiger*), big mouth sculpin (*Hemitripterus bolini*), shortspine thornyhead (*Sebastolobus alascanus*), dusky rockfish (*Sebastes ciliatus*), lingcod (*Ophiodon elongates*), prowfish (*Zaprora silenus*), decorated warbonnet (*Chirolophis decoratus*), wattled eelpout (*Lycodes palearis*), southern rock sole (*Lepidopsetta bilineata*), northern rock sole (*Lepidopsetta polyxystra*), Dover sole (*Microstomus pacificus*), Pacific halibut (*Hippoglossus stenolepis*), flathead sole (*Hippoglossoides elassodon*), butter sole (*Isopsetta isolepsis*), giant wrymouth (*Cryptacanthodes giganteus*), Arctic char (*Salvelinus alpinus*), dolly varden (*Salvelinus malma*), silver

salmon/coho salmon (*Onchorhynchus kisutch*), stellar sea lion (*Eumetopias jubatus*), harbor seal (*Phoca vitulina*), walrus (*Odobenus rosmarus*), sea otter (*Enhydra lutris*), orca/killer whale (*Orcinus orca*), beluga whale/white whale (*Delphinapterus leucas*), gray whale (*Eschrichtius robustus*), humpback whale (*Megaptera novaengliae*), and the bowhead whale (*Balaena mysticetus*).

The National Science Foundation (NSF) 'Where Discoveries Begin Multimedia Gallery – Image' site (website: http://www.nsf.gov/news/mmg/mmg_disp.cfm?med_id=61271&from=img) provided an image of the bat star (*Patiria miniata*).

The National Wildlife Federation provided an image of the Pacific littleneck clam (*Protothaca staminea*).

The North Coast Rural Challenge Network (www.ncrcn.com) provided an image of Green Anemone (*Anthopleura xanthogrammica*).

The Oregon Department of Fish and Wildlife provided a photograph of the rock greenling (*Hexagrammos lagocephalus*) and the northern rock sole (*Lepidopsetta polyxystra*).

'Oceanlink: All About the Ocean…' (website: http://oceanlink.island.net/oinfo/biodiversity/heartcrab.html) provided an image of the heart crab (*Phyllolithodes papillosus*).

The Rockefeller University website 'Science for the Benefit of Humanity' (http://phe.rockefeller.edu/barcode/blog/page/3/) provided an image of the mossy chiton (*Mopalia mucosa*).

'Seafloor Pictures detected by TV cameras on the station' (website: http://www.jamstec.go.jp/scdc/html_sysindex_e/moveha.html) provided an image of the tadpole sculpin (*Ebinania vermiculata*).

The Shedd Aquarium, Chicago, provided an image of the giant Pacific octopus (*Enteroctopus dofleini*).

Stanford University (website: http://www.stanford.edu/~bhackett/puget-sound-2004-08-21/pages/wolf-eel-(a).html) provided an image of the wolf eel (*Anarrhichthys ocellatus*).

The website http://www.sysu.edu.cn/museum/creature/animal/Chordata.htm Provided an image of the sea peach (*Halocynthia aurantium*).

The University of Arizona Marine Discovery Page (website: http://marinediscovery.arizona.edu/lessonsF00/blennies/2.html) provided an image of the red octopus (*Octopus rubescens*).

The Washington Department of Fish and Wildlife provided a photograph of the Pacific littleneck clam (*Protothaca staminea*).

'The Wet, The Wild, and The *Latin*' (website: http://depts.washington.edu/fhl/zoo432/cattlepoint/432pagemill/432cat.html) provided images of the white sea cucumber (*Eupentacta quinquesemita*) and the umbrella crab (*Cryptolithodes sitchensis*)and the Graceful Decorator Crab (*Oregonia gracilis*).

Wikimedia Commons provided an image of the Pacific Red Hermit Crab (*Elassochirus gilli*) and the Alaskan ronquil (Bathymaster signatus; website: http://de.wikipedia.org/wiki/Ronquils).

Paul H. Yancy of Whitman College and who maintains the excellent website "Deep Sea Pages: Bathyal and Abyssal Echinoderms" (http://people.whitman.edu/~yancey/echinoderms.html) provided an image of the sea sweet potato (*Molpadia intermedia*).
The '1998 Biology Field Experience: The Northeast ' (website: http://www.marietta.edu/~biol/nabs98/tripnar2.html) provided an image of the sea football (*Cucumaria frondosa*).

Foreword

Welcome to the Alaska SeaLife Center (ASLC)!

After opening its doors in 1998, this facility now welcomes many thousands of visitors each year. The ASLC is dedicated to understanding and maintaining the marine ecosystem of Alaska through research, rehabilitation, and public education.

You are no doubt anxious to begin viewing the numerous marine life forms housed at the ASLC and thereby learning more about the unique characteristics of each. Indeed, there are marine mammals such as sea lions and seals, sea birds including brightly colored puffins and red-billed oyster catchers, fishes ranging in size from herring to halibut, and a plethora of marine invertebrates, perhaps most notably the giant Pacific octopus. The purpose of this book is to provide you with a bit more information about the organisms maintained at the ASLC so that you may deepen your understanding and appreciation of them.

However, as a prelude to the more species-specific information contained in this document, there are three short chapters that explain more basic topics such as what criteria constitute living organisms, the basis for classification of living organisms, and the characteristics of a marine ecosystem. Reading these chapters should help to place the more species-oriented information (which can get quite detailed) into the broader frameworks of general and marine biology. Chapters IV through XVIII are descriptions of various phyla (e.g., Mollusks, Echinoderms, and Chordates) and/or species within those phyla that are maintained at the ASLC.

In addition, a glossary, defining many of the less familiar, more biologically-oriented terms appears at the end of this handbook. When seen for the first time in the regular text of this handbook, such terms are presented in boldface type (the word **domain**, just immediately above, is an example.)

A few words are in order regarding the information sources used in producing this work. For the descriptions of invertebrate phyla, subphyla, and classes, I have relied upon four excellent books,

Invertebrate Zoology (R.D. Barnes, 1980), Invertebrates (R.C. Brusca and G.J. Brusca, 1990), Marine Invertebrates of the Pacific Northwest (E.N. Kozloff, 1987), and Intertidal Invertebrates of California, 5th Revised Edition (R.H. Morris, D.P. Abbott, and E.C. Haderlie, 1980). For descriptions of birds, The Audubon Society Encyclopedia of North American Birds (J.K. Terres, 1996) proved invaluable. The descriptions of mammals were made based largely upon information presented in Walker's Mammals of the World, Fifth Edition, Vol. II (R.M. Nowak, editor, 1991). Other important species information was obtained from Southeast Alaska's Rocky Shores : Animals (R.M. O'Clair and C.E. O'Clair, 1998), Whales to Whelks (R.M. Harbo, 1999), Under Alaskan Seas : The Shallow Water Marine Invertebrates (Barr L. and N. Barr, 1983), A Field Guide to Pacific Coast Fishes of North America (Eschmeyer W.H., E.S. Herald, and H. Hammann, 1983), Pacific Fishes of Canada : Fisheries Research Board of Canada (Hart J.L., 1973), Between Pacific Tides, 5th Revised edition (E.F. Ricketts, J. Calvin, and J.W. Hedgpeth, 1992) Alaska'a Saltwater Fishes and Other Sea Life (Kessler D.W., 1985), and The Rockfishes of the Northwest Pacific (Love M.S., M. Yoklavich, L. Thorsteinson, and J. Butler, 2002). I recommend all of these sources to those wishing to learn yet more of the organisms inhabiting Alaska's marine ecosystems.

Please take your time to enjoy the ASLC. If you have questions, don't hesitate to ask any of the staff interpreters about questions or insights you may have. They are all here to help you learn more about the diversity of life to be found in Arctic seas and oceans. In addition, everyone at the ASLC may be able to learn from you as well!

This work attempts to present descriptions of all species that are and/or have been maintained at the ASLC. However, in the future there will be species brought in which are entirely new to this facility. Consequently, this manual shall remain a "work in progress" and will therefore likely never be truly complete. Certainly in the future new species descriptions will have to be added to keep the manual updated. It is nonetheless hoped that this first edition covers most of the species that one is likely to encounter at the ASLC

It should also be noted that not all of the species presented in this manual occur within Resurrection Bay and other waters near the Alaska SeaLife Center. For example, the Eccentric

Sand Dollar, *Dendraster excentricus*, only occurs as far north as southeastern Alaska, in the Juneau area. Nonetheless, this and some other species have been included because they are important or interesting and representative of Alaskan waters outside those of the ASLC or, though not from Alaskan waters, important Pacific species deserving of mention.

Finally, although the author and editors have endeavored to present the most accurate and up-to-date information throughout this book, they nonetheless welcome all critical commentary aimed at improving the work in this regard. Please direct all such comments to the Alaska SeaLife Center, 301 Railway Ave., P.O. Box 1329, Seward, AK, 99664.

To the Alaska SeaLife Center Interpreter

So, you have been selected as an Alaska SeaLife Center (ASLC) interpreter. Great! This should be an exciting adventure as you become more familiar with the inhabitants of the Alaskan marine environment. Interpreters seem to come from experience and educational backgrounds that are as diverse as the marine life forms that they will be helping the visitors to understand and enjoy. Still, two vitally important characteristics that are common among virtually all volunteers include 1) a fascination with the Alaskan marine environment and 2) an eagerness to learn.

During the summer of 2003, I had the privilege of volunteering as an ASLC interpreter. This was a very rewarding time for me as I very much enjoy discussing and learning about marine organisms via interacting with the visiting public. However, although formally educated and trained as a biologist, my time as a volunteer also revealed to me that I had a great deal to learn about the ASLC's birds, fishes, mammals, invertebrates, and plants. I therefore considered that a book such as this might be useful to ASLC visitors and/or interpreters (such as me!)

Most of us either visiting or working at the ASLC have an intuitive aesthetic sense for the beauty of the organisms maintained in this facility. As interpreters, this quality is our greatest asset as it is a prerequisite to deepening our understanding, and therefore appreciation, of the unique marine fauna of Alaskan shores and waters. How much more interesting, and indeed beautiful, the puffin becomes when we are supplied with the knowledge that these birds can flap their wings under water to achieve dives to depths in excess of 100 feet! Moreover, consider the muscles and nervous system that function together to propel the jellyfish through the water. This simple animal, comprised of 95% water, nonetheless utilizes both neurons and muscle cells that, at the most basic level, function in many ways identical to those in our own bodies. Clearly, the life in Alaskan waters contains much that will captivate us. We can benefit our visitors through conveying this sense of enthusiasm and wonderment.

In order to deepen one's understanding of the numerous ASLC species, this manual contains both an overview of those characteristics which constitute living systems in general as well as a

description of marine ecosystems and organisms in particular. You are encouraged to focus initially on the broad themes (e.g., what is a living thing?, what is an ecosystem?, and how are organisms scientifically classified?) presented in this book's initial chapters. Understanding these should provide you with a general background that will prove useful in understanding the details of the species, covered later in this booklet, that you'll be presenting to visitors.

If you have not had much formal education/training in biology you can nonetheless be a very effective ASLC interpreter. The very fact that you have agreed to take on the role of an interpreter signifies above average interest in the Alaskan marine environment. This booklet, written from the perspective that the reader lacks college-level, biology course work, is an attempt to bring all interpreters up to a more level playing field for understanding Alaska's marine organisms. I hope that it may help to achieve this and that your time as an interpreter will therefore be more rewarding to both inquiring visitors and to you as well.

John M. Uscian, August, 2004

I. What is a Living Organism?

The title of this chapter, a question, may sound trite, but rest assured that at least among practicing biologists this question is anything but trivial. Let's cut to the quick and present the three basic criteria used by many biologists (but by no means all of them!) to recognize a living thing:

1. **Composed of a cell or cells**
   - a **cell** is the membrane-bound basic unit of life
     - it functions to keep what is inside the membrane in a very different state from what is outside
     - the metabolic machinery, consisting of bio-generated substances (especially proteins, carbohydrates, lipids, and nucleic acids) contained within this membrane is what sustains the production of energy and building materials essential to that cell's survival

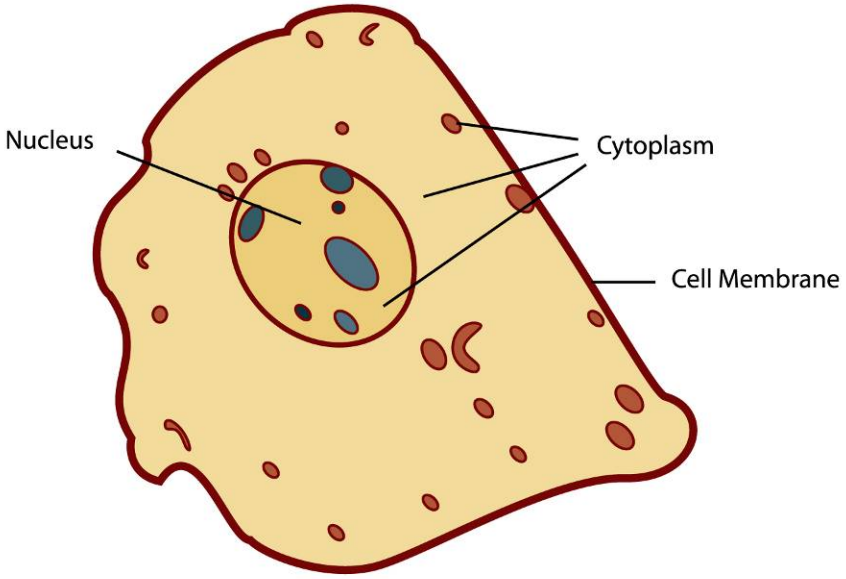


Fig. I.1. A Liver Cell (note basic components)

2. **DNA is the genetic material**
   - **DNA** is a substance that functions as a set of instructions that specifies how to construct and maintain a particular living organism
   - for the organisms (i.e., plants and animals) under consideration at the Sea Life Center, most of the DNA is located in the cell nucleus

3. **Has a metabolism**
   - the term ***metabolism*** refers to all of the chemical reactions occurring within the living cell during times of growth and repair

The above three items are the minimum characteristics that most biologists will require be in evidence for something to be regarded as living. Still, consider that some biologists also require that living entities possess certain other criteria. Some of these might include any or all of the following capacities:

- to grow
- to respond to stimuli
- to reproduce
- to evolve
- to possess controlled movement of substances within cell

We can glean from the above that not all of those who study life sciences are in agreement as to what criteria must be utilized in establishing whether or not something be considered as living. Still, if we at least agree to adhere to the first three of the eight above-listed characteristics, we will be using a very broad definition of life and this should suit our purposes well.

We can note that all of the organisms maintained at the ASLC safely meet all of the first five criteria. Consider, for example, the Steller sea lion. How many cells do you think are contained in a 1200 pound male example of this sea mammal? Given that the average human body contains 75 – 100 trillion (yes, that's *trillion*, which is the quantity one million represented one million times) cells and assuming that there are an equal number of cells in a Steller sea lion as there are in a human based on unit weight, a 1200 pound Steller sea lion would contain about 600 – 800 trillion cells! Moreover, each of these cells would have its own DNA and its own metabolism. Each cell would also have the capacity to grow and respond to stimuli. In addition, because the Steller sea lion (and virtually every other living entity featured at the ASLC) is a **multicellular** organism (by contrast, organisms such as bacteria, amoeba, and paramecia are single celled), there must be some communicatory mechanisms for coordinating the activities of such a tremendous numbers of cells occurring in one living entity. The nervous and endocrine (hormonal) systems will accomplish this (more on this later). Thus, what we perceive to be a single living creature is actually a mosaic of perhaps many trillions of different, interacting, living cells.

Just to emphasize the point that it is not always easy to define what constitutes a living entity, let's agree, for sake of argument, that an organism is not living if it cannot reproduce. Now, does this mean that organisms that are too young or too old to reproduce are not yet living or are no longer still fully alive respectively? What about a spayed or neutered dog or cat? Neither can reproduce, so can either be considered as living? And what of a woman or man who has been surgically or otherwise rendered sterile? Do we regard such individuals as being non-living beings? You might reply that such entities *could* reproduce at one time. But remember that there are many folks deep in cemetery grounds who could also reproduce at one time. Do you regard them as being alive? Clearly, these are philosophical questions and not everyone agrees on the answers. An important point to be taken is that life, from the point of view of a biologist at least, is not so easily defined (and this is especially curious in view of the fact that biologists purport to study life!)

In the interest of getting a better feeling for what a living, multicellular organism is without

going into all of the details concerning subcellular structures, tissues, and organs, let's make an analogy in which we regard a living entity as a functioning country. The breakdown of components might go something like the following (in this analogy, the functioning country equivalent of a living organism is presented in the right hand column):

Table I.1. Analogy of a Living Organism and Functioning Country

Living Organism	**Functioning Country**
made up of cells (**nerve** cells, **muscle** cells, etc.)	made up of buildings (homes, factories, stores, etc.)
cells come together to form **tissues**	buildings come together to form towns/cities
tissues form **organs** (e.g., brain, stomach, kidneys muscles, eyes)	towns unify to become states or territories (like organs, some of these may have special general functions; e.g., in the U.S. Pittsburg produces steel, Wisconsin produces dairy products, Texas produces cattle, Alaska sustains wildlife and produces processed salmon, etc.)
organs assemble into a complete, functioning organism	states/territories assemble into a multicultural society/country
organism interacts with **environment** to obtain **nutrients**	country interacts with other countries to obtain needed commerce/trade items that it cannot produce itself

It is worth mentioning at this time that the tremendous number of integrated cells comprising an animal organism, even one as small as an inch long jellyfish, are made to function in a coordinated manner by two integrating, functional systems (the term biologists use to represent such life-supporting functions is ***physiology***; we will say a bit more about physiology later). These are the nervous system and the endocrine (hormonal) system. Again, we can make use of the above analogy and compare these systems as follows:

Living Organism	**Functioning Society/Country**
Nervous System: in animals enables rapid communication rapidly between organs and tissues (e.g., message in brain is sent to muscles controlling fish tail muscles)	Telephone communications integrate activities of people separated by large distances
Endocrine/Hormonal System: chemical messengers, transported by body's circulation instructs cells in one part of the body to contribute to the functioning of the entire organism in some particular way; compared to nervous system, a slower means of relaying messages	Postal service delivers letters/packages which enable people, indeed entire corporations to interact with one another in some particular way

Ultimately, these regulatory activities make possible the functions of the many, many, many different cells comprising a single, multicellular animal organism. Now when we look at the puffins, king crabs, and giant pacific octopus, we can view these from the fascinating perspective that each is a tremendously diverse compilation of cells that collectively function to form a single, living individual.

A basic understanding of some other physiological processes that will prove useful in coming to understand all living organisms include the following (again, note that many of these apply only to animals, the main organisms featured at the Alaska sea Life Center):

Respiratory System: function in which oxygen is utilized in support of cellular energy production through chemical breakdown of carbohydrate (glucose); carbon dioxide is produced as a waste product

Muscle Function: muscles are animal organs that are composed of individual muscle cells, all of which work by becoming shorter and thus enabling an organism to move body parts; do note that muscles must be stretched out before they can again be contracted; this is accomplished by some other opposing force such as another muscle contraction

Circulatory System: an animal function that enables movement of a cell-rich fluid (in vertebrate organisms this tissue is called blood) in order to deliver nutrients, cells, and hormones to cells and tissues while simultaneously transporting the waste products to areas (for example, lungs and kidneys) where they may be voided

Urinary System: an animal function that maintains chemical balance of body fluids through retaining certain substances while ridding the body of metabolic waste products (metabolic wastes are those which are generated through chemical processes going on inside the body and

not in the digestive tract; examples of metabolic wastes include uric acid and carbon dioxide)

Special Senses: Vision, Taste, Smell, Hearing Functions: specialized animal organs which function to send signals that are interpreted by the central nervous system (brain) as vision, taste, smell, or hearing; these messages help the organism to form an awareness of its environment with regard to different forms of energy present there (i.e., eyes perceive light energy, hearing perceives motion of molecules in a fluid medium, and chemical energy is perceived by taste and smell functions)

Digestive System: function of mechanically and/or chemically breaking food molecules into forms that may be absorbed and support metabolism; the digestive system also is responsible for this nutrient absorption and the riddance of digestive wastes (feces)

Reproduction: functions that enable a parent organism to produce offspring

II. How Are Living Organisms Classified?

Upon first observing the diverse organisms maintained at the ASLC, you might feel a bit overwhelmed in trying to comprehend how these organisms are related to one another. However, a brief examination of **taxonomy** (Greek: *tasso*, to arrange or classify; *nomos*, law), that system used by biologists to categorize living organisms, can help all of us to better understand the similarities and differences among living creatures. This will in turn deepen our appreciation for the amazing ways that Alaska's **marine** inhabitants interact with one another and the rest of their environment.

Let's make the point right off that taxonomists do not always agree among themselves as to just how a particular organism should be classified. Still, making use of physical characteristics, gene analysis, and fossil studies are just some of the ways that these scientists try to better establish the place of a particular organism amongst the estimated 3 to 30 million **species** presently inhabiting the earth. As scientists learn more of the relationships between living and extinct organisms, the general trend is towards a more reliable taxonomic understanding of all living and once-living things.

Classification Categories

Biologists today classify living organisms according to the following categories, here listed from the most general (Domain) to the most specific (species):

- **Domain**
  - **Kingdom**
    - **Phylum**
      - **Class**
        - **Order**
          - **Family**
            - **Genus**
              - **Species**

Due to recent discoveries, the higher ranks of classification have changed. We now recognize three Domains: the Archaea (primitive bacteria), Bacteria, and Eukaryota. While this text very briefly considers the Bacteria and two of its representatives (see Chapter IV), all other organisms are members of the Eukaryota, species whose cells contain membrane-bound organelles (e.g., the nucleus, mitochondria, and, in some cases, chloroplasts).

The following table summarizes the characteristics of the three Domains:

Table II.1 The Three Domains

Domain Bacteria	**Characterisitcs**
	• lack a nuclear envelope • circular chromosome • DNA lacks histones • exclusively single-celled (e.g., bacteria) • lacks membrane-enclosed organelles • contain peptidoglycan (sugars cross linked with peptides) in cell wall • growth inhibited in presence of antibiotics
Domain Archaea	**Characteristics**
	• lack a nuclear envelope • circular chromosome • histones associated with DNA • exclusively single celled • lacks membrane-enclosed organelles • lack peptidoglycan (sugars cross linked with peptides) in cell walls • growth not inhibited in presence of antibiotics • some species thrive at temperatures in excess of 100 ^{o}C
Domain Eukaryota	**Characteristics**
	• have a nuclear envelope • lacks circular chromosome • histones associated with DNA • includes both single celled and multicellular examples • has membrane-enclosed organelles • growth not inhibited by antibiotics

Note that all of the domains can be differentiated from one another based upon certain subcellular (i.e., some component out of which a cell is composed) traits. Now, having considered the characteristics of the three domains, let's turn our attention to the kingdoms contained within the Domain Eukaryota. Indeed, more than 99% of the species represented in this book are members of this Domain. The characteristics of the 6+ Kingdoms from the Domain Eukaryota are summarized in the following table:

Table II.2. Kingdoms of the Domain Eukaryota

1. Kingdom Plantae	• unicellular and multicellular forms • nearly all phyla have a cell wall • photosynthetic, utilizing light energy • chloroplasts enclosed by 2 membranes • pigments: chlorophyll a and accessory pigments that include either green chlorophyll b or the red and blue phycobilin pigments • storage reserve is a form of starch (primarily α-1,4 linked glucans) • sexual and/or asexual reproduction • examples: flowering plants, gymnosperms, green and red algae, stoneworts, mosses, ferns
2. Kingdom Chromista	• unicellular and multicellular forms • most phyla have a cell wall • photosynthetic and non-photosynthetic forms • in the photosynthetic forms, the chloroplasts enclosed by 3 membranes • photosynthetic pigments: chlorophyll a and accessory pigments that include chlorophyll c and often fucoxanthin • storage reserve is a form of laminarin (β-1,3-linked glucans) • often with laterally biflagellate motile stages • examples: brown algae, diatoms, golden algae, water molds, labyrinthulids
3. Kingdom Amoebozoa	• unicellular or colonial • lack a cell wall • obtain nutrients from the environment • movement via cytoplasmic streaming. • slime molds, some amoebae
4. Kingdom Fungi (Referred to as Opistokonts when grouped with the Metazoa, their closest relatives)	• multicellular and unicellular forms • with a cell wall • absorb nutrients from environment • non motile except for reproductive cells • sexual and asexual reproduction • examples: mushrooms, mildews, Candida
5. Kingdom Metazoa (True animals -- referred to in earlier texts as Animalia)	• multicellular • lack a true cell wall • obtain nutrients from environment, often engulfing other organisms • generally motile • sexual reproduction generally occurs (with some exceptions) • examples: true animals such as sponges, vertebrates, invertebrates, tunicates, etc.

6+. Kingdoms of Protozoa (6 or more kingdoms of Protozoa are reported to exist)	• unicellular, assorted flagellates and amoebae • most often lack a true cell wall • photosynthetic and non-photosynthetic forms • often with sexual reproduction • many parasitic forms • examples: euglenoids, dinoflagellates, ciliates, trichomonads, foraminifera, radiolarians

Note that each Domain or Kingdom is characterized in accordance with unique features of the cell or cells comprising organisms belonging to that kingdom. The idea of a cell being the basic unit of life is reflected in the classification of living things, especially at this most general level.

It should be observed that each higher classification level can contain anywhere from one to many of the subsequent, more specific category. For example, the kingdom Metazoa (multicellular **animals**) contains some 14 phyla (plural of phylum), which collectively include the **sponges**, cnidarians, comb jellies, flat worms, ribbon worms, nematodes, rotifers, onychophorans, acorn worms, **annelids**, **arthropods**, **echinoderms**, and **chordates**. Similarly, in Alaska there are five species of Pacific salmon (their common names are the pink, chum, silver, sockeye, and king salmon) within the genus *Onchorhynchus*.

We should also note that this classification system categorizes organisms within the same, specific taxonomic grouping based upon characters that are believed to reflect closer relationships. Therefore, all organisms that have a membrane-bound nucleus in each cell, a cell wall, and produce energy by capturing light from the sun (photosynthesis) are classified as belonging to the plant kingdom, a very broad category. Similarly, all aquatic mammals with a length of 1.2 – 32 meters, a horizontal tail, a torpedo-shaped body, front limbs modified into flippers, a layer of blubber beneath the skin, externally opening nostrils, presence of a blowhole, no hind limbs, no sweat **glands**, and no external ears are members of the **animal** order **Cetacea**, a more specific taxonomic group that contains the whales, dolphins, and porpoises.

Just to make the taxonomic system clearer still, let's consider the Domain through species categories for a human being, the china rockfish (a very attractive fish featured here at the ASLC), and a marine algal species.

Table II.3. Classification of three organisms maintained at the Alaska SeaLife Center

	Human	China Rockfish	Rockweed
Domain	Eukaryota	Eukaryota	Eukaryota
Kingdom	Metazoa	Metazoa	Chromista
Phylum	Chordata	Chordata	Ochrophyta
Class	Mammalia	Osteichthyes	Phaeophyceae
Order	Primates	Scorpaeniformes	Fucales
Family	Hominidae	Sebastidae	Fucaceae
Genus	*Homo*	*Sebastes*	*Fucus*
Species	*Homo sapiens*	*Sebasters nebulosus*	*Fucus gardneri*

Binomial System of Naming Living Organisms

You may have wondered why biologists assign these seemingly impossible-to-pronounce, multi-syllabic, Latin names to a particular organism. The reason for this is both historical and practical. From a historical perspective, the first individuals who formalized taxonomy lived during the seventeenth century and were educated in the European tradition, which often required that students learn Greek and Latin. It seemed natural to them that they should apply one of these scholarly languages to their system of biological categorization. From a practical perspective, they also saw the benefits inherent in standardizing the name of a particular organism so that two different researchers from two different countries could be certain that they were discussing the same creature. Latin, no longer a spoken language but one that was only written, was not subject to the inevitable changes that will occur in other, spoken languages.

This is an important issue when one realizes that a common name in one country is not necessarily the same common name of that species in another country. Indeed, common names can even vary within a country. For example, in the United States, the freshwater game fish *Esox lucius* is usually referred to as "northern pike" or simply "pike." In Canada it is often called a "jack." In Florida and the Gulf states, the term "jack" is applied to large, powerful marine game fishes of the family carangidae (i.e., the jacks and pompanos). We can therefore appreciate that the use of a common name can quickly lead to taxonomic confusion! Thus in the seventeenth century arose a system of applying a specific Latin name to a particular species (we will discuss just what is meant by the term *species* a little bit later). The famous naturalist who established the accepted method for this classification system was **Carolus Linnaeus**, a Swedish

physician and botanist.

Linnaeus' method of classification is known as the **binomial**, meaning two-part name, system. The first name is the *genus*, a level of biological classification that may contain anywhere from one to many species. The second name is the specific name (specific epithet), which refers to one species within that genus. Thus, for example, as human beings we are scientifically classified as belonging to the genus *Homo* and the species *sapiens,* thereby making us *Homo sapiens.* Note that the genus name, *Homo*, is capitalized and italicized while the specific epithet, *sapiens*, is not capitalized but is italicized. To illustrate that different species can be contained within the same genus, consider that former, now extinct members of the genus *Homo* include *Homo erectus* and *Homo habilis*.

Having emphasized the need for assigning a scientific name to a species, it should be mentioned that scientists do not themselves *always* use these cumbersome binomial names to refer to the particular organism they happen to be working with, especially when they do so informally. For example, in working here at the Alaska Sea Life Center with *Gorgonocephalus caryi*, the basket sea star, most scientists are likely to refer to it as simply a basket star. If a research paper about this species were being published, the scientific name would likely appear in the title and in the early sections of the paper. However, once having established what species the paper is discussing, many scientists will subsequently refer to the animal by its common name (in this example, the basket star). Thus, do not feel as though you are being unscientific if you use a common name to refer to any living organism. Just make certain that you know what scientific name corresponds to the organism referred to by that common name. Again, do appreciate that what constitutes a common name in one geographic locale does not necessarily constitute that species' common name in another area. If there is a question that what you are calling, for example, a basket star is not the same species as what someone else is calling a basket star, then you can refer to the scientific name to make sure that you and the other individual are talking about the same species.

What is a Species?

Organisms that display the following characteristics are said to belong to a particular *species*, the lowest level of taxonomic classification:

- share a common **gene pool**
- produce viable offspring
- produce offspring that can function under natural conditions

Let's consider each of these species characteristics. For an organism to share a common gene pool, it must be capable of contributing its own genes to that of all the genes collectively contained in a population. Such genes constitute the gene pool. Production of viable offspring simply means that the offspring generated are themselves capable of reproducing. For organisms to be functional in a natural environment, they must be capable of surviving in that environment.

The giant pacific octopus, *Enteroctopus dofleini*, breeds with other giant pacific octopuses (shares a common gene pool by combining its genes, contained in egg or sperm, during reproduction) and the resulting progeny are themselves capable of reproducing (viable) and surviving in the natural marine environment (functional). Thus, all giant pacific octopuses belong to the same species.

Although a horse and a donkey can mate (again, share a common gene pool) and thereby produce a mule that can survive under natural conditions, the mule is sterile and hence non-viable. Thus, the horse and the donkey belong to separate species.

The Alaskan brown bear, *Ursus arctos*, and the polar bear, *Ursus maritimus*, were, until very recently, regarded as separate species because although they were known to mate under zoo/un-natural conditions and produce viable offspring, those offspring were assumed to be incapable of surviving in a natural environment. However, in 2006 a hunter in northern Canada shot and killed what he thought was a polar bear. Upon up-close inspection of this animal, it was noted that it had a mix of physical characteristics, some unique to brown bears and some unique to polar bears. DNA analysis confirmed that this bear was a natural hybrid between polar and brown bear parents. Thus, the verdict remains out on whether or not polar and brown bears are separate species or whether they are more closely related and thus considered subspecies of a single species. This example illustrates the challenges that taxonomists sometimes face in assigning proper phylogenetic status to an organism.

If you are feeling a bit overwhelmed with all of this taxonomy business right now, never fear! Rest assured that if you can learn the names of the following animal phyla (see chapters on phyla), learn a few of the subphyla and classes within those phyla (and maybe even the occasional order within certain classes!), and then some of the common names of the species within those classes, you'll be well on your way to understanding the classification of and relationships among the organisms featured here at the ASLC. Then, as your natural curiosity gets you to inquire a bit about the habits of species within those classes, you'll be in a position to help other folks better understand the animals. Who knows, maybe you'll even be curious to learn of the various orders, families, genera, and even the species names within those genera. Be forewarned not to overdo it on the scientific names when meeting with the average visitor; for example, instead of discussing a *Eumetopias jubatus*, you might be better off calling it a Steller sea lion, the common name of this marine mammal. Still, this is not meant to imply that there isn't a proper time and a place for the use of species names.

III. Marine Ecosystems

In order to develop a better understanding for Alaska's marine life in general, let's step back a bit now and consider how the various marine organisms featured at the Alaska Sea Life Center relate to one another in their varied native habitats. Such considerations focus on understanding the Alaska marine **ecosystem**. An ecosystem consists of all living organisms inhabiting an area as well as the nonliving physical environment with which they interact; basically a community and its environment.

With just a little reflection upon this definition, we can realize that ecosystems have the potential to be very complex! Such complexity is a characteristic of tropical rain forests, temperate forests, many lake systems, and numerous marine environments, to name but a few obvious examples. Alaska's marine ecosystems are no exception. Indeed, there are numerous different forms of geological structures representing the nonliving (**abiotic**) aspects of the Alaska marine ecosystem. Some other major abiotic factors include currents, storm surges, inorganic nutrients (e.g., phosphate), **salinity**, ice cover (especially important in Arctic and Antarctic realms), and temperature. In addition there is also, of course, a fabulous diversity of living (**biotic**) components making up this ecosystem as well. The interactions of these biotic and abiotic components are only beginning to be unraveled as we attempt to better understand the underlying themes of the complex interactions characteristic of Alaska's marine ecosystems.

In coming to better understand ecosystems at a somewhat deeper level, let's review some basic ideas. First, ecosystems depend upon **energy** flow and transformations. We can define energy as the capacity to do **work** (work itself is defined as force times distance). Thus, we can appreciate that energy presents itself to us in various forms. For example, consider the following states in which energy can exist:

- kinetic: energy of motion (for example, a squid swimming through the water has kinetic energy by virtue of its movement)
- potential energy: energy that exists because of its position relative to something else (a humpback whale about to eat a school of small shrimps [krill] could regard these shrimp-like animals as representing potential energy unto itself)
- chemical energy: potential energy resulting from electrical and magnetic attractive forces within a molecule (glucose [sugar] molecule in marine algae possess chemical potential energy)
- thermal/heat energy: energy resulting from the vibration of molecules; temperature is a measure of the amount of thermal energy something has (for example, the molecules contained inside a sea lion's blood have a rather narrow range of thermal energy as food molecules are broken down in this, and other, mammals to maintain a certain temperature)
- electromagnetic energy: for our purposes, we can think of this as light energy (for example, electromagnetic radiation [light] strikes chlorophyll in an algae and that energy is utilized in forming a glucose molecule; this process is **photosynthesis**)

The above energy states do not cover all forms of energy (some others include electrochemical energy, sound energy, and nuclear energy) but rather reflect those energy types that will be most useful to us in better understanding the role of energy in an ecosystem. The important point to be taken at this time is that energy in one form can be transformed into energy of another form.

Before we consider the role of energy in supporting an ecosystem, we need to consider the different food chain, or **trophic**, levels characteristic of ecosystems. First, all life forms in any ecosystem ultimately depend upon **primary production**, the amount of light energy converted into chemical energy via photosynthesis per unit time. Photosynthesis is itself the *process* whereby light energy is transformed into chemical energy. Like most marine ecosystems, primary production in Alaskan waters is realized through the activities of **phytoplankton**, **seaweeds** and **seagrasses**. The phytoplankton includes the photosynthesizing bacteria and unicellular algae, including the **diatoms** and **dinoflagellates.** The seaweeds consist of the multicellular green, red, and brown algae. In Alaska, the seagrasses consist of only eelgrass and surfgrass. In considering these 3 major groups of photosynthetic organisms, it is important to realize that energy transformations, such as photosynthesis (light energy being made into chemical potential energy), are essential for the support of practically all ecosystems and, indeed, for life itself. A second example would be the hydrogen sulfide-based energy production realized by certain bacteria living amongst deep sea hydrothermal vents. Such bacteria are the primary producers for these unique deep sea ecosystems. Animals depending upon this energy include specialized fishes and invertebrates, most notably giant tube worms.

In open ocean marine ecosystems, the bulk of these primary producers are only bacteria and single-celled algae. These phytoplanktonic organisms constitute the first **trophic level**. Subsequently, these primary producing phytoplankton are ingested by small, drifting animals called **zooplankton**. Such zooplankton that feed exclusively upon phytoplankton make up the **primary consumers** and represent another trophic level. The transfer of chemical potential energy from primary producer to that of primary consumer is about 20% efficient, the remaining energy being converted into heat. In turn **secondary consumers**, yet another trophic level, are carnivores that feed upon herbivores. Here, the transfer of energy is only about 10 to 15% efficient. These secondary consumers may then be themselves consumed by organisms representing higher trophic levels until, at last, what began as light energy being absorbed by phytoplankton has, by progression through various trophic levels, become chemical energy in a **top predator** (yes, in another trophic level), such as a sharks, killer whales, sea lions, and sea birds.

From the above we can see that possibly much less than 1% of the chemical potential energy generated through primary production will actually become chemical energy in a top predator. From this we can further appreciate, then, why the waters surrounding Alaska are not teaming with millions of humpback whales, orcas, stellar sea lions, and beluga whales. Indeed, despite the tremendous amounts of primary production that occur in Alaskan waters, this is still not nearly enough to sustain top predator population sizes of anything near that magnitude.

Another way to think of energy transfer in an ecosystem is to consider how much dry weight, or

biomass, of an organism is transferred into the dry weight of another creature that consumes that organism. The amount of *biomass* represented by one trophic level also represents the amount of *chemical energy* in that trophic level, therefore we can think of these terms as being equivalent. Thus, when going from a lower to a higher trophic level, biomass transfer efficiency is 10 to 20%, the same as that already noted for chemical energy undergoing such trophic transformations. Of course, the biomass of primary producers must far exceed that of top predators and, for that matter, that of any higher trophic level.

Now let's consider a simplified example of how chemical energy/biomass may be transferred from primary producers to higher trophic levels such that, ultimately, flight is made possible in a top predator from an Alaskan marine **habitat** (a habitat is the area in which an organism survives and reproduces; an ecosystem may itself be made up of a great number of habitats). In this example we consider a puffin, a common seabird of Alaska, as the top predator. We begin with light energy being converted into chemical energy by photosynthesizing algae and bacteria, the primary producers. In turn, small drifting animals (zooplankton), such as **copepods**, consume these organisms and thereby convert approximately 20% of the chemical energy of primary production into chemical energy of primary consumption. Herring feed upon the copepods and thus function as secondary consumers. Chemical energy from the copepods is converted into that of the herring with about 10 to 15% efficiency. The puffin then eats the herring and converts, at about 10% efficiency, the chemical energy in this crustacean into that of itself. As the puffin takes off from the water, some of the chemical energy becomes transformed into energy of motion, or kinetic energy, which supports the animal's flight physiology. We thus see that energy transformations are a standard feature of a food chain.

In addition, migratory animals, such as certain bird and whale species, can transfer nutrients from one ecosystem to another. For example, the migratory gray whale, which appears to feed only during its yearly northward migration from warmer Pacific waters to those of the Arctic, transfers energy from a more southerly marine ecosystem to a more northerly one.

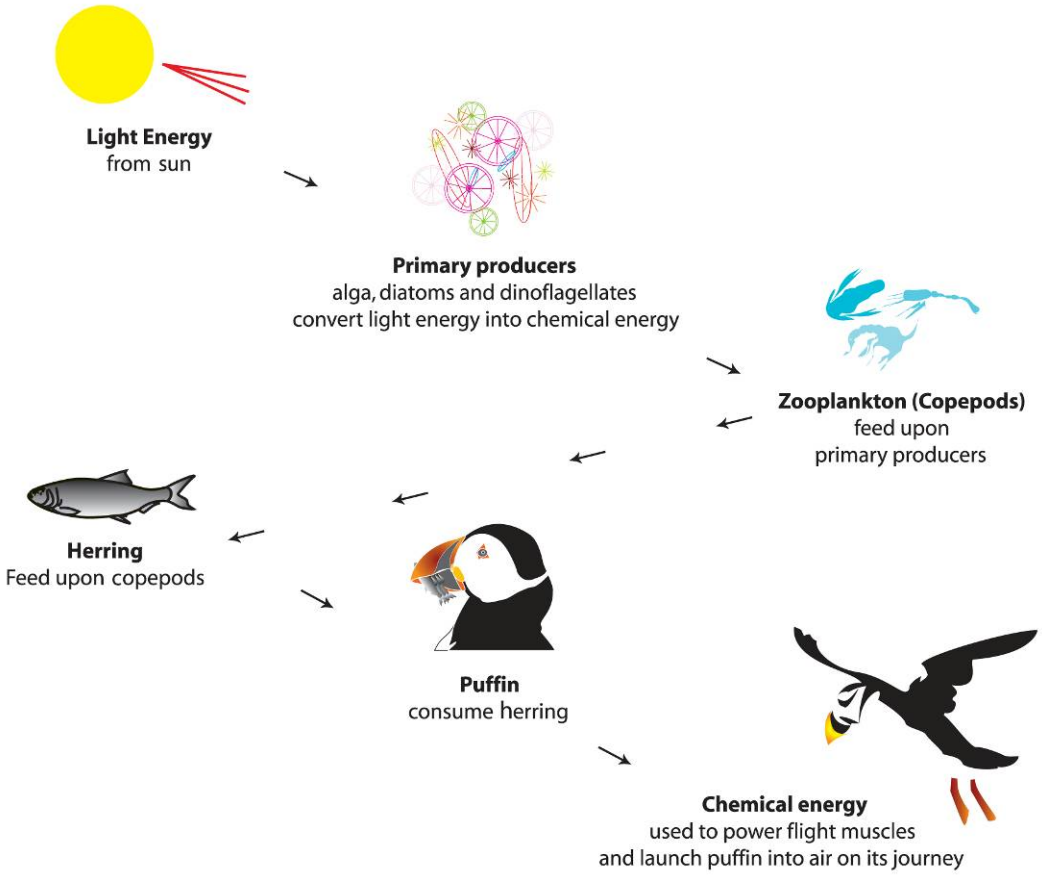


Fig. III.1. Food Chain Supporting Puffin Flight
(arrows indicate energy/biomass transfer from lower to higher trophic levels)

It is notable that, as in the puffin example in Fig. III.1, the same efficiency of chemical energy/biomass transformation from one trophic level to the next higher holds true for the Alaska marine ecosystem in general. We can get a better visualization of these transformations by considering the food chain pyramid shown in Fig. III.2. In this diagram the area contained within each trophic level of the pyramid represents the level of relative energy/biomass available. Note also that the relative area of the trophic level immediately above another represents the energy/biomass transferred to that higher level from the lower level or levels.

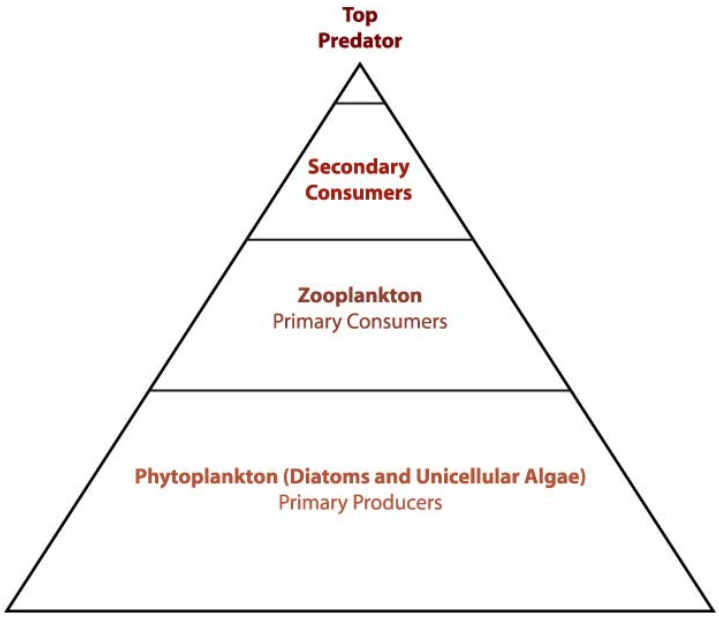


Fig. III.2. Pelagic Marine Ecosystem Trophic Pyramid

Primary producers comprise the greatest total area while top predators comprise the least. In nearshore benthic areas, primary producers also include seaweeds and seagrasses.

On the point of energy/biomass transfer, we should observe that it is quite beyond the scope and intentions of this book to begin an examination of the complexities represented by the living and nonliving interactions among components comprising the Alaskan marine ecosystems (indeed, an introduction to such an undertaking might require 10,000 pages and would properly conclude with some statement to the effect that we are only *beginning* to understand these ecosystems!)

Still, by becoming familiar with some of the regions common among many marine ecosystems, we can nevertheless begin to develop a feel for marine ecosystems in general. From there, we can be better equipped to understand how the various organisms maintained at the Alaska Sea Life Center ecologically fit into their environments. With that in mind, let's take a look at the broad geological and biological aspects of these environments that make up practically all large, marine ecosystems.

1. **Continental Shelf**: nearshore waters consisting of a gently sloping ocean bottom that extends from either 1) the shoreline to the shelf break or, 2) in the case where there is no noticeable slope, the area between the shoreline and the point at which the water is approximately 100 – 200 meters deep
2. **Open Ocean**: all areas of the ocean that are not part of the continental shelf; the boundary is where the continental shelf drops off sharply
3. **Continental Slope**: a steep slope separating the continental shelf from the open ocean

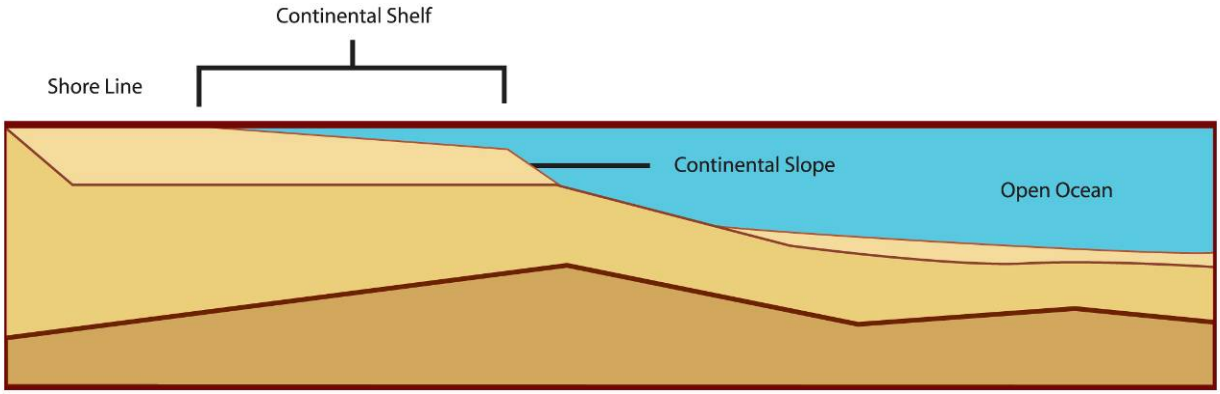


Fig. III.3 Simplified Profile View of the Continental Shelf, Open Ocean, and Continental Slope

Within these three regions may be found the following subdivisions:

Intertidal Zone/Wetland (continental shelf area)

- this is an ecosystem that is an intermediate between a purely terrestrial and purely aquatic environment
- these areas are flooded at high **tide** and then left dry at low tide
- a **tidepool** is an example of an intertidal zone occurring in a rock or sandy depression at low tide
- specific intertidal zone environments:
  - salt marshes
  - mudflats
  - sandy beaches
  - rocky beaches
- primary producers can include benthic micro-organisms, phytoplankton, seaweeds and seagrasses.
- on rocky beaches the fauna may be highly diverse as it can contain nonmotile organisms such as sponges, sea anemones, tube-dwelling worms, barnacles, mussels and other bivalves, and tunicates, as well as motile organisms such as polychaete worms, limpets, snails, nudibranchs, brittle stars, sea stars, sea cucumbers, amphipods, crabs, shrimps, and small fishes

Estuary (continental shelf area)
- area where fresh and salt waters merge together
- in Alaska, for example, the area where the Kenai River enters the Cook Inlet is an estuary
- saltiness of water in an estuary varies from wholly freshwater to wholly saltwater
- primary producers include phytoplankton, benthic diatoms, seagrasses, and some seaweeds, particularly green sea lettuce that is often so abundant that it is referred to as a **green tide**.
- crustaceans, many types of worms, clams, and snails as well as fish often inhabit estuarine areas; these organisms must be physiologically adapted to handling the highly variable changes in salt concentration levels

Pelagic Zone (occurs over continental shelf, continental slope, and open ocean areas)
- the ocean water itself.
- Organisms, some of high mobility inhabit this zone; such organisms include squid, fishes, whales, and other marine mammals.
- phytoplankton (*phyto* means plant) is present here and consists primarily of unicellular algae and to a lesser extent cyanobacteria (i.e., blue-green algae); they are the ocean's primary photosynthesizers (i.e., organisms that use light energy to produce their own energy); phytoplankton drift (*plankton* means drifter) in the pelagic zone.
- zooplankton are typically very small animals (including many juvenile forms of such organisms as jellies, crustaceans, mollusks, sea stars, and fishes, but also adult species of ctenophores, jellyfishes, polychaetes, copepods, amphipods, euphausiids, and swimming octopus) that reside among the phytoplankton; feeding upon the phytoplankton and one another, these members of the zooplankton are in turn fed upon by larger animals, such as herring, sardines, and plankton-feeding whales

Benthic Zone (occurs over continental shelf and continental slope)
- the sea floor environment.
- the organisms residing here will vary depending upon the amount of light reaching this zone.
- in areas with enough light, primary producers such as seaweeds and benthic algae may occur
- other organisms may include, fungi, sponges, sea anemones, polychaete worms, bivalves, snails, sea stars, brittle stars, sea urchins, sea cucumbers, crabs and lobsters, some species of shrimp, octopus, and fishes.
- note that not all organisms here are **sessile** (i.e., permanently affixed to the bottom/substrate).

Abyss (open ocean area)
- the very deep ocean.
- as this environment is virtually devoid of light, the organisms residing here may include bacteria and fungi as well as a variety of animals, including cnidarians, shrimps, bivalves,, squids, octopus, shrimps, and fishes, some having light-producing cells.
- in the **deep sea hydrothermal vents** (which are of great interest to both marine scientists and the public) sulfide-rich emissions promote the formation of important organic compounds from carbon monoxide (CO) and hydrogen sulfide (H_2S); prokaryotic organisms that utilize these compounds can function as primary producers in the abyss; this is especially noteworthy since no light energy derived from the sun is required for this form of primary production.

Fjord

- a narrow inlet of the sea that is of glacial origin; occurs between cliffs and steep slopes, and is at least partially filled with marine water during tides
- warmer, freshwater lies on top of cooler, denser salt water in a fjord
- the mixing of the two layers depends on the amount of freshwater (primarily from rivers) and salt water (from tidal activities) entering the fjord.
- in glacier-capped fjords, nutrients from glacial melt are abundant and support a large biomass of phytoplankton.
- Organisms include phytoplankton**,** some species of algae, may include jellyfishes, ctenophores, polychaete worms, snails, clams, mussels, sea stars, brittle stars, crustaceans, fishes (e.g., halibut and salmon), marine mammals, and sea birds
- Alaska's coastline contains a great many fjords and these are thus significant Alaskan marine ecosystems

Upwelling Zone

- areas where nutrient-rich, cold, deep ocean water rises from the ocean bottom to the surface.
- phytoplankton and seaweeds grow rapidly in high nutrient conditions; this in turn helps to greatly increase the growth and reproduction of pelagic and benthic animals.
- upwelling pelagic zones contain about four times the productivity of other pelagic zones.

It is important to note that chemical energy/biomass as well as limiting nutrients (see below) can be cycled between the various marine environments listed above. Such nutrient flow is necessary in sustaining a marine ecosystem. For example, chemical energy generated through primary production in the pelagic zone may be cycled through organisms that frequent both this and the benthic zone. An example of this is the halibut, *Hippoglossus stenolipis*. Although this fish is generally a bottom dweller (benthic) and feeder, it can temporarily frequent the pelagic zone and capture prey items there. In addition, the pink shrimp, Pandalus borealis, typically undergoes vertical migration, feeding mainly on the bottom during the day and moving upward to feed in the water column during night. Thus, pelagic biomass may be converted to mostly benthic biomass and vice versa through such shrimp and halibut feeding. There are perhaps countless other examples, all helping to ensure that energy is transferred from one ocean zone/environment to another.

Limiting Factors Affecting Primary Production in Marine Ecosystems

Primary production in marine ecosystems is limited by light and nutrients. It is therefore notable that even in "clear" waters only 5 to 10% of the incident radiation will penetrate to a depth of around 20 meters. Thus, photosynthesis, and therefore primary production, is limited to this depth, referred to as the **photic zone**.

Curiously, although equatorial regions of the world receive the greatest light intensity, these areas are not realms of great primary production. By comparison, the North Atlantic, Southern Ocean off of New Zealand, and the Gulf of Alaska are areas of rather high primary production.

Why is this so?

The relatively low primary productivity of tropical marine environments is attributable more to a lower abundance of the nutrients nitrogen and phosphorous than it is to light. Both of these nutrients are at generally low concentrations in the world's photic zones. However, deep water environments contain relatively higher levels of phosphorous and nitrogen. Thus, in upwelling areas where deep, nutrient-rich ocean water is brought to the surface, higher levels of primary production occur.

Curiously, the Gulf of Alaska is generally a downwelling area, in which nearshore waters are forced downward and replaced by nutrient-poor offshore waters. Why then should these waters be so rich in primary production? There is as yet no satisfactory answer to this very puzzling phenomenon and researchers are currently studying the Gulf of Alaska in an attempt to better understand this aspect of the marine ecosystem. We can conclude at this time that there are still many unsolved mysteries regarding the complex underpinnings of Alaska's marine environments.

General Geographical/Geological Characteristics of two Alaskan Marine Ecosystems

Different Alaskan marine ecosystems have been defined based upon various criteria. For example, some investigators have recognized **arctic** and **subarctic** ecosystems, the division between these occurring at the geographical margin separating these realms. We can get an idea of just how large Alaskan marine ecosystems may be by considering the range and some geological characteristics of two such commonly recognized environments, the Bering Sea – Aleutians Ecosystem and the Gulf of Alaska Ecosystem.

Bering Sea – Aleutians Ecosystem

- 2.3 million square kilometers of area
- northern portion is arctic, southern portion is subarctic
- a semi-enclosed high latitude sea
- 44% continental shelf
- one of the most biologically productive areas of the world
- in winter and spring, pack ice covers eastern and northern portions
- 13% continental slope
- 43% deepwater basin/open ocean
- basic flow of water is from the North pacific on through the major passes between Aleutian islands (see diagram below) and into Bering Sea; water then continues eastward along Aleutian chain, then northward along the break located at the eastern limit of Bristol Bay; water may then flow north to exit above the Bering Sea or flow westward to the eastern Russia coast, whereupon some of this water may flow back towards the Aleutian Islands and rejoin the water flowing northward through passes there; this forms a sustained gyre of water flowing around the perimeter of the Bering Sea

Gulf of Alaska Ecosystem

- 160,000 square miles of continental shelf
- at northeast end is Prince William Sound, site of the 1989 Exxon Valdez oil spill
- main flow is circular and is referred to as the Alaska Gyre; results from
- eastward-flowing Subarctic Current System, located 50^{o} N latitude, and the Alaska Current System flowing along the northern Gulf of Alaska
- seasonal variations in eddies of nearshore areas are the result of Gulf of Alaska winds

Generalized View of Primary and Secondary Production In the Subarctic and Arctic Alaskan Marine Ecosystems of the Southeastern and Northeastern Bering Sea

- primary production in the water column occurs in late winter and early spring as light penetrates the pack ice of northern waters and causes algae in the lower regions of the ice to grow
- greatest level of primary production occurs in late spring when pack ice over continental shelf starts to break up into ice **floes**, thus opening areas of the shelf to full sunlight; this results in very intense phytoplankton blooms, with 65% of primary production occurring between April and May
- phytoplankton blooms also occur over upwelling areas
- primary production is utilized by zooplankton (especially copepods and krill), which constitute secondary production
- copepods and krill are consumed by virtually all other predators (e.g., fishes and plankton-feeding whales) in the area; these crustaceans are a critical component of the Alaskan marine ecosystem food chain; these predators make up the higher trophic (feeding) levels beyond primary and secondary production

Fig. III.4. Krill, *Euphausia superba*

In summary, marine waters of Alaska are host to numerous water column and/or bottom dwelling species, all of which interact with one another to form a complex ecosystem. It should be noted that this ecosystem depends upon ocean currents, including those formed by upwellings (although a notable exception to this has been observed in the predominantly downwelling areas of the Gulf of Alaska), to bring in nutrients required by primary producers. In turn, zooplankton feed upon these to establish primary consumption, which serves to sustain the higher trophic levels represented by larger invertebrates, fishes, marine birds, and marine mammals. A deeper exploration of this subject is beyond the scope of this manual. Nonetheless, the reader may obtain further insight into this by reading the taxonomic descriptions (including, for example, those for phyla and species) provided in later chapters. In addition, many published works, as well as internet sources, provide detailed information on the ecological role of the various species featured at the Alaska SeaLife Center.

Marine Ecosystem Summary

- a marine ecosystem is defined as the interactions among living and nonliving components of a defined sea or ocean environment.
- a food chain in an ecosystem is made up of various trophic levels, each of which represents a route of energy flow within that ecosystem.
- chemical energy/biomass is transferred from one trophic level to the next higher one with an efficiency ranging from 10 to 20%.
- primary production (a trophic level) results from cyanobacteria, unicellular algae, seaweeds and seagrasses utilizing light energy to generate chemical energy which will sustain life.
- this process is called photosynthesis.
- primary consumers (a trophic level) eat primary producers and thereby convert about 20% of the primary producer's chemical energy/biomass into their own chemical energy/biomass.
- secondary consumers (a trophic level) feed upon primary consumers; the efficiency of chemical energy/biomass transfer is approximately 10 to 15 %.
- a top predator (a trophic level) is the final recipient of energy flow in an ecosystem; efficiency of chemical energy/biomass transfer is about 10%.
- marine ecosystem primary production is limited by availability of light and nutrients (especially nitrogen and phosphorous).
- a certain amount of energy/nutrients is/are cycled from one marine ecosystem to another.
- to receive limiting nutrients, such as nitrogen and phosphorous, from deep water environments, the Alaska marine ecosystem depends upon both upwelling areas and mixing (mixing can occur as a result of storms and early season overturn, which results when water temperatures drop; seasonal overturn is the most important mechanism for bringing deep water nutrients to surface waters).
- various Alaskan marine ecosystems have been geographically/geologically defined.
- all Alaskan marine ecosystems are complex and the interactions among the various components, both living and nonliving, are only beginning to be understood.

IV. Bluegreen Bacteria: Kingdom Eubacteria, Phylum Cyanobacteria

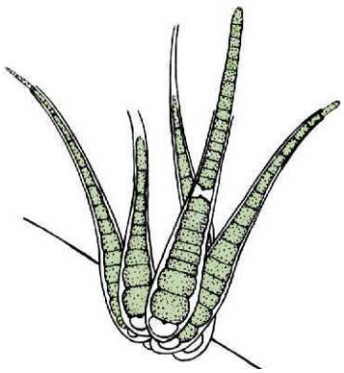
It might surprise many readers that marine bacteria constitute important components of the marine ecosystem. However, with its primary focus on animal life, the Alaska SeaLife Center does not exhibit these organisms. Nonetheless, we present a very basic overview of the Kingdom Eubacteria in this chapter and also describe two species of Eubacteria that are very important to the marine environment.

Characteristics of the Eubacteria (including the Cyanobacteria)

- Single celled, filamentous, or colonial (groups of cells living together) organisms that are typically microscopic.
- cells generally 1 to 10 μm (i.e., 10^{-6} meters) in size (about ten times smaller than plant, fungus, or animal cells), but some filamentous genera may reach 20 or 30 μm in diameter.
- cells lack a membrane-bound nucleus, but instead have their DNA diffusely arranged in the cell as a single, loop-shaped molecule
- reproduction occurs by cell division and fragmentation.
- most all have a cell wall outside their membrane.
- cell shape can be spherical, rod-like, curved, spiral or filamentous.
- originally based on cell shape and physiology, the classification of all Eubacteria is currently being revised using molecular (DNA) characteristics.
- many marine Eubacteria utilize sources of dissolved organic carbon as an energy source and do not undergo photosynthesis.
- one group of Eubacteria, the Cyanobacteria, does photosynthesize (i.e., utilize light energy to produce carbohydrate from carbon dioxide); this photosynthesis releases oxygen into the atmosphere in return for carbon dioxide.
- Cyanobacteria, also called blue green algae, are known to be some of the first living organisms on Earth and are thought to be the source of all early oxygen in our atmosphere.
- Cyanobacteria occur in planktonic and benthic habitats, in fresh and marine water, as **symbionts** on plants, fungi, or invertebrates, and even in hot springs
- many Cyanobacteria undergo **nitrogen fixation**, incorporating elemental nitrogen into biomolecules that are essential for the survival of most all eukaryotic algae and plants.
- In marine habitats, Cyanobacteria are particularly important on mudflats, in estuaries and in the open ocean.

Although the Alaska Sea Life Center does not exhibit these microscopic organisms on purpose, many Eubacteria are present on and in the plants and animals on display and in the seawater system. But, only a few of these are Cyanobacteria. We present two important Cyanobacterial species here that can affect marine ecosystems in dramatic ways.

1. Black Felt/Black Balls/Tar Spot, *Calothrix crustacea*



http://www-biol.paisley.ac.uk/biore/Eubacteria/Calothrix.html

Kingdom Eubacteria
Phylum **Cyanobacteria**
Class Cyanophyceae
Order Nostocales
Family Nostocaceae
Genus and Species *Calothrix crustacea*

Occurrence……	• Cosmopolitan • Occuring in benthic marine and estuarine habitats from the high intertidal down to the subtidal. • Often very abundant, sometimes felting the substratum or forming a slippery dark band high in the intertidal similar to that of the black lichen, *Verrucaria maura*. • Attaches to rock, seagrasses, marsh grasses, mangrove roots, seaweeds, and invertebrates.
Form/Function……..	• Thalli consist of sheathed tapering **trichomes** (filaments) that narrow to a hair; trichomes are unbranched or falsely branched and bear basal and rarely intercalary **heterocysts**. • Trichomes range from 8-18 µm in basal diameter and may reach 1 mm or more in height. • Trichomes may be solitary, in small groups, or radially arranged from a central core into hemispherical or globose ball-like clusters, referred to by some as the separate genus

	Rivularia. • Gelatinous sheaths enclose from 1-3 trichomes and help to prevent them from drying out. • In the *Rivularia* form, the radiating trichomes are also enclosed in a somewhat firm mucilage that may be layered and encrusted with lime. These colonies are generally 2-3 mm in diameter, but they are known to reach 6 cm in some habitats. • The colonies of *Calothrix* appear black, dark olive, or bluegreen, but the color of individual trichomes is typically yellow-green.
Reproduction ….....	• Asexually by **hormogonia**, short propagating filaments that form when intercalary cells die and cause the trichome to fragment.
Noteworthy Facts ….....	• Heterocysts are the site of nitrogen fixation in this species • Known as "tar spot" in the tropics due to the black dots that it makes on floating *Sargassum, Calothrix* plays a major role in the survival of this species in the nutrient-poor tropical seas. • Some forms of *Calothrix* can bore into limestone. • In Alaskan estuaries, *Calothrix* occurs abundantly on red algae late in the summers.

2. **Sea Sawdust,** *Trichodesmium erythraeum*

Kingdom Eubacteria
Phylum **Cyanobacteria**
Class Cyanophyceae
Order Oscilliatoriales
Family Oscilliatoriaceae
Genus and Species *Trichodesmium erythraeum*

Occurrence……..	• Marine and planktonic • important in warm temperate and tropical seas.
Form/Function ……..……..	• Microscopic narrow filaments (trichomes) that group together into flake-like or scale-like bundles (visible to the naked eye) that are held together by a soft transparent sheath material • Trichomes are 7-25 µm in diameter and sometimes narrow at their ends; the trichome tips may be hemishpherical or truncated. • Cells have gas vacuoles that help with flotation.
Reproduction….....	• Hormagonia aid in asexual propagation
Noteworthy Facts….....	• Forms massive surface phytoplanktonic blooms that discolor the water; sometimes these blooms are so large and conspicuous that they can be photographed from outer space • Because *Trichodesmium* species can fix nitrogen (i.e., they can incorporate atmospheric nitrogen into molecules which can be absorbed and used by plants), their blooms can have a large impact on nutrient cycling in marine ecosystems • Such blooms can impact changes in phytoplankton

	and zooplankton structure • First *Trichodesmium* bloom described was that of Captain Cook sailing in Australian waters in the 1700s; the yellowish bloom was thought at first to be a sandbar on which the ship might run aground. • Word origin for genus name is Greek: *trichos* = hair, *desmus* = joined

V. Seagrasses and Green Algae: Kingdom Plantae

By Gayle I. Hansen
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With the new techniques developed for cell and molecular biology in the late 20th century, our knowledge of the evolution of organisms increased dramatically. To coincide with this advance, we modified our system for the classification of all living things (**see Chapter II**). In addition to establishing the 3 Domains of Life (Archaea, Bacteria, and Eukaryota), we also changed the organization and content of the Kingdoms within these Domains, particularly those within the Eukaryota. One Kingdom that was particularly affected was the Plantae.

Initially, the Kingdom Plantae was established to contain all photosynthetic **chlorophyll a** containing organisms, including the algae and land plants. The bluegreen algae were considered a part of this group since they contain chlorophyll a, the primary photosynthetic pigment. However, since they are **prokaryotic**, they were soon removed from the **eukaryotic** Plantae, transferred to the Eubacteria, and renamed the bluegreen bacteria. However, they remained a group of great interest because, with the possession of chlorophyll a, they appeared to be an evolutionary link to the eukaryotic groups still contained within the Plantae.

In addition to chlorophyll a, the bluegreen bacteria also contain a suite of accessory pigments that help in photosynthesis. The best known of these are the red and blue **phycobilin pigments** that give these bacteria their bluegreen color. These somewhat rare accessory pigments also occur in the eukaryotic red algae, providing them with their red color. In recent decades, a few species of bluegreen bacteria were noted to be green rather than bluegreen in color. On closer examination, these were found to contain **chlorophyll b** instead of the normal phycobilin pigments. Chlorophyll b is the major accessory pigment found in the eukaryotic green algae and land plants. The occurrence of both chlorophyll b and phycobilin pigments in bluegreen bacteria provided further evidence of their link to the Plantae.

During the last half of the 20th century, there were multiple theories about the origin of the eukaryotic cell. One popular one was the **Endosymbiotic Theory**. One part of this theory proposed that the **chloroplast** was created by a primitive protozoan engulfing a bluegreen bacterium that became a permanent symbiotic resident within the cell. As outlandish as it seemed at the time, this theory has now been supported by both ultrastructural and molecular evidence. The phyla now considered a part of the Plantae all have chloroplasts that are bound by a double membrane originally created by the outer membrane of the primitive bluegreen bacterial cell and the vacuolar membrane of the host. This along with evidence from their chloroplast DNA has verified that the Rhodophyta or red algae, Chlorophyta or green algae, and all land plants, including the Anthophyta or flowering plants, are a part of the new Kingdom Plantae.

The Endosymbiotic Theory explained one other thing that has become important to our understanding of the algal groups. It actually proposed that at least two sequential **primary endosymbioses** took place during the development of the eukaryotic cell. These endosymbioses

were considered primary because they were the first engulfment to form an organelle (see the Chromista for **secondary endosymbioses**). In addition to the chloroplast, the **mitochondrion** was thought to be the product of an endosymbiotic event. Mitochondria were proposed to have evolved via the engulfing of a photosynthetic purple bacterium (an alpha proteobacterium) that later lost its photosynthetic abilities. Thus the **cristae** membranes that we see in mitochondria are interpreted as remnants of the pigment-containing membranes of the purple bacterium. Two different types of cristae exist – flattened and tubular. The occurrence of these different types varies throughout the Eukaryota. However, all land plants, Chlorophyta, and Rhodophyta have been found to have flattened cristae, lending further support to their inclusion together in the Kingdom Plantae.

Seagrasses: Phylum Anthophyta

General:
The Anthophyta are the flowering plants. They include nearly 300,000 known species and are by far the most diverse of all the plant groups. With the exception of the ferns and gymnosperms, they include all of the large plants that we see in our forests and fields. Flowering plants occur in all temperate and tropical regions where there is enough water, soil, and nutrients to support them, and they are even common on the tundra in the Arctic. They have proven to be an important resource for mankind. Most agricultural crops are flowering plants. Many medicinal drugs come from this group. Wood products are derived from the timber of both hard and softwood forests. Moreover, the Anthophyta provide us with a substantial portion of the oxygen we breathe and act as a major carbon dioxide sink, helping to reduce greenhouse gasses.

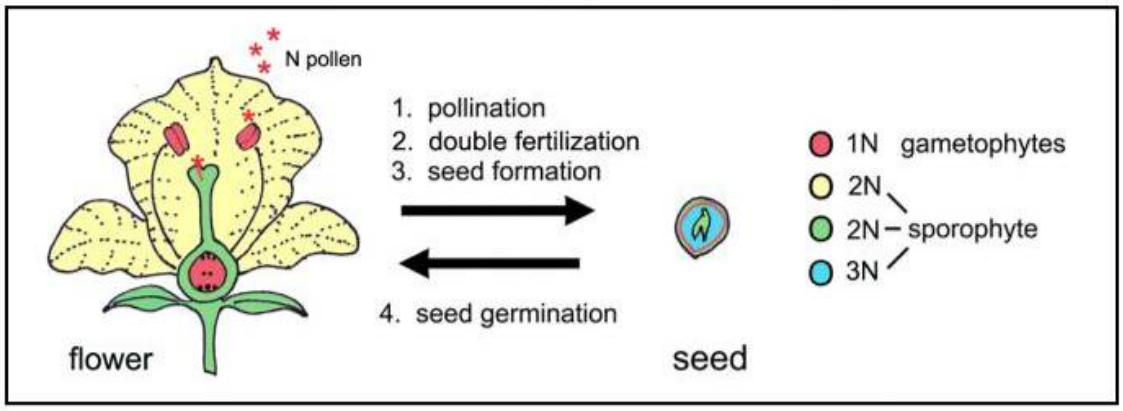
Unifying Features:
Several **ultrastructural** and chemical features characterize the Anthophyta. Like all other Plantae, they have a double membrane around their chloroplasts and mitochondria with flattened cristae. Like other green members of the Plantae, they have **chlorophyll b** as their major accessory pigment and a chloroplast ultrastructure that includes **thylakoids** (pigment bearing membranes) that occur in stacks of 2-6 or more and often in column-like stacks referred to as **grana**. Like in other green Plantae, the photosynthetic energy reserve is a true **starch** that is stored as granules inside the chloroplasts.

Primarily terrestrial plants, the Anthophyta share many anatomical and life history traits with other land plants. Like the ferns and gymnosperms, they absorb water and nutrients through their roots and transport it up to their leaves and other plant parts through specialized **vascular tissue**, called phloem and xylem. Like the gymnosperms, they produce **seeds** for reproduction, an adaptation that helps them to protect the young embryos from environmental stress. The Anthophyta alone have developed **flowers** and **fruit**. Flowers help to attract birds or insects to insure fertilization and fruit assists with seed dispersal. It is probably these traits have contributed the most to the rapid speciation and enormous success of the flowering plants.

Life History:
A simplified Anthophyta life history is diagrammed below. The main vegetative plants that we

see are **sporophytes** that are **diploid** (2N, with 2 sets of chromosomes). When a plant becomes fertile, it produces flowers that may be male, female, or both male and female, depending on the species. Within these flowers are the reproductive structures: **ovules** in the female and **anthers** in the male. Meiosis followed by mitosis occurs in each of these structures and tiny multicellular **gametophytes** develop that are **haploid** (1N). When the male gametophyte matures, it produces small binucleate **pollen** grains that are released into the air or water to pollinate the ovules. The female gametophyte expands within the ovule and one nucleus becomes an egg cell, and 2 others remain in the center of the gametophyte as precursors to the endosperm. Anthophyta undergo **double fertilization**. When the pollen grains attach to the female, they extend a tube into the ovule and release 2 sperm nuclei. One fertilizes the egg nucleus and this develops into an **embryo** that is diploid (2N). The other nucleus fertilizes the 2 endosperm nuclei to form **endosperm**, a nourishing tissue that is triploid (3N). All of these are ensheathed in the ovule wall that hardens to become the protective seed coat. At maturity, the seeds are released and the embryo germinates to form a new plant. Many consider the Anthophyta life history to be a modified biphasic life history (see the Chlorophyta) with the tiny reduced gametophyte stage parasitic on the sporophyte.

Fig. V.1 **Simplified Anthophyta Life History**



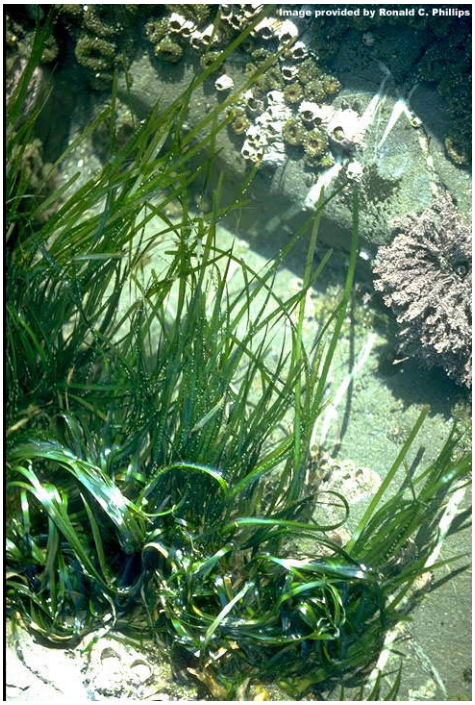
(Note that the gametophytes are reduced structures within the sporophyte.)

Subgroups:
The Anthophyta consist of 2 classes of plants, the **Monocots** (Liliopsida) and the **Dicots** (Magnoliopsida). These are distinguished by the features shown in Table 1. Both groups occur primarily on land, although many species occur in freshwater environments like lakes and streams. In the marine environment, they are represented only by the Monocots and in that group only by the seagrasses, a group of only 50 known species. In SC Alaska, there are 2 genera and 3 species of seagrasses.

Table V.1. Diagnostic Characters of the Monocots and Dicots.

Character	Monocots	Dicots
Cotyledons or seed leaves	1	2
Flower parts (petals, etc)	In multiples of 2	In multiples of 4 or 5
Leaf veins	Parallel	Reticulate (net-like)
Stem vascular bundles	Scattered	In a ring
Secondary growth	Absent	Often present
Roots	Adventitious, diffuse	With a central radical
Pollen furrows or pores	1	3
Number of Species	65,000	235,000

1. **Serrulated Surfgrass,** *Phyllospadix serrulatus*

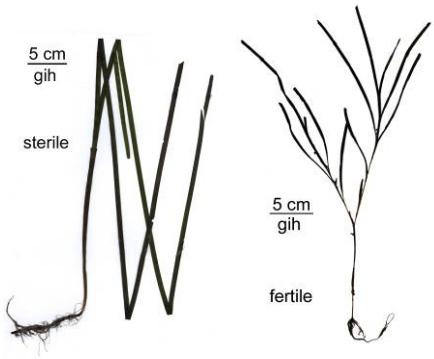


Kingdom Plantae
Phylum **Anthophyta**
Class Liliopsida
Order Potamogetonales
Family Cymadoceaceae
Genus and Species *Phyllospadix serrulatus*

Species Occurrence….....	• Chirikof I., Alaska to Cape Arago, Oregon • Marine, low intertidal • On rocks in exposed to semi-sheltered areas • **Perennial** rhizomes with **ephemeral** leaves
Form/Function ….....…….....	• Narrow ribbon-like leaves with blunt tips that alternately shoot upward from a creeping **rhizome** (a horizontal stem) that bears masses of wooly fibers and 2 roots from each closely spaced **node**. • Leaves reach 1-2 feet in length and about 0.2 inches in width and contain 5-7 parallel veins. They bear **lacunae** or internal air chambers that help with leaf floatation. • Minute teeth or "**fin cells**" occur along the leaf margins near their tips. • Leaf sheaths are open. They decay along with the leaves, leaving the rhizome fibers.
Reproduction….....	• Both sexual and asexual reproduction known. • The life history is typical of Angiosperms • Dioecious and summer fertile

	• The reproductive axis is a single stalked **spathe** with a linear **spadix** that bears male or female flowers in a zig-zag pattern. At maturity, thread-like pollen is released from the male flowers into the water to fertilize the female ovules. When the seeds mature, the female spadix projects outside the spathe to release the U-shaped seeds. • The upper arms of the U are actually barbs that enable the seeds to hook onto algae and seagrasses where they germinate quickly. • *Phyllospadix* species in the NE Pacific have a strong female-biased sex ratio (10:1). • Asexual reproduction occurs by growth and fragmentation of the rhizome.
Noteworthy Facts….....	• Provides habitat for many marine organisms • Certain red, brown, and green algae are uniquely **epiphytic** on seagrass leaves. • Susceptible to heat stress, desiccation, and sewage pollution
Congeneric Species….....	• 2 species of *Phyllospadix* occur in SC Alaska. The second species is ***P. scouleri.*** • 3 species occur in the NE Pacific.

2. **Eelgrass,** *Zostera marina*



Kingdom Plantae
Phylum **Anthophyta**
Class Liliopsida
Order Potamogetonales
Family Zosteraceae
Genus and Species *Zostera marina*

Species Occurrence….....	• Widespread in the Atlantic and Pacific. In the Pacific, from Alaska to Baja California, Mexico, Japan, Korea • Low intertidal to subtidal • Prefers sheltered and estuarine areas • On mud, sand, silt, or gravel mixed with sand • Long lived. Basal rhizomes are perennial, reported to live for 20 to >200 years. Leaves are ephemeral, surviving for 4-6 weeks (in Oregon).
Form/Function…..……..... .	• Narrow ribbon-like leaves with rounded or **mucronate** (with a tiny spine) tips that shoot upward from a creeping rhizome (a horizontal stem) with spaced out nodes that each bear from 5-20 roots. • Leaves typically 8-20 inches in length, but in some areas reaching 6.5 feet. Leaf width typically 0.2 to 0.5 inches with 5-11 parallel veins • Leaf bases with a tubular sheath. • Leaves and rhizomes bear lacunae (air spaces) that assist in leaf buoyancy.
Reproduction….....	• Sexual and asexual reproduction known.

	• Life history typical of Angiosperms. • Plants are monoecious and hermaphroditic. • Reproductive shoots are branched and bear up to 5 linear spadixes, each enclosed by a sheath. Male and female flowers develop alternately along each spadix and female flowers mature earlier than the male. • After fertilization and seed development, small ovoid ribbed seeds are released into the water from the spadix, at first while it is attached to the plant and later while it drifts free in the currents, widening the dispersal. • Asexual reproduction occurs through clonal growth and fragmentation of the rhizomes. This is the most common form of propagation in this species
Noteworthy Facts….....	• Forms subtidal beds that help to stabilize the substratum and act as a nursery for fish and marine invertebrates • A wasting disease caused by *Labrinthula marina* severely impacted the Atlantic beds.
Congeneric Species…….	• Only 1 species of *Zostera* is currently known from SC Alaska. • *Zostera japonica*, a high intertidal introduced species, has colonized more southern areas in the NE Pacific, but it has not yet been reported from SC Alaska.

Terminology in Seagrasses vs. Seaweeds

Although seagrasses live primarily in water, they are vascular plants. Vascular plants all have specialized vascular tissue that provides support to their plant bodies and enables them to transport water and nutrients from their roots to their stems and leaves. On the other hand, the **seaweeds** (the multicellular marine algae) do not have vascular tissue. They live primarily in seawater where their plant bodies are supported by their buoyancy or occasionally by specialized floats. Since they are immersed in their nutrient solution, they absorb nutrients through their entire plant body, rather than just through their roots. Therefore, they generally don't need vascular transport tissue. This lack of vascular tissue in seaweeds means that the basic structures of seaweeds and seagrasses are not equivalent. So, specialized terms have evolved.

Vegetative Structure: In the seaweeds, the plant body is referred to as the **thallus** (from Thallophyta, a historical grouping that included both algae and fungi). The leaf-like structures are referred to as **blades**, the stem-like structures as **stipes**, and the root-like structures as **holdfasts**. Indeed the holdfast does just hold the plant fast. Some holdfasts include **rhizoids** and/or **haptera**. Some groups have multiple blade structures called **fronds**. Floats are sometimes referred to as **pneumatocysts**. In overall appearance, seaweeds are considered to be **encrusting**, **prostrate** or **erect**. In addition, they may be described as **filamentous** (thread-like) or **foliose** (leaf-like) and in more detail as **terete** (round in cross section), **compressed** (broadly oval in cross section), or **complanate** (flattened in cross section). In anatomical structure, seaweeds are considered to be **filamentous**, **membranous**, or complex thalli that are **parenchymatous** (composed of closely spaced isodiametric cells) or **pseudoparenchymatous** (composed of densely intertwined filaments), containing both an outer **cortex** and an inner **medulla**. The pseudoparenchymatous forms can also be **uniaxial** or **multiaxial**. All seaweeds grow by **meristems** (growth areas) that can be **apical** (at the apex), **intercalary** (between the top and bottom), or **diffuse** (anywhere on the thallus).

Reproductive Structure: Although the terms for life histories will be discussed with the various groups, we will see some reproductive terms that apply to all algae (and to vascular plants). **Sporangia** are structures that produce spores. Motile spores are called **zoospores** and non-motile spores are called **aplanospores**. **Gametangia** are structures that produce male or female gametes. A **dioecious** alga has the sexes on separate thalli. A **monoecious** alga has both sexes on the same thallus. A **hermaphroditic** alga has both sexes together on one thallus in the same structure (see *Fucus*). The gametes in a species may be **isogamous** (of identical size), **anisogamous** (of different sizes), or **oogamous** (with at least the female egg cell non motile).

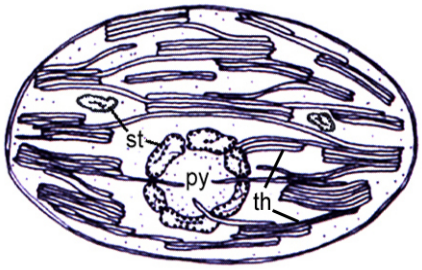
Location: Seaweeds are **marine** or **estuarine**, and they can be **intertidal** or **subtidal**. They can be **epilithic** (on rock), **epiphytic** (on plants), **endophytic** (inside plants), or **epizooic** (on animals). Seasonality terms will be discussed with the Chlorophyta.

All these terms will be seen in the descriptions that follow of the green, red, and brown algae.

Green Algae: Phylum Chlorophyta

General:
The Chlorophyta or green algae are estimated to include nearly 17,000 species. Although a few unicellular species occur on land, most species are aquatic with by far the greatest number occurring in freshwater habitats. Only 10% of the green algal species are marine. Most freshwater species are small and unicellular, colonial, or filamentous. These forms can also occur in the marine environment, but those considered to be **seaweeds** (macroscopic algae) are generally **encrusting** or **erect** and **filamentous** or **membranous**, although some are sponge-like with densely intertwined filaments. As with the freshwater forms, the green seaweeds are widespread around the world and occur from temperate to tropical areas and, during summer, even in subpolar seas. They can occur from the high intertidal down to the deep subtidal, but they are most prevalent in intertidal and shallow subtidal areas. In nutrient-rich areas like harbors, some become nuisance species that reproduce so abundantly that they are referred to as "**green tides**". Rich in nutrients, green seaweeds are an important food source for many animals, including humans. In Asia and other areas, sea lettuce is used in salads and dried and pulverized for use as a healthy salt substitute.

Unifying Features:
Like all Plantae, the green algae possess chloroplasts that are bounded by a double membrane and mitochondria with flattened cristae. Like the Anthophyta and other land plants, their major accessory pigment is **chlorophyll b** that helps to give them their green color. Their chloroplasts contain **thylakoids** (th) that occur in stacks of 2-6, and the major photosynthetic reserve is **starch** (st) stored inside the chloroplast (See Fig. V.2). Unlike most land plants, the green algae can absorb nutrients from the water through their entire plant body. As aquatic organisms, they do not need specialized vascular tissue to transport water and nutrients. Rather than having flowers and seeds, the green algae produce simple gametangia and sporangia. All green seaweeds release motile gametes or zoospores into the water. These cells have 2-4 apically inserted flagella that are **isokont** (of equal length) and generally smooth (without hairs), a feature that contrasts greatly with other seaweed groups. The cell walls of green algae most often contain cellulose like vascular plants, but a few species contain mannan and xylan in place of cellulose. In the tropics, many green seaweeds contain calcium carbonate impregnated into their cell walls. When these algae die they contribute substantially to the carbonate sand deposits in these areas.



Chlorophyta typical chloroplast
(After Sze, 1998)
Fig. V.2

Life History:
The life histories of the green seaweeds can be either **uniphasic** or **biphasic**. In **uniphasic** life histories, like in *Codium* (shown below), only one phase occurs, and it is diploid (2N). **Meiosis** occurs inside this plant in specialized gametangia that mature to release haploid (N) motile gametes into the water. The gametes undergo **syngamy** (fuse) and germinate to recycle the parent (2N) phase. However in temperate regions, most marine green algae are **biphasic** with 2 free-living phases. This life history, shown in *Ulva*, is diagramed below. A haploid gametophyte produces haploid motile gametes that fuse and develop into a second phase, the diploid sporophyte. The sporophyte then undergoes meiosis to produce haploid motile spores that regenerate the haploid gametophyte. If the 2 phases are identical in morphology, as in *Ulva*, they are considered **isomorphic**. If they are different, they are considered **heteromorphic**. In addition to sexual reproduction, some green seaweeds can reproduce asexually either through the production of asexual **mitospores** (spores produced through mitosis) or through **fragmentation**.

Fig. V.3. Simplified Uniphasic Life History (*Codium*)

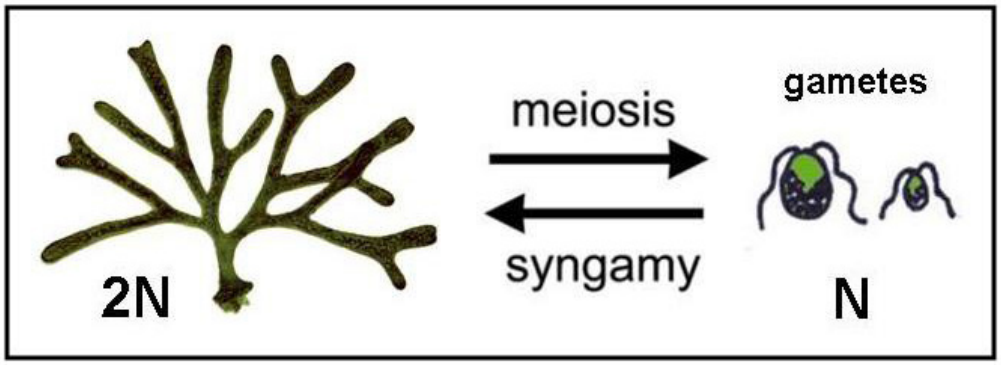
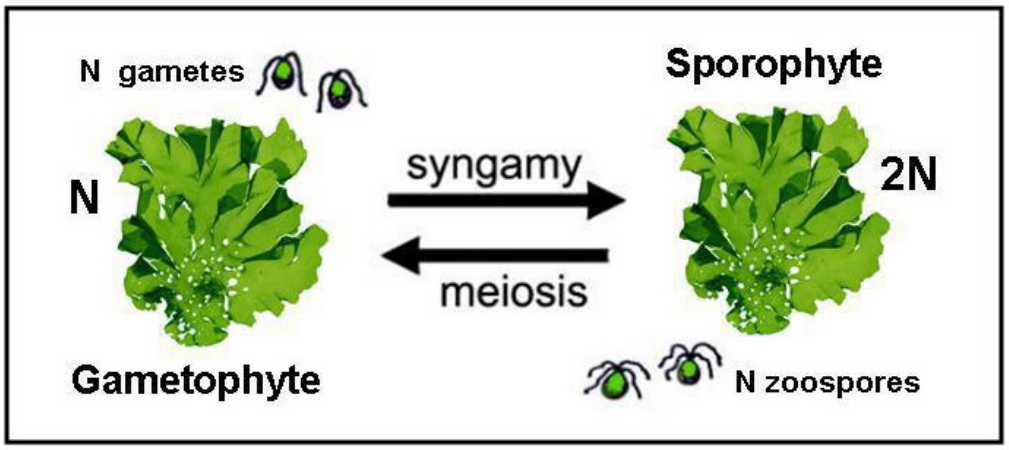


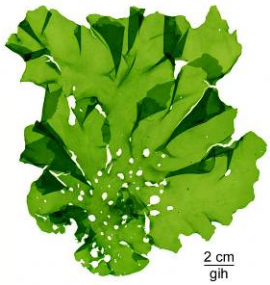
Fig. V.4. Simplified Biphasic Life History (*Ulva*)



Seasonality:
Seasonality greatly affects the life histories of all seaweeds. Generally a species has a consistent type of seasonality for its erect stage that is triggered by environmental factors, particularly daylength and temperature. The following terms are used in describing seaweed seasonality.

- **Aseasonal Annuals** or **Ephemerals** – short lived species that can occur and reproduce anytime during the year when the conditions are favorable
- True **Annuals** – species that generally live less than a year and reproduce once, multiple times, or over long periods during growing season.
- **Perennials** – species that live longer than a year and reproduce multiple times
- **Pseudoperennial** – species with one part perennial and another part annual that can reproduce multiple times.

3. **Sea Lettuce,** *Ulva spp*



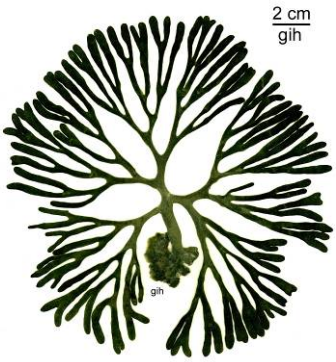
Kingdom Plantae
Phylum **Chlorophyta**
Class Ulvophyceae
Order Ulvales
Family Ulvaceae
Genus *Ulva*

Genus Occurrence…….....	• Worldwide distribution, many species • Intertidal and subtidal • On rocks, other algae or free-floating • Marine and estuarine habitats • Many species are ephemeral
Form/Function…..…….....	• Thalli consisting of thin sheets 2 cells thick or delicate tubes 1 cell thick • Thalli grow rapidly and reproduce frequently to quickly colonize new areas. • A diffuse meristem enables any viable cell to grow and replenish the blade after damage or fragmentation.
Reproduction….....	• Both sexual and asexual reproduction occur • Biphasic, isomorphic life histories • Motile gametes and zoospores develop in cells along the blade margins, leaving these (marginal) cells empty upon their release. • Some species reproduce as frequently as every 2 weeks at low tide. • Asexual reproduction occurs via asexual spores or fragmentation.

Noteworthy Facts….....	• Common ship-fouling organisms, thought to be dispersed around the world in this way • Some species tolerate low salinities and high nutrients and are good indicators of pollution. • Responsible for "green tides".
Congeneric Species.……....	• Based on DNA analysis, *Ulva* now includes both *Ulva* and *Enteromorpha* species. • 17 species are recognized in the NE Pacific

4. Dead Man's Fingers, *Codium fragile*

a.



Kingdom Plantae
Phylum **Chlorophyta**
Class Bryopsidophyceae
Order Bryopsidales
Family Codiaceae
Genus and Species *Codium fragile*

Species Occurrence….....	• Including all subspecies, *C. fragile* is widespread on both sides of the Atlantic and Pacific. In the NE Pacific, our native subspecies occurs from Prince William Sound, Alaska, to Baja California. • Mid intertidal to subtidal • On rocks in semi-exposed areas • Perennial
Form/Function…..……....	• One or more erect, **dichotomously** branched, spongy, finger-like thalli arise from a basal cushion. The plants reach 16 inches in height with individual branches up to 1/3 inch in diameter • Thalli grow apically • Anatomically they consist of a central core of colorless densely intertwined **siphonaceous** filaments (lacking cross walls) that terminate on the thallus surface in closely aligned

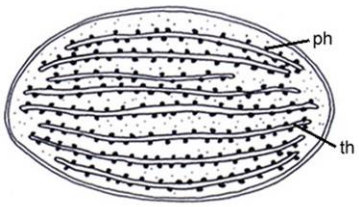
	utricles (club-shaped structures) that bear the chloroplasts • Utricles have mucronate tips (with a terminal spine) and occasionally also bear long sterile hairs laterally giving a fuzzy appearance to some specimens. • Deep green in color
Reproduction….....	• Only sexual reproduction known for the main subspecies • Uniphasic life history, dioecious. • Erect plants produce motile gametes that are anisogamous (of different size). These fuse to recycle the parent thallus. • Gametangia are embedded in the parent thallus. They develop laterally from the utricles near their tops and are club-shaped with a basal cross wall. Meiosis and mitosis occur within the gametangia, and, at maturity, each explosively releases a gelatinous mass of gametes (its entire contents) into the water for fertilization.
Noteworthy Facts….....	• The subspecies *tomentosoides* is a well-known introduced species. It is very similar in appearance to the native subspecies, but it is able to reproduce quickly through asexual spores and fragmentation. Originally from Japan, this subspecies has invaded many temperate areas of the world and become a nuisance. It has recently been reported in California and Washington, but it has not yet made it to Alaska.
Congeneric Species……	• 3 species of *Codium* occur in Alaska. The other 2, *C. setchellii* and *C. ritteri*, are encrusting species. .

VI. Red Algae: Kingdom Plantae, Phylum Rhodophyta

By Gayle I. Hansen
Oregon State University

General:
The Rhodophyta or red algae include nearly 6,000 known species worldwide. Although there are a few terrestrial and several dozen freshwater species, by far the majority of the species are marine making them the most species rich of all marine macrophytes. Red algal species may be **encrusting** or **erect** and **unicellular**, **membranous**, or **filamentous**. The filamentous forms can be simple and thread-like or densely intertwined **pseudo-parenchymatous** blades that may be **uniaxial** or **multiaxia**l with a wide variety of shapes and sizes. Some of the most delicate and lace-like species fall within this group. Red algae range in size from small microscopic plants to large foliose thalli up to 10 or 12 feet in length. They are widespread around the world and occur in all climatic regimes and in all tidal zones from the high intertidal to the subtidal. Encrusting forms have been reported to occur down to –268 meters in clear tropical waters, making them the deepest living of all photosynthetic plants. Red algae are notably high in amino acids and vitamins, and in several countries they are eaten as a food. **Nori**, the purple cellophane-like wrapper around **sushi**, is actually the red alga, *Porphyra*. Some species have been found to have potent anti-viral properties. Water extracts of *Cryptosiphonia* are active against the *Herpes* virus.

Unifying Features:
Like other Plantae, the red algae have a double membrane around their chloroplasts and mitochondria with flattened cristae. They contain chlorophyll a, but unlike other Plantae, their major accessory pigments are the red and blue phycobilin pigments, **phycoerythrin**, **phycocyanin**, and **allophycocyanin**, not chlorophyll b. The phycobilin pigments give the algae their reddish color and enable them to live deeper in the subtidal than any other algae because their red pigments can absorb green light, the deepest penetrating light of all the visible spectrum. The variation in color in red algae, from nearly black or greenish to burgundy to bright red, is caused by the variation in the proportions of these pigments. Also unlike other Plantae, the chloroplasts of the red algae contain numerous singular **thylakoids** (th), unassociated with one another. Each thylakoid is dotted on both sides with a dense covering of **phycobilisomes** (ph), small spherical or discoidal structures that contain the phycobilin pigments. In the red algae, the major photosynthetic reserve is **floridean starch**, a modified form of true starch that is stored outside the chloroplast in the cytoplasm. Like other Plantae, the cell walls of red algae contain with few exceptions cellulose microfibrils embedded in an amorphous matrix. But, in the red algae, the wall matrix is thicker and its components differ. In the red algae, the matrix often contains the **phycocolloids**, **agar** and **carrageenan**. These compounds are very abundant in some red algal groups and are extracted for a wide variety of commercial products. They are particularly common in foods as thickening, gelling, and stabilizing agents. Some red algal groups contain calcium carbonate. The encrusting and articulated **coralline** algae are well known for this, and in

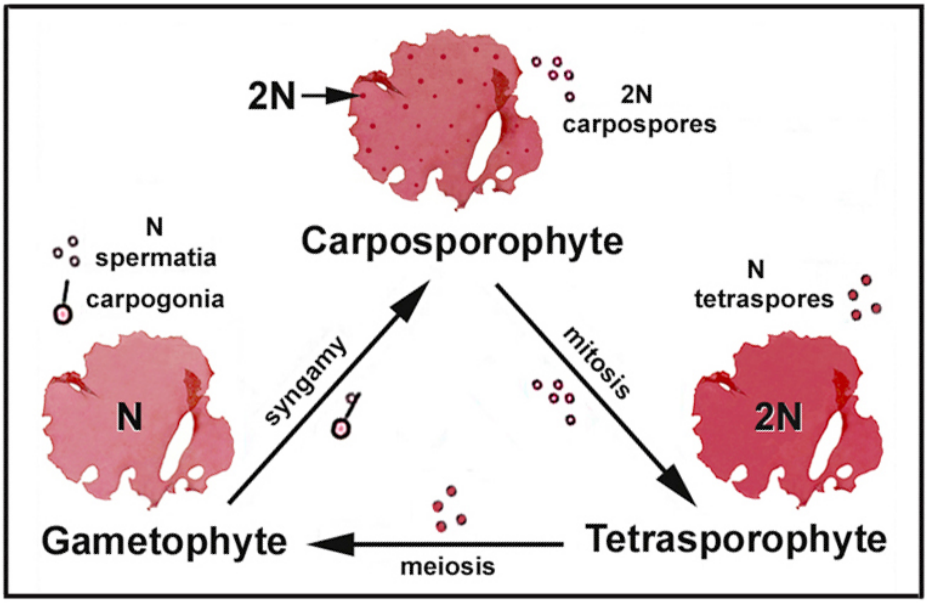


Rhodophyta typical chloroplast
(after Sze, 1998)
Fig. VI.1

the tropics they play a major role in reef building. The red algae are unique among the seaweeds in not containing any motile reproductive cells.

Life History:
The typical life histories of red algae are the most complex among the seaweeds. They are **triphasic**. They have 2 free-living phases, a **gametophyte** and a **tetrasporophyte**, similar to the phases in green algae, and these may also be isomorphic or heteromorphic. But, in addition, they have a third phase, the **carposporophyte**, that grows like an embryo on the female gametophyte. The life history works like this. All red algae are **oogamous**, meaning that they produce eggs (non-motile female gametes). The female plants produce specialized sessile egg cells called **carpogonia** that have hair-like extensions on them called **trichogynes**. These trichogynes protrude out from the carpogonial base into the water above the thallus. The male plants produce clusters of small **spermatangia** that each release a single non-motile **spermatium** (the sperm) into the water. These spermatia float passively along until they accidentally hit a female trichogyne and are able to fertilize the carpogonium. The zygote then remains in place, germinating within the female plant to form the diploid filamentous carposporophyte. At maturity, each carposporophyte releases many diploid **carpospores** into the water that germinate to form the free-living diploid tetrasporophyte generation. At maturity, the tetrasporophyte produces meiotic **tetrasporangia** that each release 4 haploid spores (**tetraspores**) into the water. These then germinate to form the free-living haploid gametophytes, completing the life history.

Fig. VI.2 Simplified Triphasic Life History



Modifications of this life history and asexual reproduction can occur in some species, but the typical triphasic life history is prevalent throughout the red algae. Among all the seaweeds, only this group has evolved a carposporophyte, a phase that multiplies the progeny of a single fertilization. With the lack of motile sperm and less common occurrence of fertilization, it is a useful adaptation, and possibly one of the reasons the red algae have become the most species rich

and widespread of all the seaweed groups.

1. **Little Nori,** *Smithora naiadum*

Kingdom Plantae
Phylum **Rhodophyta**
Class Compsopogonophyceae
Order Erythropeltidales
Family Erythrotrichiaceae
Genus and Species *Smithora naiadum*

Species Occurrence….....	• Kodiak I., Alaska to Mexico and Costa Rica • Mid and low intertidal often in tide pools • Epiphytic mainly on seagrasses – though occasionally seen on understory algae • Perennial holdfasts, ephemeral blades
Form/Function…..……....	• Cushion-like holdfasts that produce numerous erect membranous blades, 0.7 to 2.0 inches in height. • Blades are 1 cell thick and **obovate** narrowing in a stipe-like attachment to the basal parenchymatous cushion. • Blade bases lack rhizoidal filaments • Cells each contain a single **stellate** chloroplast with a central **pyrenoid**. • Basal cushions overwinter, producing the erect blades in season • Deep purple to pinkish-red in color
Reproduction….....	• Life histories irregular • Asexual and sexual reproduction reported • Asexual reproduction by **archaeospores** formed from the blade margins, and **monospores** formed on the basal cushions • Sexual reproduction uncertain but thought to involve unequal division of cells in the blade to produce large female and small male cells.
Noteworthy Facts….....	• Patchy on seagrasses, but when present, it is abundant and densely aggregated.

	• Studies have shown that *Smithora* is able to take advantage of its habitat by deriving nutrients directly from its seagrass host
Congeneric Species..…….	• *Smithora* has only 1 species.

2. **Nori**, *Porphyra spp.*

Kingdom Plantae
Phylum **Rhodophyta**
Class Bangiophyceae
Order Bangiales
Family Bangiaceae
Genus *Porphyra*

Genus Occurrence…..…….....	• Worldwide with many species • High intertidal to subtidal, specific to species • On rock or on other algae • Annual macroscopic blades, seasonal and sometimes surviving only a few weeks • Perennial microscopic filamentous phase
Form/Function…….....…….....	• Erect membranous blades, 1 or 2 cells thick • Attached to the substratum by narrow holdfasts made up of microscopic rhizoidal cells that aid in attachment • Some species reach 5 feet or more in length • Color variable between species: deep red, greenish-blue, purple-brown, etc.
Reproduction….....	• Sexual and asexual reproduction known • Triphasic, heteromorphic life histories • The gametophyte is the **macrothallus**; the sporophyte is a microscopic shell-boring phase referred to as the *Conchocelis* phase. • On the gametophyte, patches of male gametangia are yellow in color, fertilized female patches are reddish in color • Asexual reproduction takes place in a few species where monosporangia are produced on the macrothallus
Noteworthy Facts….....	• High in vitamins and amino acids • An important foodstock around the world

	• Cultivated and eaten in Japan for > 300 years.
Congeneric Species..……	• More than 25 species occur in the NE Pacific • The most genetically diverse red algal genus

3. Pacific Dulse, *Palmaria mollis*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Palmariales
Family Palmariaceae
Genus and Species *Palmaria mollis*

Species Occurrence….....	• Alaska to San Luis Obispo County, California • Low intertidal to subtidal • On rocks • Perennial blade bases and holdfasts –reported to generate new blades for up to 3 years
Form/Function…..……....	• Thallus forming foliose deeply lobed to strap-shaped blades often branched near the base and **proliferous** from the margins. • Blades papery in texture • Generally 4-8 inches tall, but can grow to 30 inches or more under optimal conditions • Color light to medium red • Blades lack **veins** or **midribs**, but have large internal bubble-like medullary cells that can be seen in sterile blades by holding them up to the light.
Reproduction….....	• Sexual and asexual reproduction known • Sexual life histories unusual – biphasic in lacking a carposporophyte generation • Sexual plants dioecious and heteromorphic: male and tetrasporic plants have a typical *Palmaria* morphology, but the female plants are microscopic discs. After fertilization, the tetrasporophyte develops directly from the

	female disc without the intervention of a carposporophyte. • At maturity, the male and tetrasporangial blades develop mottled reproductive sori covering the surfaces of the blades • Asexual reproduction through fragmentation
Noteworthy Facts….....	• High in vitamins and amino acids • Used as foodstock for cultivated abalone • Edible for man • *Palmaria palmata*, true Dulse, is a valuable food crop in Europe and eastern Canada. It is eaten dried like potato chips, or it is pulverized into a powder and added to breads and soups to increase their nutritional value.
Congeneric Species……	• 4 species of *Palmaria* known in SC Alaska

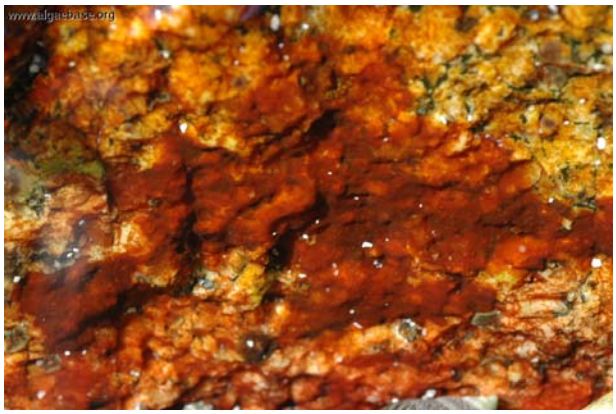
4. **Nailbrush,** *Endocladia muricata*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Gigartinales
Family Endocladiaceae
Genus and Species *Endocladia muricata*

Species Occurrence ….....	• Alaska to Punta Santo Tomas, Baja California, including the Channel Islands • Very high intertidal on rocks • Perennial in most areas
Form/Function ….....…….....	• Erect, small (1.6 – 3.2 inches tall), very highly branched turf-like thalli • Branches terete to compressed, narrow (0.5 mm), and densely covered by short spines giving the plant a rough nailbrush-like texture and some protection from herbivory. • The bushy thalli are often clustered in dense beds, providing them with some water holding capacity at low tide. • Dark red to blackish-brown in color
Reproduction ….....	• Both sexual reproduction and asexual propagation from the holdfast occur. • Triphasic, isomorphic life histories • Tetrasporophytes similar but slightly larger than sexual plants; tetraspores develop on swollen outer branches • Sexual plants monoecious with large (1 mm) globose carposporophytes
Noteworthy Facts……	• Most always exposed to air, the thalli quickly rehydrate on re-immersion in seawater.

	• Provides habitat for small animals, notably mollusks and crustaceans
Congeneric Species……	• 1 species in the local flora

5. **Rusty Rock**, *Hildenbrandia* spp.



Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Hildenbrandiales
Family Hildenbraniaceae
Genus *Hildenbrandia*

Genus Occurrence….....	• Reported to be widespread and abundant • High to mid intertidal • In tidepools and crevices or on exposed rock • Perennial and thought to be long-lived
Form/Function…..……....	• Thalli are crustose, irregular in outline, very hard and thin, almost transparent. • They grow tightly appressed to rocks without rhizoids assisting in their attachment • Anatomically consisting of closely adjoined erect filaments. • Bright brick to rusty red in color
Reproduction….....	• Only asexual reproduction known • Crustose thalli bear mitotic tetrasporangia that release spores that recycle the diploid phase. • The tetrasporangia develop in cup or flask-shaped **conceptacles** embedded in the crust
Noteworthy Facts….....	• An uncalcified, encrusting species, harder in texture than other red non-calcareous crusts. • Sometimes covering extensive areas in the intertidal
Congeneric Species……	• 2 *Hildenbrandia* species in the Alaskan flora

6. **Coral Leaf,** *Bossiella* spp.

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Corallinales
Family Corallinaceae
Genus *Bossiella*

Genus Occurrence…..….....	• Alaska to Mexico, Japan, Russia, Chile • High intertidal pools to the subtidal • Perennial, long lived
Form/Function…..…….....	• Calcareous thalli with extensive crustose bases and erect branching **articulated** fronds • Articulated fronds composed of alternating **intergenicula** (calcified segments) and **genicula** (uncalcified joints) allowing the calcareous frond some flexibility. • Fronds pinnately or dichotomously branched, depending on the species. • Intergenicula generally flat and winged, but they are terete in 1 SC Alaskan species. • Intergenicular segments vary from 1-12 mm in length depending on the species
Reproduction….....	• Only sexual reproduction known • Triphasic, isomorphic life histories • Reproductive structures form in **conceptacles** (embedded flask-shaped structures) that are cortical in origin • Conceptacles develop on intergenicular surfaces below the branch apices • 2-8 conceptacles may occur on each fertile intergeniculum
Noteworthy Facts….....	• Branching fronds often bilaterally flattened

	with a distinctive upper and lower side. • Dead articulated fronds bleach white in the sun and are often found in the drift, appearing like tiny skeletons
Congeneric Species……	• 6 species occur in the NE Pacific

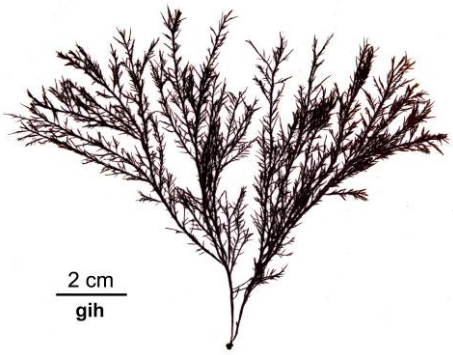
7. **Tidepool Coralline Seaweed**, *Corallina officinalis* var. *chilensis*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Corallinales
Family Corallinaceae
Genus and Species *Corallina officinalis*
Variety *chilensis*

Variety Occurrence…….....	• Alaska to Baja California, Peru and Chile • Mid intertidal pools to shallow subtidal • On rock • Perennial, long lived
Form/Function ….....….....	• Calcified thalli consisting of an extensive crustose base and erect articulated feather-like fronds, reaching 2 to 6 inches in height. • Fronds with terete to compressed axes bearing bilaterally flattened pinnate branches. • Calcified axial intergenicula 1-2 mm long and up to 1.5 mm broad; • Lateral branch tips swell when fertile with reproductive conceptacles • Pinkish to purplish in color
Reproduction….....	• Only sexual reproduction known • Triphasic, isomorphic life history • Reproductive structures occur in cavities called conceptacles that are axially derived • Conceptacles occur singly in the branch tips of this species • Life history studies have shown that tetraspores settle in 48 hours and develop into extensive crusts before the fronds develop
Noteworthy Facts….....	• In high energy areas, fronds are shorter and crusts more extensive • Sensitive to desiccation; dies if 15% of water

	is lost • Similar to *Bossiella*, a genus that bears its conceptacles on the intergenicular surfaces
Congeneric Species……	• 7 *Corallina* species occur in the NE Pacific

8. **Bleached Brunette,** *Cryptosiphonia woodii*

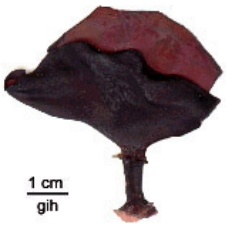


Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Gigartinales
Family Dumontiaceae
Genus and Species *Cryptosiphonia woodii*

Species Occurrence….....	• Unalaska Island, Alaska, to San Pedro, California • Mid intertidal on rocks • Spring-summer annual
Form/Function…..…….....	• Thalli terete and irregularly radially branched to 4 orders, reaching 4-9 inches in length. • Individual branches are 1-2 mm in diameter at their centers and characteristically taper at both ends. • Thalli uniaxial in structure with a tightly compacted outer cortex • Generally deep maroon to dark brown in color, but the outer branches may become yellowish in color, thus its common name, "bleached brunette".
Reproduction….....	• Only sexual reproduction known • Triphasic, isomorphic, and dioecious • Male plants develop spermatangia in a **sorus** (a visible clustering of reproductive structures) that covers almost the entire surface. • In female plants, carposporophytes develop embedded in swolen outer branches • In the tetrasporophytes, the tetrasporangia form scattered in the outer cortex

	• After gamete or spore release, the branches desintegrate.
Noteworthy Facts….....	▪ Water extracts of this alga have been found to prevent outbreaks of *Herpes* infections.
Congeneric Species……	• 1 species of *Cryptosiphonia* in Alaska

9. **Mermaid's Cup**, *Constantinea simplex*



Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Gigartinales
Family Dumontiaceae
Genus and Species *Constantinea simplex*

Species Occurrence….....	• Kodiak Island, Alaska, to central California • Low intertidal to subtidal • Epilithic, often forming beds on exposed, wave-swept cliffs • Perennial
Form/Function…..…….....	• Thalli are cup-shaped, 2-2.4 inches in diameter and **peltate** to **perfoliate** on short thick central central stipes that are usually unbranched • The cup-like blade is thin and entire when young, often holding water and well deserving its nickname, "mermaid's cup". With age, the blade thickens and tears, becoming irregularly radially dissected • New blades are formed once a year during the winter via the stipe growing through the old blade to produce the new cap, while the old blade erodes leaving a visible scar on the stipe. By counting the scars, thalli have been found to live for up to 7 years. • Deep red in color

Reproduction….....	• Only sexual reproduction known • Triphasic, isomorphic, and dioecious • Reproductive structures form on the outer rim of the cap and distinctively color the margin yellowish in male caps and deep purple in female and tetrasporangial thalli. After gamete or spore release, the cap margins disentegrate.
Noteworthy Facts….....	• This attractive algae is also known as the "cup and saucer" alga • Extracts of this and other species in the Dumontiaceae are known to have potent anti-viral properties.
Congeneric Species……	• 3 species of *Constantinea* occur in Alaska

10. **Turkish Washcloth,** *Mastocarpus papillatus*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Gigartinales
Family Phyllophoraceae
Genus and Species *Mastocarpus papillatus*

Species Occurrence…….....	• Alaska to Baja California, Mexico, Bering Sea, E. Russia, Japan • High to mid intertidal on rock • A perennial encrusting phase and an erect thallus that may be perennial or annual, depending on the area
Form/Function…..…….....	• Gametophytes consist of erect dichotomously branched often heavily **papillate** foliose blades, 3-6 inches tall that narrow to a small holdfast. • Immature blades are typically planar (not grooved as in other species) – but see description of reproductive blades below. • Blades are rubbery texture due to the carrageenan in their cell walls • The tetrasporophyte generation is a thick fleshy non-calcareous crust, originally thought to be the separate genus *Petrocelis* • The crust is nicknamed “tar spot” for its reddish-brown to black tar-like appearance. • Tetrasporic crusts can reach 3 feet or more across and 2.5 mm thick. They are known to be slow growing and very long lived

	• Color is dark red brown.
Reproduction….....	• Triphasic and heteromorphic life histories typical, but biphasic life histories with direct development of the gametophytes from the tetrasporophyte are known • The erect blades are dioecious gametophytes. • Male plants are smooth to slightly roughened and larger and broader than the female plants. • Female plants are much more abundant than males and, when fertile, are very rough in texture, covered on both surfaces by papillae (stalked spherical structures that contain the reproductive structures). The common name, "Turkish Washcloth", refers to this rough texture. • Tetrasporophyte crusts consist of tightly appressed erect filaments that bear single tetrasporangia midway in the filaments.
Noteworthy Facts….....	• The "Petrocelis"stage of this alga has been found to live for up to 90 years
Congeneric Species……	• At least 3 species of *Mastocarpus* occur in the N and NE Pacific

11. **Iridescent Blade,** *Mazzaella splendens*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Gigartinales
Family Gigartinaceae
Genus and Species *Mazzaella splendens*

Species Occurrence….....	• Alaska to Baja California, Mexico • Low intertidal to subtidal on exposed coasts and in semi-sheltered locals • On rock • Perennial basal stipes and crusts can regenerate new blades
Form/Function…..…….....	• Large, broadly lanceolate to ovate blades that narrow to a wedge or heart-shaped base with an ample 2-3 inch stipe. Blades are known to reach up to 4 feet or more in length. • Rubbery in texture due to the presence of carrageenans in the cell walls • Blades often appear **iridescent** when floating due to the **birefringence** of light hitting the thick cell walls • Light to dark purple to brownish purple
Reproduction….....	• Sexual and asexual reproduction known • Triphasic, isomorphic and dioecious • Fertile female and tetrasporic plants both bear their reproductive structures in dot-like structures on the thallus surface. Each dot consists of a single carposporophyte in the female or a cluster (a sorus) of embedded tetrasporangia in the tetrasporophyte. Male plants bear their spermatangia in a uniform

	continuous lawn on both surfaces of the thallus, making them appear lighter in color than the other phases. • Although morphologically similar, the tetrasporangial and gametangial blades are chemically different because they contain different carrageenans
Noteworthy Facts….....	• The high content of commercially valuable carrageenans makes these algae attractive for aquaculture and commercial use. • Researchers have shown that in British Columbia the reproductive phases of this alga can recycle asexually with tetrasporophytes predominating in the winter and gametophytes in the summer
Congeneric Species……	• At least 12 species of *Mazzaella* are recognized in the N and NE Pacific

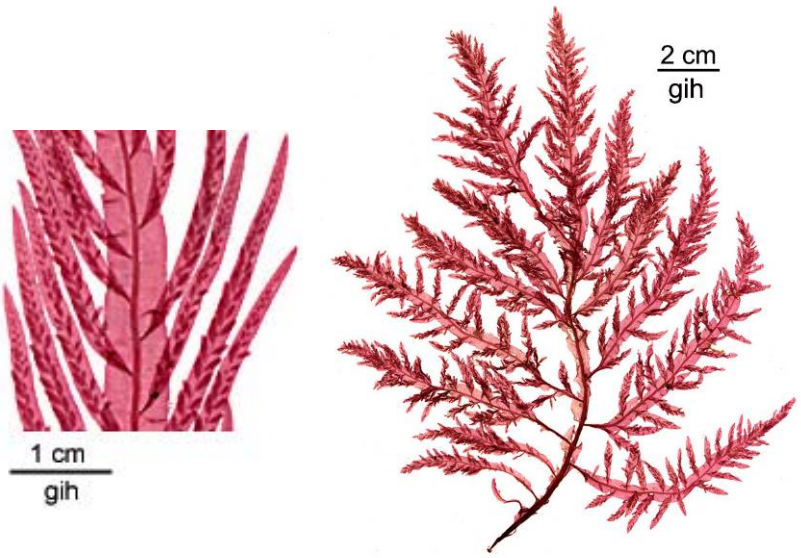
12. Red Feather, *Ptilota filicina*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Ceramiaceae
Genus and Species *Ptilota filicina*

Species Occurrence….....	• Alaska to Punta Baja, Baja California, E. Russia, Japan • Low intertidal to subtidal • On rocks • Annual
Form/Function ….....…….....	• Small feather-like branching thalli that reach 4 to rarely 14 inches in height • Axes uniaxial, **corticated**, and compressed. • Each axis bears a tight series of short bilaterally flattened opposite branchlets that can resemble small leaves. In an alternating pattern, one of each opposite pair remains smaller, developing slower than the other • The leaf-like branchlets are toothed along both margins, some so deeply incised as to appear like small **pinnate** branchlets. • Opposite branchlets are similar in form in tetrasporangial thalli, but they are unlike in male and female thalli • Dark red in color
Reproduction….....	• Only sexual reproduction known • Triphasic, isomorphic life histories • Reproductive structures form on the branchlet tips and teeth
Noteworthy Facts….....	• New anti-inflammatory **eicosapentaenoic acids** have been isolated from this species

Congeneric Species……	• 2 species of *Ptilota,* and 4 species of *Neoptilota* are recognized in the NE Pacific. • Species of *Neoptilota* have recently been merged with *Ptilota* by Japanese workers

13. **Winged Rib,** *Delesseria decipiens*

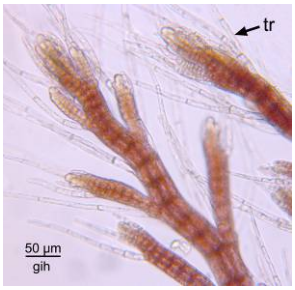


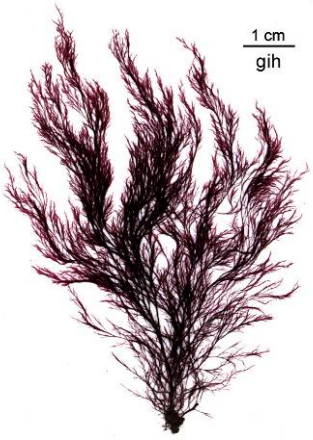
Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Delesseriaceae
Genus and Species *Delesseria decipiens*

Species Occurrence….....	• Aleutian Islands, Alaska to Baja California and Peru • Low intertidal to subtidal, often in deep pools or in the shade of overhanging rocks • Short-lived spring annual that rarely occurs in the summer and fall
Form/Function ….....…….....	• Delicate, ribbon-like, branched membranous thalli with prominent central **midribs** and small discoid holdfasts. • Thalli are pendant in clusters and 4-10 inches in length with individual branches reaching 0.30-0.45 inches in diameter • Midribs are **polystromatic**. The sterile margins or wings are **monostromatic** with microscopic veins diagonal to the midrib • Branching is alternate and always initiated from the midrib of a prior blade. • 4-5 levels of branching can occur. The wings of the basal branches are frequently eroded • Straw colored to dark purplish-red
Reproduction….....	• Only sexual reproduction known

	• Triphasic, isomorphic life histories; dioecious • Female structures and carposporophytes appear along the midribs. Male and tetrasporangial sori occur on the blade wings
Noteworthy Facts….....	• The beautiful feathery-fan appearance of this alga can only be truly seen when it is floating in water
Congeneric Species……	• Only 1 species in the genus in the NE Pacific

14. **Polly,** *Polysiphonia* spp.



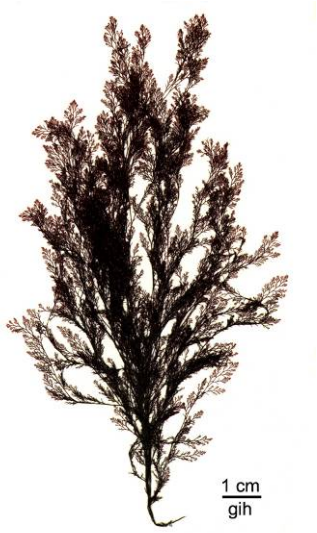


Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Rhodomelaceae
Genus *Polysiphonia*

Genus Occurrence…..…….....	• The genus occurs worldwide, many species. • From upper intertidal pools to the subtidal, depending on the species • Sometimes very abundant • Seasonal annuals or ephemerals
Form/Function ….....…….....	• Thalli erect, filamentous, and radially branched, attached by unicellular rhizoids • **Polysiphonous** – microscopically the filaments appear tiered, each consisting of a central row of axial cells each surrounded by a whorl of cells of the same length • Deciduous **trichoblasts** (tr, microscopic branched hairs) form on the branch tips of many species and are shed below, leaving visible scar cells • Reddish-brown to reddish-black in color • Some species reach >10 inches in height
Reproduction….....	• Sexual and asexual reproduction known • Triphasic, isomorphic life histories • Dioecious with male plants forming specialized spermatangial **stichidia** and the

	females developing stalked **pericarps** • Tetrasporophyes form1 tetrasporagium/tier in a straight series • Asexual reproduction by fragmentation
Noteworthy Facts….....	• Often confused with *Pterosiphonia*, a closely related genus whose species do not bear trichoblasts and are often slightly flattened. • A ship fouling alga enabling some species to be widespread
Congeneric Species…..…….	• 21 species occur in the NE Pacific, AK to CA

15. **Black Tassel,** *Pterosiphonia bipinnata*



Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Rhodomelaceae
Genus and Species *Pterosiphonia bipinnata*

Genus Occurrence…..…….....	• Japan, eastern Russia; Alaska to California. • Mid intertidal to upper subtidal • Often abundant in exposed locals • Seasonal annual or ephemeral
Form/Function ….....…….....	• Attached by rhizoidal branches that generate erect terete axes that are alternately branched, intertwined and bilaterally flattened. Lower branches often curve outward helping to hook the branches together. Branches near the tips typically curve inward overtopping the apex, causing a characteristic flattened clustering of the branch tips. • All branches are **polysiphonous** (see *Polysiphonia*) with each axial cell surrounded by a whorl of 10-12 cells of the same length • Without vegetative **trichoblasts** • Reddish-brown to reddish black in color • Thalli reach 4-10 inches in height
Reproduction….....	• Sexual and asexual reproduction known • Triphasic, isomorphic life histories • Dioecious: male plants form spermatangial **stichidia** laterally near the branch tips, and females develop subglobose **pericarps** terminally on short lateral branches • Tetrasporophyes form a straight series of 1 tetrasporagium/tier in the upper branches

	• Asexual reproduction by fragmentation
Noteworthy Facts….....	• Often confused with *Polysiphonia*, a radially branched genus whose species bear vegetative trichoblasts.
Congeneric Species…..…….	• 4 species of *Pterosiphonia* occur in Alaska

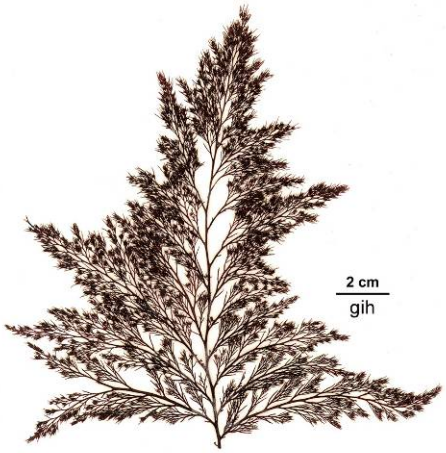
16. **Black Pine**, *Neorhodomela larix*

Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Rhodomelaceae
Genus and Species *Neorhodomela larix*

Species Occurrence….....	• Aleutian Islands, Alaska to Baja California, Bering Sea, Eastern Russia, Japan • Mid to low intertidal on exposed coasts • Perennial basal axes
Form/Function…..……....	• Thallus with prostrate and erect axes that appear like narrow, irregularly branching bottle brushes, ¼ to ½ inch in diameter and 8-12 inches or more in length. • Each axis is beset with a dense continuous spiral of short finger-like lateral branches that may be simple or forked and up to ¼ inch in length and 1 mm in width. • Overwintering prostrate axes generate new branches in the winter and spring
Reproduction….....	• Triphasic, isomorphic life histories • Reproductive branchlets form in the axiles of the spiral laterals in this species • Tetraspore release is reported to be continual throughout the growing season
Noteworthy Facts….....	• This species forms large beds in the mid intertidal in Washington & Oregon • Provides shelter for a wide variety of invertebrates, particularly amphipods,

	isopods and small snails
Congeneric Species..…….	• 3 species of *Neorhodomela* are recognized in the NE Pacific

17. **Cocklebur Alga**, *Odonthalia floccosa*



Kingdom Plantae
Phylum **Rhodophyta**
Class Florideophyceae
Order Ceramiales
Family Rhodomelaceae
Genus and Species *Odonthalia floccosa*

Species Occurrence….....	• Aleutian Islands, Alaska to Santa Barbara County, California, Bering Sea, E. Russia • Mid to low intertidal • On exposed rocks • Perennial basal branches over winter and generate new erect axes in the spring
Form/Function…..……....	• Highly branched tufted thalli, 5-15 inches in height, attached by discoid holdfasts • Each thallus consists of several terete to compressed main axes (to 1 mm in diameter) that are branched in a repeated alternate **distichous** pattern when young but become more radially branched when mature. Fertile thalli are laden with reproductive branch clusters, giving them a tufted appearance • Blackish brown to yellowish brown
Reproduction….....	• Triphasic, isomorphic life histories • Dioecious gametophytes • Reproductive structures form in specialized branch clusters that develop in the axiles or on the tips of the lateral branches. The common name is based on the resemblance

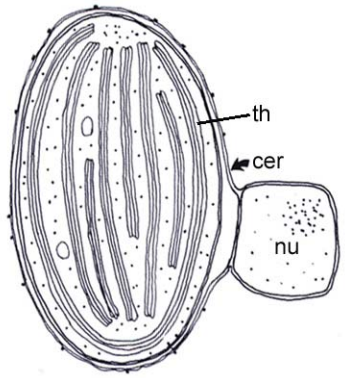
	of these tufts to the **cockleburs** of the composite Anthophyte genus *Xanthium.*
Noteworthy Facts….....	• Forms dense mats in British Columbia and Alaska, offering shelter to a wide variety of invertebrates • A cold water species, surviving temperatures only up to 77^{o} F
Congeneric Species……	• 5 species of *Odonthalia* in the NE Pacific.

VII. Brown Algae: Kingdom Chromista, Phylum Ochrophyta

By Gayle I. Hansen
Oregon State University

The Kingdom Chromista is a large and extremely diverse group of organisms. It contains both photosynthetic and non-photosynthetic forms, including some groups that were originally thought to be part of the Protozoa or Fungi. The Chromistan species range in size from small unicellular **plankton** to huge multicellular **kelps** that can reach the height of a 10-story building. Nearly all of the species occur in marine or freshwater environments, and some can be very abundant. Unicellular members include the diatoms, coccolithophorids, cryptophytes, chrysophytes, and silicoflagellates. Multicellular members include the brown algae, yellow-green algae, water molds, and slime nets or labyrinthulas.

Originally, the photosynthetic Chromista were thought to be members of the Kingdom Plantae since they contain **chlorophyll a**, the primary photosynthetic pigment. However, they differ from the Plantae in many features including their accessory pigments, storage products, and many aspects of their ultrastructure. All contain **chlorophyll c** as their major accessory pigment and often also **fucoxanthin**, a pigment that gives some members their golden brown color. One group, the cryptophytes, contains phycobilin pigments as well as chlorophyll c. The cell storage reserves include the oil **leucosin** and/or the carbohydrate **laminarin** (or chrysolaminarin), both deposited in vesicles in the cytoplasm. The mitochondria bear cristae that are tubular rather than flattened as they are in the Plantae. The chloroplasts have thylakoids (th), pigment containing membranes, that occur in bands of 3 (see Fig. VII.1) or occasionally 2 with an encircling band located just inside the chloroplast envelope. In addition, the chloroplast envelope has been found to consist of 4 membranes rather than the traditional 2 that we see in the Plantae. Together, these differences provided enough evidence to establish the Kingdom Chromista in the late 20th century.

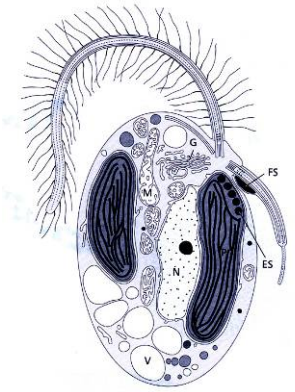


Chromista
typical chloroplast
(after Sze, 1998)

Fig. VII.1

As with the Plantae, the Endosymbiotic Theory has also been used to explain the development of the Chromista. These eukaryotic organisms also appear to have undergone a symbiosis to obtain their chloroplast. But, unlike in the Plantae, these early unicells engulfed a eukaryotic cell. So the Chromista have actually undergone 2 endosymbioses: a primary and a secondary event. The remnants of the **secondary endosymbiosis** include the 4 membranes around the chloroplasts, 2 from the endosymbiont and

2 from the host (the cell membrane and the vacuolar membrane), with the latter 2 often referred to as the **chloroplast endoplasmic reticulum** (CER). In one group, there is even a **nucleomorph**, a DNA-containing residue of the symbiont nucleus, occurring between the 2 double membranes. Further evidence of the secondary endosymbiosis has now also been obtained from molecular biological studies. Since the chloroplasts of all photosynthetic organisms contain DNA, scientists have been able to compare the DNA of Chromistan chloroplasts with that of all other photosynthetic organisms. Through these studies, they have discovered that all Chromistan chloroplasts developed initially via the endosymbiosis of a red algal cell.



Ochrophyte Motile Cell
(after Graham and Wilcox, 2000)
Fig. VII.2

Within the Chromista, the organization of the phyla is still being researched. Recent taxonomic schemes have separated the photosynthetic from the non-photosynthetic groups. The photosynthetic forms fall into 4 phyla: the diatoms, coccolithophorids, cryptophytes, and a new phylum, the Ochrophyta. The Ochrophyta, named for its ocher or golden-brown color, includes all photosynthetic Chromista that have motile cells with 2 laterally inserted flagella that are **heterokont**, meaning that they are of unequal length. In these cells, the posterior flagellum is short and smooth, and the anterior flagellum is long and tinsel with 2 lateral rows of **mastigonemes** (tripartite tubular hairs) that help to propel the cell forward (see Fig. VII.2). The Ochrophyta are particularly important to our study because they are the only phylum in the Chromista that contains seaweeds.

Phylum Ochrophyta, Class Phaeophyceae

General:
The Phaeophyceae or brown algae are estimated to include about 1800 species. Only 8 genera occur in freshwater. All of the rest are marine and are considered to be seaweeds. They vary in size from small microscopic crusts and filamentous forms to large parenchymatous thalli that may reach 60 meters or more in length. Brown algae are widespread around the world, occurring in temperate, polar and tropical seas and from the high intertidal down to the subtidal. One species has been reported to exist at –220 meters in clear tropical waters, almost as deep as the red algae. In the northern hemisphere, the Laminariales or kelps are the most diverse and abundant of the large brown algae. In temperate regions, they form large subtidal kelp forests that shelter and support a wide variety of fish and invertebrates. In the southern hemisphere, the Fucales, including our familiar rockweed, are the most diverse and abundant. Many south temperate species in this group rival the Laminariales in their complexity and size. In the tropics, another Fucalean genus, *Sargassum*, forms huge floating meadows that shelter and feed a specific community of animals. High in vitamins and minerals and particularly high in calcium, some species of kelp and rockweed are eaten in Asia and other countries in soups and stews, and some are farmed. Dried and powdered *Laminaria* is a major component of the macrobiotic diet

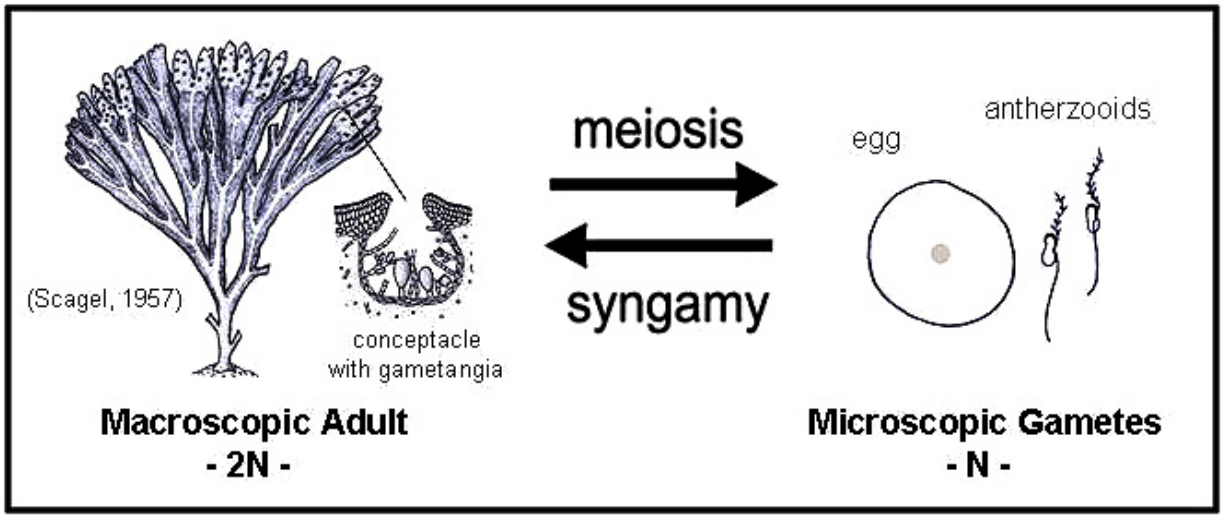
for cancer patients.

Unifying Features:
Like other Chromista, the brown algae have 4 membranes surrounding their chloroplasts and mitochondria with tubular cristae. They contain chlorophyll c and fucoxanthin as their major accessory pigments, and their chloroplasts have thylakoids stacked in bands of 3 including an encircling band that runs just under the chloroplast envelope. Their photosynthetic reserves include **laminarin**, an insoluble polysaccharide, and also **mannitol**, a soluble sugar alcohol. In large kelps, mannitol is often transported from the sunlit canopy to the shaded understory through phloem-like cells. Some Phaeophyceae contain **physodes**, small refractile tannin-filled vesicles that function in herbivore resistance. The cell walls contain cellulose microfibrils embedded in a thick amorphous matrix somewhat like the Rhodophyta, but here the amorphous matrix contains **alginic acid** or **fucoiden**. Both of these compounds are **phycocolloids** (gelatin-like compounds) that are harvested for a wide variety of commercial products equally as diverse as those used for the phycocolloids of red algae. A few tropical species also contain calcium carbonate. Brown algal motile cells (zoospores and most gametes) always have the typical Ochrophyta motile cell morphology.

Life History:
Like the green algae, the brown algae have sexual life histories that are either uniphasic or biphasic.

In the browns, only the Fucales are **uniphasic** (see Fig. VII.3). In these forms, the macroscopic phase that you see is the only life history phase, and it is diploid (2N). Meiotic reproductive structures develop directly on this phase and produce the haploid (N) gametes. These fuse and germinate into the diploid parent phase. In the Fucales, the gametes are produced in gametangia (antheridia and oogonia) that form in tiny protective cavities called conceptacles. You will see these mentioned in *Fucus* and *Cystoseira*.

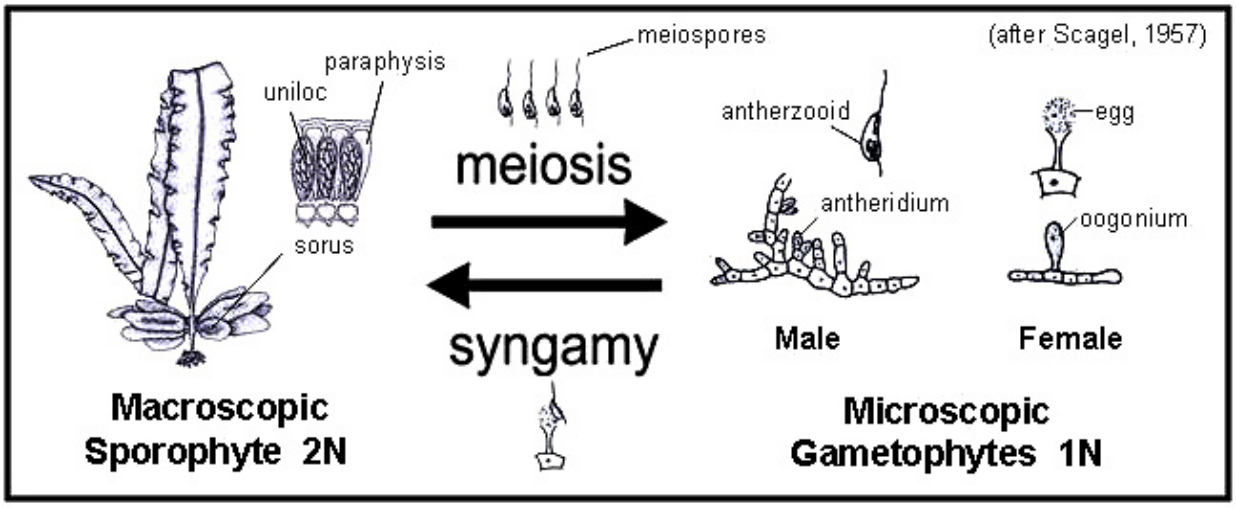
Fig. VII.3. Uniphasic Life History (Fucus)



All other brown algal groups are **biphasic** with **heteromorphic** or **isomorphic** phases (See Figs. VII.4 and VII.5). Most brown algae have biphasic heteromorphic life histories. In the large browns like the Desmarestiales (acid weed) and Laminariales (the kelps, e.g. *Alaria* shown in Fig. VII.4), the macroscopic plants that you see in the field are sporophytes (2N). The gametophytes (N) are tiny filamentous phases that can only be seen with a microscope. In other heteromorphic brown algae, the situation varies. In *Scytosiphon*, the large erect tubes that you see are gametophytes (N) while the sporophyte (2N) is a tiny crust. Often we can identify the sporophyte of a biphasic brown alga by looking at its reproductive structures. Only the sporophyte (2N) can produce **meiospores** (spores formed through meiosis) and these develop in **unilocular** sporangia (with 1 cavity producing multiple spores) that are unique to this phase. **Mitospores** and gametes (both formed through mitosis) develop in sporangia or gametangia that are **plurilocular** (with multiple cavities, each producing only 1 spore or gamete). These occur on the gametophyte but also on the sporophyte in some species, so they are not unique to a specific phase. The kelps are good candidates for demonstrating the use of reproductive structures to determine a life history phase. In the macroscopic thalli of these algae, the sporangia form in densely packed patches called **sori** (**sorus** = singular). If you section through

a kelp sorus, you will see a thick surface layer of unilocular sporangia (unilocs) intermixed with **paraphyses** (sterile hairs that protect the young sporangia). The presence of these unilocs indicates that the phase you are looking at is a sporophyte.

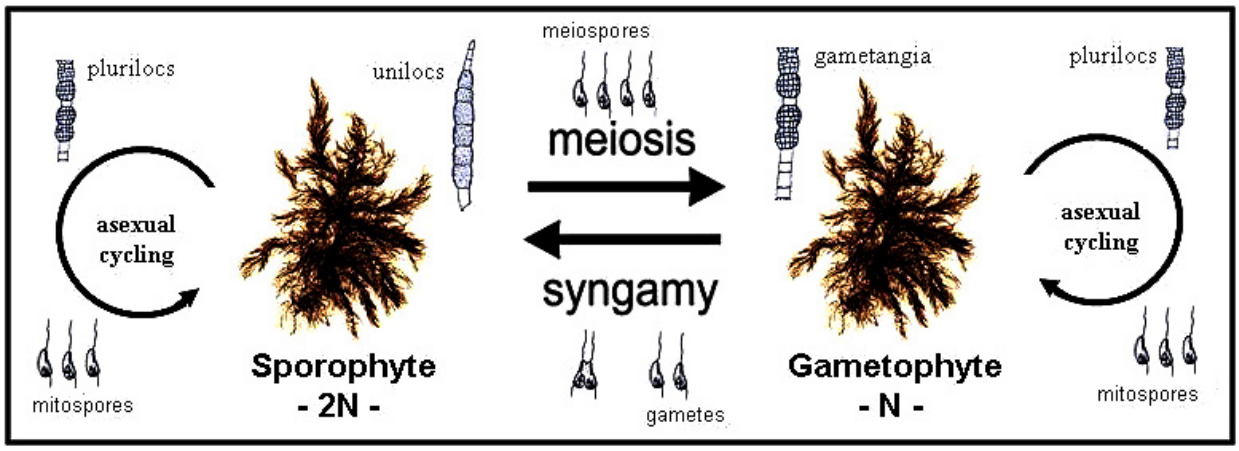
Fig. VII.4. Biphasic Heteromorphic Life History (*Alaria*, a kelp)



Within the brown algae, there is an array of gamete types. The gametes are formed in **gametangia** (mitotically in biphasic life histories and meiotically in uniphasic life histories). Both female and male **gametes** may be motile and **isogamous** (similar in size) or **anisogamous** (different in size), or the female may be non-motile and the male motile as occurs in **oogamy**. In oogamy, the **eggs** are often produced in a gametangium referred to as an **oogonium** and the sperm or **antherzooids** are produced in an **antheridium**. In some brown algae, the female gametes exude **pheromones** (diffusible hormones) that trigger the release of male gametes and attract them to the female gametes. All brown algal pheromones identified to date are unsaturated hydrocarbons that have been characterized and given names. **Lamoxirene** is the pheromone common to all kelps.

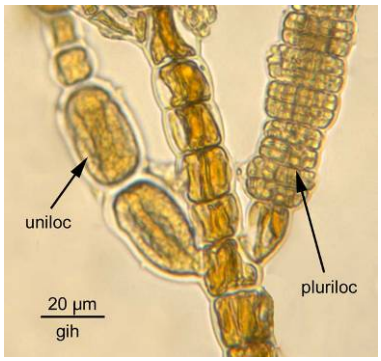
Asexual reproduction is common in a few groups of brown algae, particularly in the smaller less-complex filamentous forms such as *Pylaiella*, shown in Fig. VII.5. In these filamentous groups, it generally occurs through fragmentation or through the production of asexual mitospores that are generally produced in plurilocular sporangia (plurilocs).

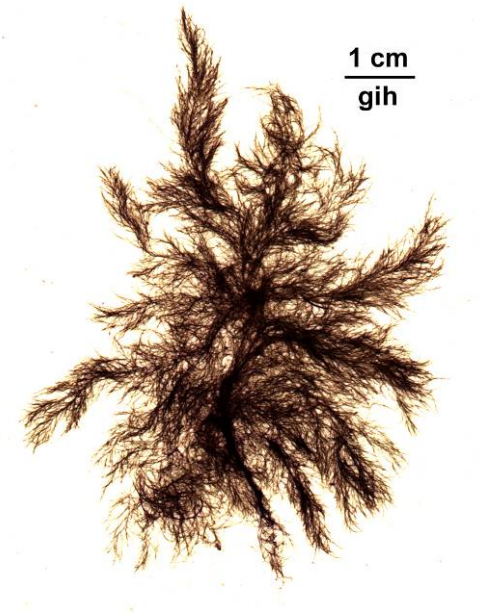
Fig. VII.5. Biphasic Isomorphic Life History with Asexual Cycling (*Pylaiella*)



The larger browns, like the kelps, have been thought to have only sexual reproduction. However, studies of brown algae that fall into the middle-size range have shown us that asexual cycles can be hidden. Several brown algal groups have recently been found to produce their heteromorphic phases in some areas in response to environmental cues like day length and temperature rather than through syngamy and meiosis. In some species, the motile phases are not even present and one phase germinates directly from the other in a process called **direct development**. When these types of life histories occur, the **ploidy** level of the gametophyte and sporophyte can be the same, and the phases are considered **facultative** in function since they may or may not be sexual. So, there is now a tendency to call the phases of all heteromorphic brown algae **macrothalli** and **microthalli**, thus avoiding altogether the terms gametophyte and sporophyte that indicate ploidy and true sexuality. Further research is obviously needed to better understand the life histories and reproductive biology of the brown algae.

1. Common Sea Felt, *Pylaiella littoralis*





Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Ectocarpales
Family Acinetosporaceae
Genus and Species *Pylaiella littoralis*

Species Occurrence….....	• Nearly worldwide – Alaska to Mexico, Bering Sea, Japan, E. Russia, North and South Atlantic, Australia, Hawaii • Mid intertidal • On algae, rock, wood, or free-floating • Ephemeral
Form/Function……..	• Thalli consisting of richly branched tiny **uniseriate** (1-cell thick) filaments that grow from a prostrate basal system and often intertwine, forming a dense felt-like mat. • The filaments grow diffusely (from any cell) and branching is scattered and opposite to irregular along the axes. • Individual cells contain several discoid chloroplasts, each with 1-2 pyrenoids. • Commonly 1-3 inches tall but can grow in mats to 12 inches or more in diameter. • Dark brown to yellowish brown
Reproduction….....	• Sexual and asexual reproduction known • Biphasic, isomorphic life histories with motile isogametes and zoospores • Unilocular and plurilocular reproductive structures develop in intercalary chains on

	the filaments • Asexual reproduction occurs through fragmentation and through the production of mitotic zoospores
Noteworthy Facts….....	• The *rupincola* variety of this species twists into long cord-like strands and grows to nuisance quantities in many areas of the world.
Congeneric Species……	• 5 species of *Pylaiella* are recognized in the NE Pacific, 9 are known worldwide.

2. Bulb Seaweed/Oyster Thief, *Colpomenia peregrina*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Ectocarpales
Family Scytosiphonales
Genus and Species *Colpomenia peregrina*

Species Occurrence….....	• Widespread. Aleutian islands, Alaska, to southern California; western North Pacific; North Atlantic; Mediterranean; Australia; New Zealand • Mid to low intertidal • On rocks or other algae • Spring-summer annual
Form/Function…..……....	• A thin, smooth to wrinkled globular thallus, that becomes hollow at maturity and is attached by a filamentous holdfast • Generally 1-4 inches in diameter, but to football size in invaded habitats in Europe • Grows by a surface meristem • Light brown in color, drying to green
Reproduction….....	• North Pacific plants possibly uniphasic. • The macrothallus appears to be an asexual gametophyte, forming plurilocular sporangia in extensive continuous patches (sori) on the lower parts of the thallus. • The sporophyte generation is unknown.
Noteworthy Facts….....	• An invasive species in Europe, introduced into France in the late 1800's on juvenile American oysters for aquaculture. • Nicknamed "oyster thief" because large plants attached to oysters get swept up by the currents often causing the host oysters to be

	ripped off the substratum
Congeneric Species……	• 4 known species in the NE Pacific, 10 reported worldwide (AlgaeBase).

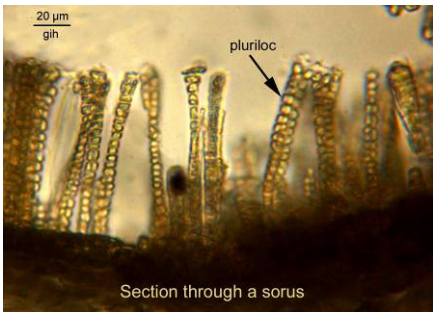
3. False Kelp, Petalonia fascia

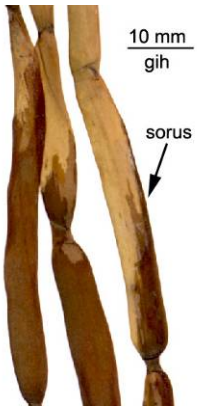
Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Ectocarpales
Family Scytosiphonaceae
Genus and Species *Petalonia fascia*

Species Occurrence….....	• Widespread in temperate to arctic seas: Western North Pacific, Aleutian Islands, Alaska to Baja California, Mexico; Chile; Arctic Sea, North Atlantic; North Sea, Baltic Sea, Mediterranean • Mid intertidal to shallow subtidal on rock or other algae • Erect blades are winter ephemerals, recycling the plant up to 3 times.
Form/Function…..…….....	• The erect macrothalli are smooth, broadly **lanceolate** (sword-shaped) blades that narrow to a short stipe and small discoid holdfast, sometimes appearing like a small kelp, providing the basis for the common name, “false kelp”. • Blades have diffuse growth and are typically 3-10 inches in length, although subtidal plants may be larger. • Parenchymatous in structure consisting entirely of **subglobose** cells with surface cells much smaller in diameter than the internal cells • Golden brown in color.

	• The microthallus is a small crust, typically less than 1 cm in diameter.
Reproduction….....	• Biphasic heteromorphic life history that usually cycles asexually. • The macrothallus is a facultative gametophyte that bears uniseriate (1 cell wide) plurilocular structures in a nearly continuous sorus on both surfaces of the blade. At maturity, each reproductive cell releases up to 264 zoospores into the water. These settle and germinate into either the erect or crustose phase. • The microthallus is a crustose facultative sporophyte that develops unilocular sporangia that release zoospores that can also germinate into either phase.
Noteworthy Facts….....	• The asexual cycling of the life history has been shown to be influenced by day length and temperature with short days/low temperatures triggering the erect blades and long days/high temperatures causing crust formation.
Congeneric Species…….	• 2 species of *Petalonia* in SC Alaska

4. Soda Straws, Scytosiphon lomentaria



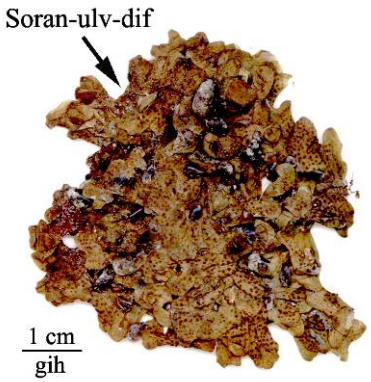


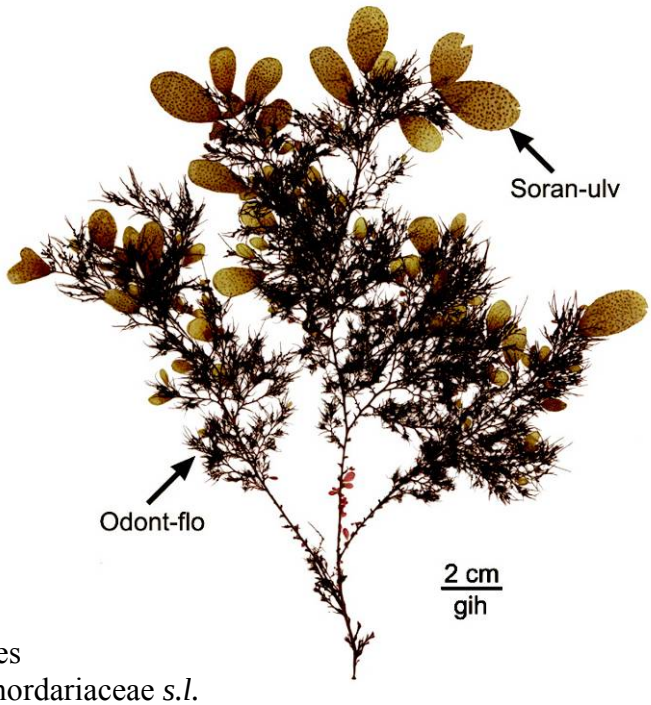
Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Ectocarpales
Family Scytosiphonaceae
Genus and Species *Scytosiphon lomentaria*

Species Occurrence….....	• Aleutian Islands, Alaska to Baja California; Mexico; western North Pacific; North Atlantic; Chile; Peru; southern Australia • High to low intertidal on rock, often in pools • Tubular phase thought to be winter annuals or ephemerals, similar to *Petalonia*
Form/Function ….....…….....	• Macrothallus consists of clustered erect unbranched tubes that arise from a discoid holdfast and typically become crimped like a chain of sausages when mature. • Parenchymatous in structure with small cells making up the outer cortex. • Thalli have diffuse growth and frequently reach up to 20 inches or more in height
Reproduction….....	• Biphasic heteromorphic life history that can cycle sexually (in Japan and Australia) or asexually (in California and Europe). • The tube-like macrothallus is a facultative gametophyte that bears plurilocular structures in a dark brown sorus that covers most of the tube surface. At maturity, motile cells are released that act either as gametes or zoospores, recycling either phase of the life

	history. • In this species, clear swollen paraphyses (sterile cells) occur scattered in the sorus, appearing under the microscope like clear dots on a brown lawn. • The microthallus is a small crustose facultative sporophyte that bears unilocular sporangia.
Noteworthy Facts….....	• The life history is similar to *Petalonia* in being influenced by day length and temperature.
Congeneric Species……	• 4 species of *Scytosiphon* occur in SC Alaska

5. **Studded Sea Balloon,** *Soranthera ulvoidea*





Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Ectocarpales
Family Chordariaceae *s.l.*
Genus and Species *Soranthera ulvoidea*

Species Occurrence….....	• Alaska to Mexico, Japan, Eastern Russia; f. *difformis* is only reported from Alaska • Mid-intertidal, often abundant in tidepools • Epiphytic on *Odonthalia* and *Neorhodomela* • Summer annual
Form/Function…..……....	• The macrothallus is a globose to irregular membranous sack that attaches to its host by a penetrating base. Initially solid, the sacks become hollow and inflated at maturity, sometimes reaching 2 inches or more in height and 1 inch in width. • Thallus shape varies with the host. On *Odonthalia floccose* the sacks are ovoid to bi-lobed. On species of *Neorhodomela*, the sacks range from spherical to multiply lobed, prostrate and sponge like (see above). These irregular forms are sometimes referred to as f. *difformis.* • The thalli are parenchymatous in structure and have a surface meristem. The sack walls are 5 or 6 cells thick with the cells

	progressively smaller toward the outside. • Pale brown to yellow-brown in color
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is a sporophyte • Small, dark, slightly elevated, dot-like sori form evenly scattered over the surface of the sack. Within each 0.04 inch (1 mm) wide sorus, ovoid to club-shaped unilocular sporangia develop that are interspersed with multicellular hairs that protect the sporangia as they develop. At maturity, biflagellate zoospores are released into the water that germinate to form the microthallus • The microthalli are small branched prostrate filaments that form uniseriate (1-cell thick) plurilocular structures. These release biflagellate zoospores that germinate into either additional microthalli or the globose macrothallus. • Sexual fusion has not been documented.
Noteworthy Facts….....	• The National Cancer Institute has reported that extracts of *Soranthera* are active against some kinds of cancer.
Congeneric Species……	• One species is currently recognized. Two forms have also been recognized (f. *ulvoidea* and f. *difformis*). Recent studies have shown that these forms are not molecularly distinct.

6. Acid Weed, *Desmarestia ligulata*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Desmarestiales
Family Desmarestiaceae
Genus and Species *Desmarestia ligulata*

Species Occurrence….....	• Widespread,:Aleutian Islands, Alaska to Mexico, Japan, E. Russia, Hawaii, Australia and New Zealand, Antarctica, NE Atlantic. • Low intertidal to subtidal on rock. • Moderately sheltered to exposed locales. • Annual or perennial depending on the area.
Form/Function……	• Macrothalli leaf-like with one or more branched lanceolate to ribbon-shaped blades arising from a short stipe and a conical to lobed holdfast. • Often 3-5 feet tall with a 0.5 – 1 inch blade diameter – rarely reaching 30 feet in length and 36 inches in blade diameter. • Thalli are uniaxial and the blades all have a faint central vein with opposite lateral veins that extend out to a fringed, toothed or sometimes smooth blade margin. • Lateral branches originate from the blade margins at the tips of the lateral veins. Branches are lanceolate, tapering at both ends. Branching is to 4 orders. • Growth occurs primarily on the blade margins at the base of the fringing **deciduous** hairs. Behind this meristem, branching filaments develop that from the main and

	lateral axes (the veins), giving the leaf-like appearance to the thallus.
Reproduction….....	• Biphasic, heteromorphic life history. • The macrothallus is the sporophyte. • Unilocular sporangia form scattered over the thallus surface often in small patches. • The microthallus is a microscopic filamentous gametophyte similar to those in the kelps – dioecious and oogamous. • **Desmarestene** is a specialized pheromone released by the egg to attract the sperm in this genus.
Noteworthy Facts….....	• Sulfuric acid forms in the vacuoles of *D. ligulata* causing them to have a pH down to 0.8 – very acidic indeed. When the thalli die, acid leaches out of their vacuoles killing everything in contact with them – often leaving white bleached-out imprints on the rocks and algae beneath them. • Other acidic species in this genus include *D. viridis*, a species with narrow nearly terete opposite branches. This species is even more acidic than *D. ligulata*.
Congeneric Species..……..	• 4 species of *Desmarestia* are recognized in Alaska

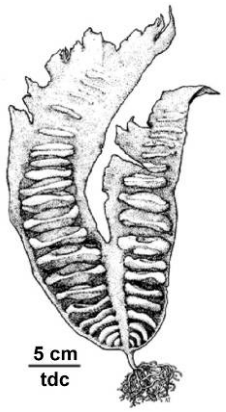
7. **Sugar Kelp,** *Saccharina latissima*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Laminariaceae
Genus and Species *Saccharina latissima*

Species Occurrence….....	• Widespread – Arctic and Subarctic Seas; Aleutian Islands, Alaska to Santa Catalina Island, California; Japan; Russia; North Atlantic; North Sea • Low intertidal and shallow subtidal on rocks • Prefers sheltered or semi-sheltered areas • Pseudoperennial with the stipe and holdfast living for up to 4 years.
Form/Function…..……....	• Macrothalli with large relatively thin strap-shaped blades, unbranched stipes, and finely branched holdfasts – up to 7 feet long. • The blades are **entire** (whole) or rarely torn into segments and have surfaces that are smooth or with 2 longitudinal rows of **bullae** (a characteristic rumpling) running parallel to the margins. • Stipes are terete (round) to compressed in cross section and lack **mucilage ducts** • As in most kelps, growth occurs in an intercalary surface meristem located at the top of the stipe and the base of the blade. • Medium brown in color
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte, bearing unilocular sporangia in large soral patches on the blade surfaces

	• The microthalli are microscopic filamentous gametophytes–dioecious and oogamous.
Noteworthy Facts….....	• Species of both *Saccharina* and *Laminaria* are referred to as *Kombu* in Japan. • Eaten in Asia and elsewhere; high in vitamins, calcium and iodine. • Frequently found fouling the hulls of ships; thought to have been introduced around the world by shipping. • Tolerates cold temperatures, surviving winter under the ice in the Beaufort Sea.
Congeneric Species……	• DNA analysis has recently shown that many species in the Laminariaceae should be placed in the resurrected genus *Saccharina*. • 18 species in the genus worldwide, 4 species known in the NE Pacific. • Synonym: *Laminaria saccharina*

8. Split Blade Kelp, *Saccharina subsimplex*



Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Laminariaceae
Genus and Species *Saccharina subsimplex*

Species Occurrence….....	• Aleutian Islands, Alaska to central California, Bering Sea and E. Russia • Low intertidal and subtidal. • On rock in exposed to semi-exposed shores • Pseudoperennial, regenerating new blades each year from the stipe
Form/Function…..……....	• Macrothallus consists of a thick oval to linear blade that is often torn into segments, a terete to compressed stipe, and a coarsely branched holdfast. • Blades can be smooth or have 2 longitudinal rows of bullae. • Stipes vary from 1-25 inches in length, and are typically longer in more exposed habitats. • A ring of mucilage ducts occurs just beneath the stipe surface. • Thalli reach 6 feet or more in length and grow via a typical intercalary kelp meristem. • Color brown to almost black
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte. • Unilocular sporangia develop in soral patches on the blade surfaces during fall and winter • The microthalli are microscopic filamentous gametophytes–dioecious and oogamous.
Noteworthy Facts….....	• *S. subsimplex* has thicker blades and more coarsely branched holdfasts than *S. latissima*, a species with which it is often confused.
Congeneric Species……	• 18 species in the genus *Saccharina*. • Synonyms: *Laminaria groenlandica* in the

	Pacific, *Laminaria bongardhiana*

9. **Tangle,** *Laminaria setchellii*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Laminariaceae
Genus and Species *Laminaria setchellii*

Species Occurrence….....	• Yakutat, Alaska, to Baja California, Mexico; possibly some plants on the Kenai Peninsula • Low intertidal to upper subtidal • On rocks in exposed, wave-swept areas often forming large beds • Pseudoperennial, with blades dropping off in the fall and early winter and stipes beginning regrowth of the blade within a few weeks.
Form/Function…..……..... ...	• Macrothallus consists of a smooth, flexible oval to deeply split blade born on a stiff terete stipe with a coarsely branched holdfast. Blades are at times multiply dissected into many uniform segments. • Stipes reach ½ to 1 inch in diameter and up to 3 feet in height. Blades reach a similar length and can be seen hanging limply down from the stipes at low tide. • Mucilage ducts are present in the stipe, occurring as a ring deep in the cortex, inside the annual cortical rings that occur toward the surface in older plants. • A thickened collar is often visible at the top of the stipe, showing the contrasting ages of the stipe and blade. • A typical kelp intercalary meristem is present. • Dark brown in color
Reproduction….....	• Biphasic, heteromorphic life history

..	• The macrothallus is the sporophyte • Unilocular sporangia develop in irregular linear sori on the split parts of the blade during the early spring. • The microthalli are microscopic filamentous gametophytes–dioecious and oogamous.
Noteworthy Facts….....	• *Saccharina dentigera,* a similar smooth split-blade species, occurs in high surf areas from Yakutat through the Aleutians and E. Russia. This species gets much larger and thicker, and the blade is more shallowly split. In addition, the stipe bears mucilage ducts in a different location, just under the surface as in *Saccharina subsimplex.* • The blade of *Laminaria setchellii* is edible and is used as a Kombu in soups and stews.
	• 7 species of *Laminaria* are still recognized in the NE Pacific

10. Three-Ribbed Kelp, *Cymathaere triplicata*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Laminariaceae
Genus and Species *Cymathaere triplicata*

Species Occurrence….....	• Attu Island, Aleutian Islands, Alaska to Neah Bay, Washington; Bering Sea, E. Russia • Low intertidal to upper subtidal • On rock in exposed and sheltered regions. • Spring-summer annual, disappearing by July
Form/Function ….....…….....	• Macrothallus consists of a long ribbon shaped blade with 3 closely spaced folds or runnels running longitudinally down the center, a short stipe, and a discoid to slightly lobed holdfast. . • The blades can reach 13 feet in length and 8 inches in width with the stipes only 10 inches tall. • Blades are initially thin and flexible with shallow runnels, but mature specimens become leathery and the central runnels deepen to nearly 1 inch in height. • Light yellow brown to red brown in color.
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte. • Unilocular sporangia develop during the summer in a single large dark brown sorus located at the base of the blade.

	• The microthalli are microscopic filamentous gametophytes – dioecious and oogamous.
Noteworthy Facts….....	• The thalli often form in small clusters on boulders or cobble • The cucumber-like smell given off by this algae can be detected from some distance away; this smell is unmistakable if one tears open a blade and sniffs the center folds
Congeneric Species……	• 2 species in the genus, 1 in the NE Pacific

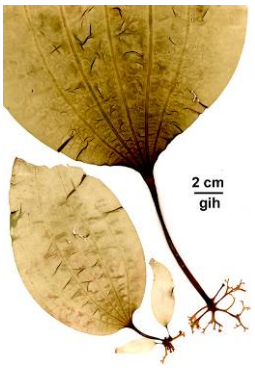
11. **Bull Kelp,** *Nereocystis luetkeana*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Laminariaceae
Genus and Species *Nereocystis luetkeana*

Species Occurrence….....	• Aleutian Islands (Umnak I) to San Luis Obispo County, California • Subtidal, forming extensive offshore floating kelp beds • On rock and cobble in exposed areas • Annual, but sometimes over-wintering to a 2nd year. 2nd year plants often bear epiphytes.
Form/Function…..…….....	• Macrothallus consists of a highly branched conical holdfast, a long cylindrical mostly hollow stipe that gradually increases in size to a large spherical terminal float that bears 2 terminal tufts, each of up to 50 long narrow flattened blades. • The entire thallus has been reported to reach 125 feet in length, but more often the stipe reaches only 30 feet with the blades about 15 feet long and 6 inches wide. • Floats are 4-6 inches across and were nicknamed “orange heads” by the early explorers. They contain primarily air, but studies have shown that up to 10% of this is carbon monoxide, a toxic gas that may act as

	a feeding deterrent to herbivores. • Tiny young thalli consist of a simple undivided blade, stipe and holdfast. During development, the float forms and the initial blade splits in 2 vertically. Each half then repeatedly splits vertically until the large blade tufts are created. • With a typical kelp intercalary meristem, the blades grow at their bases and erode away at their tips. The stipes grow and elongate below the float until it reaches the surface. In optimal growing conditions, stipes grow as fast as 6 inches a day. • Yellow-brown in color
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte • Unilocular sporangia develop on the blades in a linear row of large rectangular sori of sequential age (with the oldest near the top). Sori are present during the summer and fall. • When a sorus becomes mature, the whole soral patch is released from the blade into the water to float with the currents along the bottom releasing zoospores – a feature that helps to increase its dispersal area. • The microthalli are microscopic filamentous gametophytes; dioecious and oogamous
Noteworthy Facts….....	• The huge subtidal beds shelter many fish and invertebrates and help to buffer the shoreline from erosion. However, the thalli are seasonal, ripping loose and dying in the fall and winter. New young thalli are often not seen at the surface again until May. • A popular edible. The stipes are boiled and made into pickles, and the blades are dried, fried and eaten like potato chips. • Native Americans used the stipes for fishing line by stretching them out until they were only a few mm in diameter. The trick to fine line is apparently repeated freshwater soaking, stretching, twisting and drying. • The stipes and floats are also used to make bull kelp horns and rattles.
Congeneric Species……	• Only 1 species in the genus *Nereocystis*

12. Five-Ribbed Kelp/Seersucker, *Costaria costata*

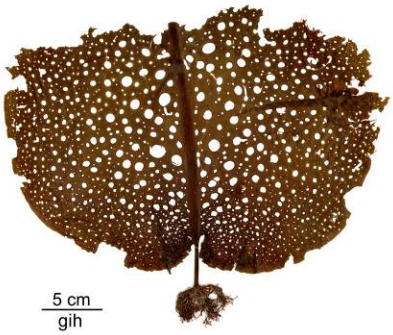


Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Costariaceae
Genus and Species *Costaria costata*

Species Occurrence ….....	• Unalaska Island, Alaska, to Channel Islands, California, N. Japan, E. Russia • Lower intertidal to subtidal • On rock in sheltered to exposed habitats • A spring-summer annual
Form/Function ….....….....	• Macrothallus consists of a coarsely branched wide-spreading holdfast, a short stipe, and a broadly oval to ribbon shaped blade that bears 5 parallel longitudinal ribs (3 on one side of the blade and 2 on the other) with bullations between the ribs. • Thalli range from 4 to 10 feet in height. SE Alaskan thalli typically have blades 6.5 feet long and stipes 2 feet tall. • Blade width is variable, with quiet water forms reaching 15 inches or greater and wave swept forms much narrower and ribbon-like. • Stipes are terete to compressed near the blade and finely ribbed • Thalli possess a typical intercalary kelp meristem with the top of the blade eroding away with age.
Reproduction ….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte.

	• Unilocular sporangia form in soral patches irregularly distributed over the lower blade throughout the summer. Blades are tattered by August. • The microthalli are microscopic filamentous gametophytes, dioecious and oogamous.
Noteworthy Facts ….....	• Edible to sea urchins. • Damaged by heat and overexposure to sun.
Congeneric Species……	• Only 1 species in the genus

13. **Shotgun Kelp,** *Agarum clathratum*



Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Costariaceae
Genus and Species *Agarum clathratum*

Species Occurrence….....	• Alaska to N. Washington, Bering Sea, E. Russia, Japan, Arctic, W. Atlantic & Greenland to Massachusetts • Upper subtidal to –100 ft, rarely low intertidal • On rocks in sheltered and exposed areas • Perennial up to 6 years
Form/Function…..…….....	• Macrothallus consisting of a small finely branched holdfast, a narrow stipe, and a large oval to basally heart-shaped blade that is filled with holes except for a midrib-like **fascia** or flattened area that extends up the center of the blade. • The blades reach 3-6 feet in length and 1-2 feet in breath. They are perforated with small and large holes (up to 0.8 inches in diameter) that decrease in size toward the margins and are absent from the central fascia. The margins are undulate or wavy, and the texture is leathery but thin, tearing easily. • The stipe is terete to flattened near the blade, <1/4 inch wide and up to 10 inches long.

	• A typical intercalary kelp meristem occurs. • Brown to black in color
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte • Unilocular sporangia develop in irregular dark sori near the base of the blade. • The microthalli are microscopic filamentous gametophytes; dioecious and oogamous.
Noteworthy Facts….....	• A high polyphenolic content makes this species inedible to herbivores. Often it is the only seaweed surviving in urchin barren-grounds • Forms extensive underwater beds in some areas and is reported to be a nursery ground for spot prawns that inhabit the area after settling out of the plankton.
Congeneric Species……	• 3 species are in *Agarum*. 2 occur in Alaska

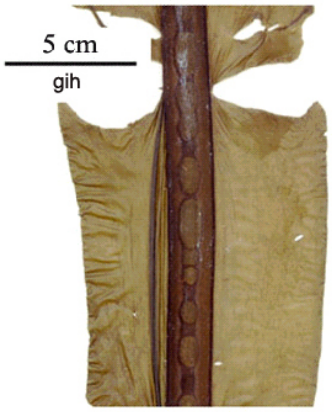
14. Ribbon Kelp (winged kelp), *Alaria spp*.

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Alariaceae
Genus *Alaria*

Genus Occurrence….....	• Circuboreal in north temperate and boreal regions in the N. Atlantic, N. Pacific, and Canadian Arctic. • Low intertidal to upper subtidal • On rocks in exposed or moderately exposed areas • Both annual and perennial species occur
Form/Function…..……....	• Macrothallus consists of a long ribbon-shaped vegetative blade with a prominent raised central **midrib**, a terete to compressed stipe bearing 2 lateral rows of **sporophylls** (reproductive spore-bearing blades) near its top, and a finely branched holdfast. • Thalli in different species range in size from 6 inches to 50 feet in length and 1-36 inches in width. • Some species bear scattered hairpits on the blade surface, but their occurrence appears to be environmentally regulated • Sporophylls begin to develop at the top of the stipe while the plant is still young. Since the stipe grows apically, the oldest sporophylls are those closest to the holdfast. At maturity,

	each sporophyll bears a single dark sorus of unilocular sporangia. • After zoospore release, the old sporophylls drop off leaving scars along the stipe. • In perennial species, both the blade and sporophylls drop off in the winter and the stipe continues to grow producing a new blade and sporophylls the following spring. • Dark brown to dark tan in color
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte • Unilocular sporangia develop in specialized sporophylls, but in rare cases, they have been seen in sori on the vegetative blade. • The microthalli are microscopic filamentous gametophytes, dioecious and oogamous.
Noteworthy Facts….....	• Several species of *Alaria* are popular edibles. The midribs and blade are harvested and eaten fresh in salads, boiled in soups, or rolled around rice and steamed in an egg roll like dish.
Congeneric Species..…….	• About 8 species of *Alaria* occur in Alaska, but the taxonomy is still in flux. Some species are thought to interbreed with one another. • 17 species reported worldwide.

15. **Dragon Kelp,** *Druehlia fistulosa*



Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Alariaceae
Genus and Species *Druehlia fistulosa*

Species Occurrence….....	• Aleutian Islands, Alaska, to northern British Columbia, Japan, E. Russia • Forms large subtidal floating kelp beds • On bedrock and boulders • Annual (Brenda Konar, UAF, personal communication).
Form/Function…..……....	• Macrothallus consists of a *Alaria*-type thallus with a long ribbon-shaped blade with a central midrib, a stipe, sporophylls, and coarsely branched holdfast. However, this species differs. • The midrib reaches about 1-2 inches in diameter and is filled with a longitudinal series of blister-like air chambers (the fistula) that enable the blade to float • In size, this species can get very large – some thalli reach 80 feet in length and 7.5 feet in width. More often they are shorter and narrower–about 33 feet in length and 1-2 feet in width. • Thalli have a typical kelp meristem with

	growth occurring at the base of the blade and the top of the stipe. Since blades are annual and shed each year, they reach their huge size in a single growing season. • Thalli are dark brown to light brown in color.
Reproduction ….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte • Elongate sporophylls occur abundantly on either side of the **rachis** (the top of the stipe). Up to 220 have been recorded/thallus. The sporophylls can reach 2 feet in length and 3.3 inches in width • Unilocular sporangia develop in soral patches that almost entirely cover the sporophylls except for a narrow sterile margin. • Sporangia are present most of the growing season and when the spores are shed, the sporophylls drop off, leaving characteristic scars on the stipe. • The microscopic filamentous gametophytes are dioecious and oogamous as they are in *Alaria* species.
Noteworthy Facts ….....	• Forms huge canopy-forming floating kelp beds in Alaska. They shelter a wide variety of fish and invertebrates in the summer and fall when the blades are present.
Congeneric Species..……	• Recent molecular studies have demonstrated that dragon kelp is a new genus separate from *Alaria*, a similar genus

16. Sea Spatula, *Pleurophycus gardneri*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Alariaceae
Genus and Species *Pleurophycus gardneri*

Species Occurrence….....	• Alaska to central California • Low intertidal and subtidal on rock, • Pseudoperennial. The stipe and holdfast survive for 3+ years, but the blade is deciduous, dropping off the stipe in late fall just before the new growth is initiated.
Form/Function…..……....	• Macrothallus consisting of a holdfast, stipe, and simple lanceolate to ribbon-shaped blade with a broad central midrib. The wings of the blade are rubbery in texture with delicate wrinkling adjacent to the midrib. • Blades reach 5 feet in length and 16 inches or more in width with the midrib from 1-2 inches broad. • Stipes are up to 2 feet long, terete near the base and flattened near the blade. • Holdfasts reach 4 inches in diameter and consist of whorls of rigid haptera • Dark olive green to brown in color
Reproduction….....	• Biphasic, heteromorphic life history. • The macrothallus is the sporophyte. • Unilocular sporangia develop in irregular

	soral patches on the young blades starting in March. • The microthallus is a tiny branched filamentous gametophyte that is dioecious and oogamous
Noteworthy Facts….....	• Though generally believed to be rare in California, this species has been found growing in large numbers below the giant kelp forests in water 100 – 150 feet deep
Congeneric Species……	• Only 1 species in the genus

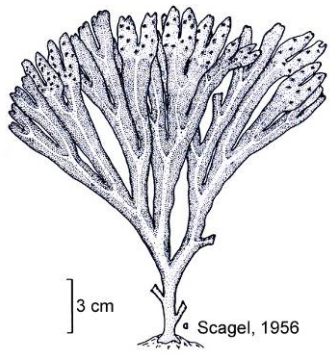
17. **Walking Kelp,** *Pterygophora californica*

Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Laminariales
Family Alariaceae
Genus and Species *Pterygophora californica*

Species Occurrence….....	• Cook Inlet, Alaska, to Baja California • Shallow subtidal • On bedrock, cobble or other kelp • Pseudoperennial often to 12+ years. The perennial stipe over-winters to produce new terminal and lateral blades annually.
Form/Function…..……....	• Macrothallus consists of 1 terminal and 10-20 lateral strap-shaped blades born at the top of a 5-foot-long rigid walking-stick-like stipe attached to the substratum by a coarsely branched holdfast. • The terminal blade reaches 32 inches in length and 4 inches in width. It bears a faint midrib-like central thickening and remains sterile. The lateral blades grow to a similar length and become sporophylls. • The entire plant may reach 7.5 feet in height with the major growth occurring at the top of the stipe and the base of the blades.

	• All blades are deciduous, shed after spore release during the winter
Reproduction….....	• Biphasic, heteromorphic life history • The macrothallus is the sporophyte • Unilocular sporangia form in dark soral patches on both sides of the sporophylls and occasionally on the main blade in late fall • Zoospores lack eyespots like all kelps • The microthallus is a microscopic filamentous gametophyte that is dioecious and oogamous.
Noteworthy Facts….....	• Acts as an understory kelp in most areas. • Stipes have cortical growth rings suggestive of the **annual rings** in trees. These have been used to estimate a thallus age of up to 25 years in some individuals.
Congeneric Species..……..	• 1 species in the genus

18. **Rockweed,** *Fucus gardneri*



Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Fucales
Family Fucaeae
Genus and Species *Fucus gardneri*

Species Occurrence….....	• Bering Sea and Aleutian Islands to central California; Chuckchi Sea; Kamchatka • High to mid intertidal • Perennial
Form/Function…..……..... ..	• One or more thick dichotomously branched ribbon-shaped thalli with prominent central midribs arise from a discoid holdfast. The branch tips may be broadly rounded or acute. The lateral wings of the blades are generally smooth but often erode away near their bases. Tiny, often microscopic, hair pits are scattered over the blade surface. When the thalli are mature, the branch tips transform into reproductive **receptacles** that are swollen, bumpy, and filled with mucilage. • Thallus size varies with habitat. Blades reach from <1 to >20 inches in length with branches from <0.1 to >2 inches in diameter. Outer coast plants are typically 4-10 inches tall and ½ inch in diameter. • Dark brown to olive or yellow brown
Reproduction…..... .	• Uniphasic, monoecious and hermaphroditic • Swollen apical receptacles are dotted with **conceptacles**, tiny embedded flask-shaped structures that each bears both male and female gametangia.

	• Each conceptacle bears many gametangia. The oogonia bear 8 non-motile eggs, and the antheridia 64 motile sperm. During flooding tides, both are released outside of the conceptacle in a mucilaginous mass. The eggs release a sexual pheromone called **fucoserratin** that attracts the sperm so that fertilization can occur.
Noteworthy Facts….....	• Can withstand freezing and desiccation • Polyphenols in the tissues make this plant undesirable to most herbivores. • A common substrate for herring eggs, this species is often harvested during the Herring-Roe-On-Seaweed open season. • Rich in vitamin C, rockweed is sometimes dried, pulverized and made into tea.
	• Only 2 species of *Fucus*, *F. gardneri* and *F. spiralis*, are known to occur in Alaska.. • The dwarf estuarine species, incorrectly called *Fucus cottonii* in the Pacific, is now known to be a form of *Fucus gardneri.* • 16 species currently recognized worldwide. • The true name of *Fucus gardneri* is under investigation as this species may be identical to 2 other north temperate *Fucus* species.

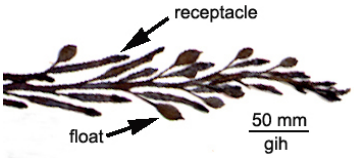
19. Northern Bladder Chain Kelp, *Cystoseira geminata*

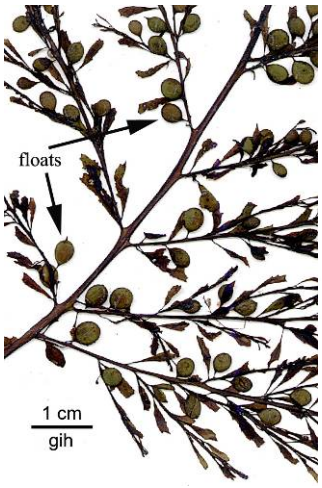
Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Fucales
Family Sargassaceae
Genus and Species *Cystoseira geminata*

Species Occurrence….....	• Aleutian Islands, Alaska, to Whidbey I., Washington, Bering Sea, Japan • Low intertidal to upper subtidal • On rocks in semi-exposed areas, often in tidepools. • Pseudoperennial. Short perennial primary axis with long deciduous erect shoots.
Form/Function…..……....	• Thallus with a discoid holdfast and short stout perennial primary axis (1-2 inches long) that initially produces several ephemeral blades basally. Then, near the apex, it produces a tight spiral of deciduous secondary axes. These bolt upward developing into long **monopodial** axes, each covered with densely branched laterals. The laterals typically bear leaf-like branches basally and highly branched spine-like branches toward their tops. The spine-like branches develop subterminal floats and, when mature, also subterminal reproductive receptacles

	• The floats are **ovoid** and occur singly or in short spaced-out chains. The apical float often appears pointed due to the protrusion of the branch apex. Floats are 1/16-1/8 inch in diameter. • Thalli reach 3-15 feet in length • Dark brown to yellow brown
Reproduction….....	• Uniphasic life history, dioecious • The narrow warty reproductive receptacles develop in intercalary locations on the spine-like branches during the summer. Each is composed of whirls of embedded flask-shaped conceptacles surrounding the axis, each containing gametangia. • Only female gametangia have been observed. The oogonia bear single eggs that are released outside of the conceptacle on mucilaginous stalks to await fertilization. • In the fall, after gamete release, the secondary axes drop off, leaving scars on the primary axis.
Noteworthy Facts….....	• Easily confused with *Sargassum muticum*, a nuisance species introduced to the west coast in the 1930's that has spread north to SE Alaska and south to Mexico. This species is differentiated from *Cystoseira* by having floats that are always singular and terminal on the axes (without terminal spines).
Congeneric Species……	• 1 species in the genus in Alaska, 4 species in the NE Pacific. • 44 species are recognized worldwide • The Seaweeds of Alaska website indicates that *C. geminate = C. spicigera,* an earlier name, but they have not used the new name.

20. **Wireweed,** *Sargassum muticum*





Kingdom Chromista
Phylum **Ochrophyta**
Class Phaeophyceae
Order Fucales
Family Sargassaceae
Genus and Species *Sargassum muticum*

Species Occurrence….....	• Native in Japan, China, Korea, and SE Russia. • Introduced along the American west coast and in Europe. Currently, it's northern limit along our coast is SE Alaska. • Low intertidal to upper subtidal • On rocks in quiet and semi-exposed areas. • Pseudoperennial. Short perennial primary axis with long deciduous secondary shoots. Annual in some areas.
Form/Function…..……....	• Thallus with a discoid holdfast and 1 to several short primary axes that bear ephemeral blades basally and erect deciduous secondary axes apically. In season, these shoot upward to form long monopodial axes reaching 15 feet or more in height – each bears a series of alternate lateral branches that are densely covered by small branchlets, blades, air-filled floats, and eventually receptacles.

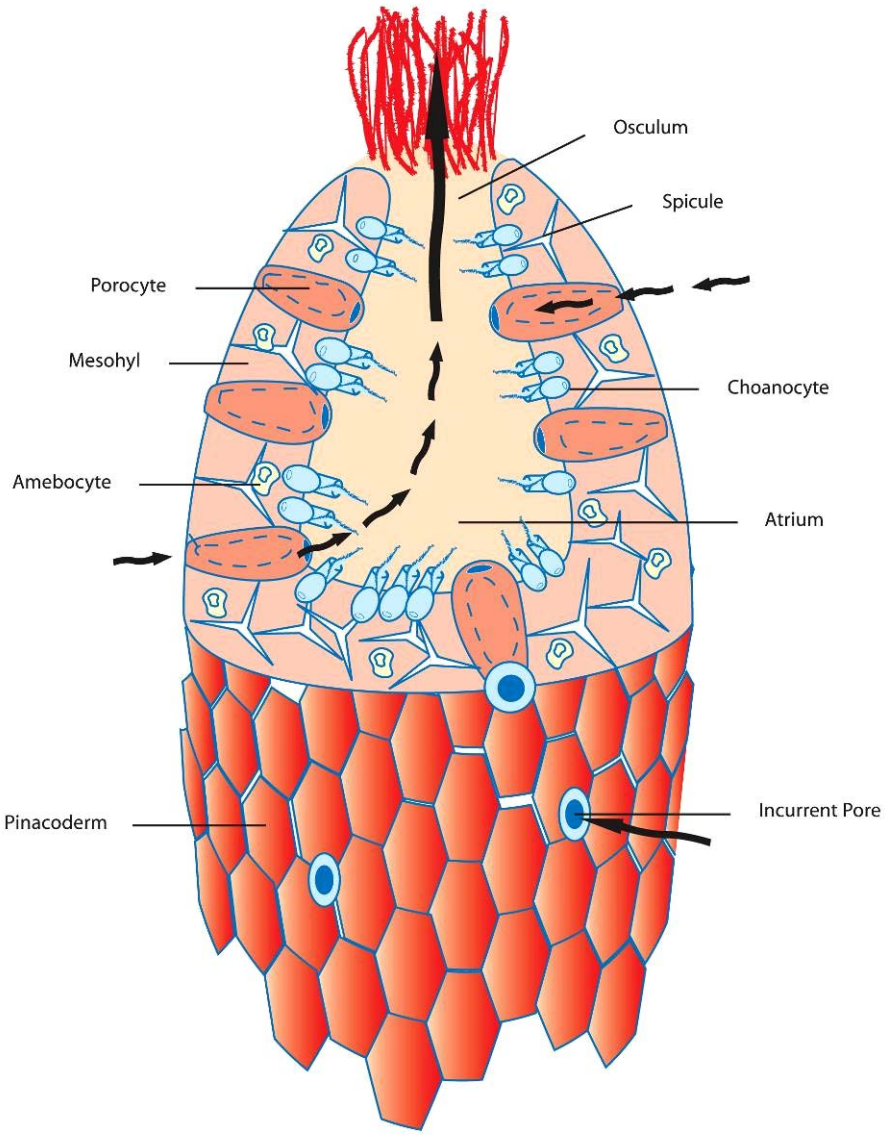
	• Floats occur singly or in clusters on the secondary axes and aid in buoyancy. They develop on small branchlets that form in the leaf and branch axils. Initially subterminal, they soon expand to fill and terminate the branchlet tips, becoming globose in shape and about 1/10 inch in diameter. • Dark brown to yellow brown
Reproduction….....	• Uniphasic, monoecious and **androgynous** • Terete, club-shaped receptacles develop in the axils of the blades and floats during the summer. Each is composed of embedded whorls of male and female flask-shaped conceptacles that surround the axis. • Female conceptacles contain oogonia, each with a single egg. On release, the eggs remain at the conceptacle mouth tethered by mucilaginous threads to the oogonium. Here they remain until fertilization and embryo development occurs. • Male conceptacles release antherozooids (sperm) explosively in a mucilaginous slurry. These fertilize the eggs that begin to develop while still on the parent plant. • Young embryos then drop to the sea floor to attach and further develop • In the fall, the long erect secondary axes drop off the parent plant, leaving scars on the primary axis. • The detached secondary axes drift passively with the currents continuing to drop embryos. Increasing the dispersal range of the progeny.
Noteworthy Facts….....	• An aggressive invader. Introduced from Japan to Washington on cultured oysters before 1944. This species now has spread north to SE Alaska and south to Mexico in western North America. In Europe, it was found in England in 1973 and has spread north to Norway and south to Spain and Italy. • Sometimes confused with *Cystoseira geminata*, a native species with spine-like terminal branches that frequently bears its floats in spaced out chains.
Congeneric Species……	• Usually a tropical genus. Only 1 species in the genus in Alaska; 3 species are reported to

	occur in California

VIII. Sponges : Kingdom Animalia, Phylum Porifera

Members of the phylum Porifera, the sponges, are aquatic, primarily marine organisms that possess pores (the name Porifera means pore-bearing). The group consists of approximately 9000 species. Depending upon species, sponge sizes range from 0.5 – 80 inches tall and colors may be dull tones of gray or white to striking greens, reds, oranges, purples, yellows, or blues. Shapes can be assymetrical to spherical, cup, fan, or vase shaped. The following is a summary of other important sponge characteristics:

- most primitive multicellular animals
- cells do not form true tissues or organs
- are sessile (nonmotile, affixed to substrate)
- body architecture displays no definite symmetry
- skeleton composed of many, many small spines called **spicules**
    - living sponge cells surround spicules
- no true body cavity, although canals and other fluid-filled spaces are present
- reproduce sexually or asexually; many **hermaphroditic** (i.e., individual produces both sperm and eggs) examples
- suspension feeders
- planktonic larval stage
- no nervous or musculoskeletal (i.e., muscles attached to skeleton) system
- some sponges reproduce asexually by forming buds that are released into the water



VIII.1. Generalized Simple Sponge (note labeled features; arrows indicate flow of water pumped through the animal for respiratory and filter feeding purposes)

Sponges Featured at the Alaska SeaLife Center

1. Breadcrumb Sponge/Gunpowder Sponge, *Halichondria panicea*

Kingdom **Animalia**
Phylum **Porifera**
Class Desmospongiae
Family Halichondridae
Genus *Halichondria*

Occurrence ….....	• Arctic to Cape Cod; Bering Sea to southern California • low tide line to waters over 200 feet deep
Form/Function …..…….....	• greenish to yellowish encrusting sponge • shape irregular to globular surface rough • firm texture • incurrent pore openings small and numerous • large excurrent openings large and few • a few green specimens have symbiotic zoochlorellae (photosynthetic, symbiotic algae) living in their tissues; these provide additional nutrients
Reproduction ….....	• asexual bud formation
Noteworthy Facts ….....	• name reflects irregular shape of the encrusting colony • though often occurring affixed to stones, this species can also foul pilings and floating docks

2. **Hermit Crab Sponge,** *Suberites suberea*

Kingdom **Animalia**
Phylum **Porifera**
Class Desmospongiae
Order Hadromerida
Family Suberitidae
Genus *Suberites*

Occurrence ….....	• Bering Sea to southern California; North Atlantic • intertidal to 115 feet deep
Form/Function ….....	• living sponge is bright orange • form is massive to sub-hemispherical • 1.5 to 4 inch diameter • consistency is firm to slightly compressible • surface is smooth with many depressions of variable size
Reproduction ….....	• asexual bud formation
Predators/Prey ……..	• preyed upon by the nudibranch *Archidoris montereyensis*
Noteworthy Facts	• often live affixed to gastropod shells utilized by a hermit crab

3. **Yellow Boring Sponge,** *Cliona celata*

Kingdom **Animalia**
Phylum **Porifera**
Class Desmospongiae
Order Hadromerida
Family Clionidae
Genus *Cliona*

Occurrence	• Alaska to Mexico • intertidal to 65 feet deep
Form/Function .....….....	• living sponge is bright yellow • lacks definite shape and size • minute excurrent openings • smooth, irregular surface is covered by rounded **papillae** whose bases are surrounded by a conspicuous groove • excavates tunnels in material made of calcium carbonate (such as shells of living or dead snails, clams, barnacles, scallops, etc.)
Reproduction	• asexual bud formation
Noteworthy Facts	• often found growing on scallop shells, which are gradually worn away by this sponge; slows growth of organism into which it bores and may ultimately kill that organism • a problem species in eastern North American oyster beds

IX. Jellyfish, Sea Anemones, Corals, and Hydroids : Kingdom Animalia, Phylum Cnidaria

The Cnidarians are most familiar to us as jellyfish, sea anemones, true corals, and Portugese man-of-war. Other examples include the sea fans, sea whips, and precious corals. In this chapter we present the general characteristics of the Phylum Cnidaria, the features of the Classes within this Phylum, and descriptions of the Cnidarian species maintained at the Alaska SeaLife Center.

Phylum Cnidaria

- more than 9000 species
- polyps are radially symmetrical
- two basic forms

Polyp: a cylindrical structure, with one end affixed to the substrate and the other, bearing the mouth and tentacles, facing upward; reproduction is through asexual budding in this stage

Medusa: bell-shaped, with tentacles hanging from the bell margin, the convex side facing upward and the concave side having the mouth located at its center; reproduction is sexual (sperm and egg produced) in this stage

Fig. IX. 1. Lion's mane jellyfish, *Cyanea capillata*, a species common to the waters of Alaska's Resurrection Bay; note trailing tentacles beneath bell

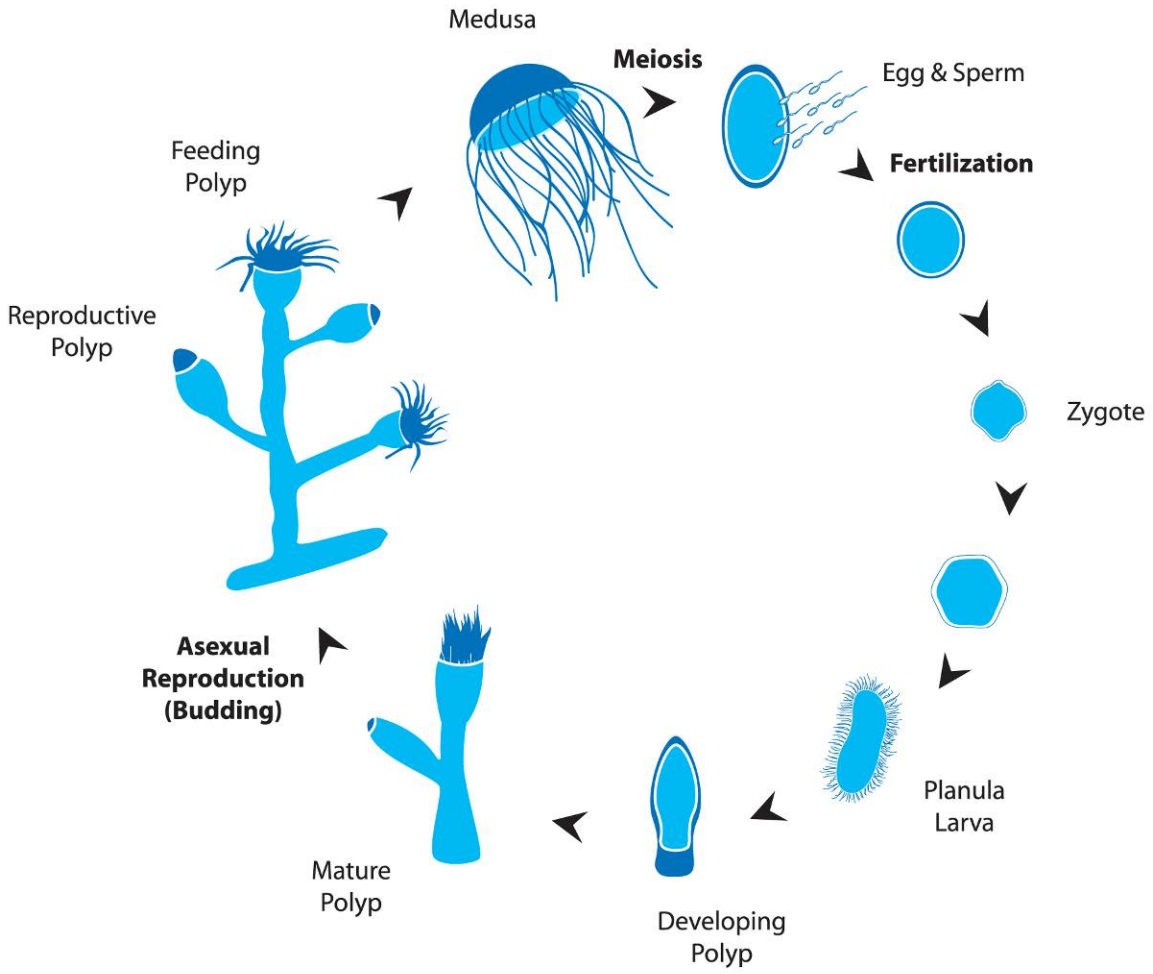


Fig. IX. 2. Life stages of a hydroid

- movement made possible by development of primitive muscles possess an internal digestive space (called a **gastrovascular cavity**); lies along animal's polar axis and opens as a mouth to the outside
- presence of mouth enables cnidarians to consume a much wider range of food sizes than is possible for protists and sponges
- food is captured with **tentacles**; **cnidocytes**, specialized cells with adhesive and/or stinging abilities, function to immobilize prey; most common cnidocytes are called **nematocysts**
- have limited organ development and hence are more primitive animals
- nervous system arranged as a net (no central nervous system; hence, no brain)
- all species are predatory, feeding either on zooplankton or larger animals

- with the exception of a few freshwater species, cnidarians are exclusively marine

- Class **Anthozoa**: Sea Anemones and Corals
    - with over 6000 species, the largest cnidarian class
    - occur as individuals (e.g., sea anemone) or as colonies (e.g., corals)
    - possess nematocysts (cells that eject poison microscopic poison darts into prey)
    - mouth leads to a "throat" (pharynx) which extends more than half way into the gastrovascular cavity

    - **Sea Anemones**
        - average size is about 2/3" to 2" high, with a diameter from the size of a dime to a half dollar
        - occur throughout world in coastal waters
        - live attached to rocks, shells, and other submerged debris but some extend into sand or mud
        - some species are commensals on other animals
            - for example, through attachment to the shells of hermit crabs
        - several species burrow in sand or mud
        - a few species can detach from the substrate and use undulatory movements or lashing of their tentacles, which enable them to be carried by water currents to another location
            - this is probably a defense mechanism since some of these anemones are preyed upon by a number of species, including nudibranchs and sea stars
        - most of body is a heavy column
        - mouth, located at the center of the **oral disc**, end can bear from eight to several hundred tentacles
        - **cilia** near the mouth generate water currents which "pump up" the gastrovascular cavity with water; this creates a **hydrostatic skeleton** that the muscle can function in opposition to
        - sea anemones contract by shortening their retractor muscles (which run the length of the column)
        - feed on invertebrates; large species can capture fish
            - prey is paralyzed by nematocysts and brought to the mouth via the tentacles
        - many sea anemones have symbiotic algae living inside their tentacles and oral disc
        - sexual reproduction occurs in all species with separate sexes in most species
        - some species are hermaphroditic (i.e., produce both sperm and eggs and thus fertilize their own eggs
        - asexual reproduction common
            - one method occurs by a moving anemone leaving parts of the pedal (foot) disc behind on the substrate; some undergo fission

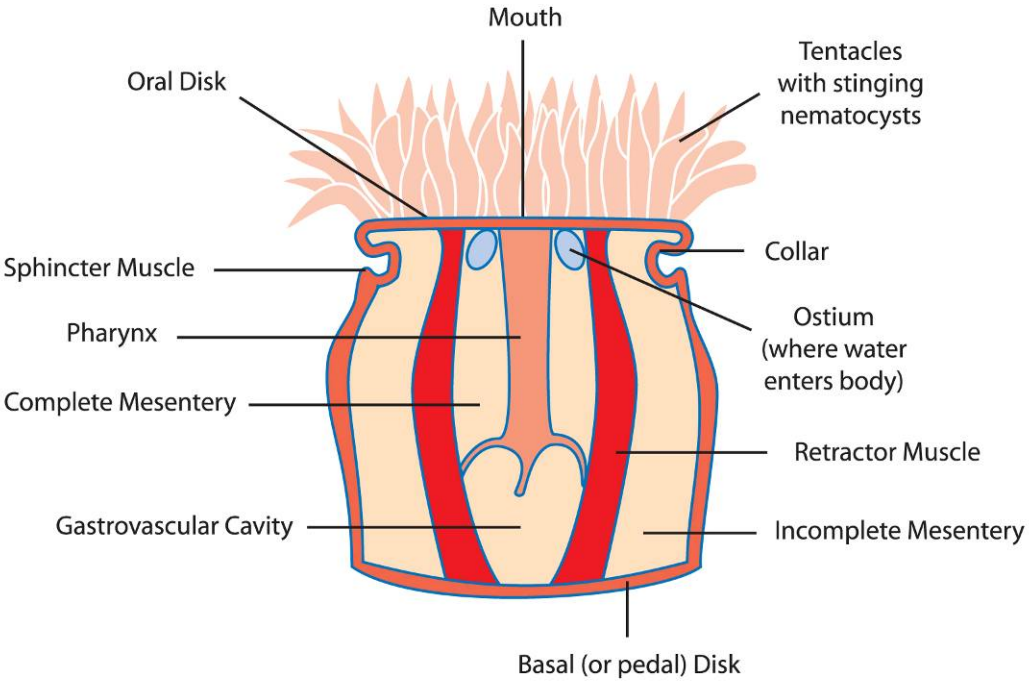


Figure IX. 3. Sea Anemone Internal and External Anatomy

- **Sea Pens**, Subclass Octocorallia, Order Pennatulacea
  - most complex and variable Anthozoans
  - are colonial corals with internal skeletal structures
  - are bottom dwellers (sessile)
  - main structure is a stem (actually an initial, or primary, polyp) with "leaves" (actually more polyps) protruding from it
  - base of primary polyp anchors in the sediment
    - upper portion produces rows/whorls of polyps that appear as "leaves" off the main stem
    - some "leaf" polyps have tentacles and are involved in feeding; capture small animals
    - other "leaf" polyps create water currents through the colony
  - reproduction may be sexual or asexual

Fig. IX. 4. Sea Pen (note different structures formed by polyps)

Sea Anemones and Sea Pens Maintained at the Alaska Sea Life Center

1. Burrowing Green Anemone, *Anthopleura artemisia*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Anthopleura*

Occurrence	• Gulf of Alaska to southern California • intertidal and subtidal waters up to 30 feet deep
Form/Function	• base attaches to rock while animal is partially buried in sand • preyed upon by some sea stars and fishes • dome-like projections (**tubercles**) at column top • tentacles long and slender; colors are green, tan, to pink, copper, gray, or with incomplete encircling white bands • lower two thirds white • upper third black or gray • eats invertebrates, fish eggs, perhaps fishes as well • this anemone helps deter desiccation (drying out) at low tides by contracting and covering its top with shell fragments, which function to reflect away sunlight
Reproduction	• reproduction sexual or asexual reproduction through release of eggs and sperm into open sea/ocean • asexual reproduction through longitudinal fission of anemone from base to top
Noteworthy Facts	• common intertidal anemone

2. Giant Plumose Anemone, *Metridium giganteum*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Metridiidae
Genus *Metridium*

Occurrence	• Alexander Archipelago, Alaska to south along Pacific coast of North America through California • subtidal in bays or open water; typically occurs affixed to substrate objects
Form/Function	• base attaches to rock while animal is partially buried in sand • opaque white to dull orange-brown • may reach 3 feet 3 inches in height • expanded tentacles are fine, not thick • column smooth • has the appearance of a white sock with a rock in the toe when the tide is out
Reproduction	• reproduces sexually
Predators/Prey	• preyed upon by the leather star, *Dermasterias imbricate*, as well as various nudibranch species • carnivorous: captures small prey with tentacles • eats small invertebrates, fish eggs, perhaps small fishes as well
Noteworthy Facts ……	• look for this colorful anemone on rocky beaches, docks, and pilings

3. Short Plumose Anemone, *Metridium senile*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Metridiidae
Genus *Metridium*

Occurrence	• Alaska to southern California • Circumpolar • intertidal, found up to 1000 feet deep • attaches to rocks
Form/Function	• color can vary from white, cream, orange, to tan • is taller than it is wide; column height to 20" or more • less than 100 slender tentacles; inners larger than outers • tentacles branch profusely, especially in adults • oral disc not lobed or ruffled in appearance • can be confused with giant plumose anemone, which has an oral disk that appears lobed or ruffled
Reproduction	• asexual or sexual reproduction through males and females releasing gametes into open water • asexual reproduction through two methods: 1. Shedding of a portion of the pedal disc; this shed portion later develops into an anemone 2. Longitudinal fission of anemone such that bottom to top splits down middle
Predators/Prey .....….....	• preyed upon by sea stars and some fishes • small specimens feed upon relatively large prey items while larger specimens are filter feeders
Noteworthy Facts ……	• often occurs on pilings, rocky bottoms, and harbor floats • one of the largest and most conspicuous of Alaskan sea anemones

4. **Green Anemone,** *Anthopleura xanthogrammica*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Anthopleura*

Occurrence	• Alaska to Panama • in tide pools and deep channels on exposed rocky shores • on rocks and concrete pilings in open bays and harbors and on exposed rocky shores • low intertidal and subtidal
Form/Function .....….....	• column to 6.8 inches diameter • covered with irregular, compound, adhesive tubercles • crown to 10 inches diameter base of a greater diameter than the column and attaches to rocks • and pilings very firmly • tentacles are numerous, short, conical, pointed or blunt, in six or more circles in a narrow band located around the margin • column and base green to dark greenish brown but lighter in shaded locations • tentacles greenish, bluish, or white, not marked or banded • oral disk flat, gray-blue, green or greenish blue
Reproduction	• reproduction sexual; does not reproduce by **fission** • releases sperm and brownish eggs in late spring and summer • larvae are presumed to float freely and thereby become widely dispersed
Noteworthy Facts ……	• one of the most dramatic animals to be found in Pacific coast tidepools • individuals living in bright sun are brilliant green in color as a result of possessing **zooxanthellae**: individuals in caves are pale because they lack

	zooxanthellae • hermit crab *Pagurus samuelis* often found walking up and down the column; can even walk among the tentacles without being stung • perhaps walking on the column initially coats the crab with mucus such that the anemone responds to the crab as though it were the anemone's tissue • nematocysts cause tentacles to stick to fingers

5. Yellow Zoanthid, *Epizoanthus scotinus*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Zoanthidea
Family Epizoanthidae
Genus *Epizoanthus*

Occurrence	• southern Alaska to Southern California • low intertidal to 180 feet
Form/Function .....….....	• column color from tan to brown or light yellow; tentacles light yellow to white • tentacles more pale than column • 0.75 inches across
Reproduction	• capable of either sexual reproduction or reproduction via asexual budding
Noteworthy Facts ……	• can produce dense, clonal aggregations via asexual budding

6. Aggregating Anemone, *Anthopleura elegantissima*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Anthopleura*

Occurrence	• Alaska to Baja California • occurs in large numbers on rocks, tidepools or crevices, wharf pilings, singly or in aggregations • middle intertidal zone of partially protected rocky shores of bays and the outer coastal region
Form/Function	• individuals living in aggregations have a column diameter of 3.2 inches across the crown of tentacles; solitary individuals may have a crown diameter of 10 inches across • column white green to white, twice as long as wide when extended, and with longitudinal rows of tubercles to which debris is often attached • tentacles numerous and short, occurring in five row; variously colored but often having pink, blue, or lavender tips
Reproduction	• reproduction sexual or asexual via longitudinal fission • spawning observed in September in the San Francisco area • ova present in February and develop until their release in July • sperm are released through the summer
Predators/Prey .....….....	• preyed upon by the nudibranch *Aeolidia papillosa*, the snail *Epitonium tinctum*, and by several sea star species • feeds upon copepods, isopods, amphipods, and other small animals that encounter its tentacles
Noteworthy Facts ……	• crude extracts produced from this anemone have

	• at low tide covers itself with shells to prevent desiccation • displayed activity against ascitic tumors in mice

7. **Whitespot Anemone,** *Urticina lofotensis*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Urticina*

Occurrence	• Alaska to San Diego, California; also in northern Atlantic • low intertidal and subtidal areas
Form/Function	• conspicuous white tubercles smooth and arranged in lengthwise rows • bright red column rarely more than 4 inches in diameter; white spots arranged in a neat, lengthwise rows run up and down the column • column usually does not accumulate sand, gravel, or bits of shell; column height to 6 inches • yellow tentacles have pink-red tips and are banded with pink and
Reproduction	• unknown
Predators/Prey .....….....	• unknown
Noteworthy Facts ……	• a very attractive anemone

8. **Crimson *Anemone,*** *Cribrinopsis fernaldi*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Cribrinopsis*

Occurrence	• Aleutian Islands, Alaska to Puget Sound; Washington • subtidal waters up to 1000 feet deep • attaches to rocks
Form/Function	• column up to 10 inches tall • crown adorned in slender, drooping tentacles that drape over the column and possess zig-zag lines • color varies from white to pink • nematocysts cause fingers to stick to tentacles
Reproduction	• sexual • fertilized eggs brood in female for about 20 days prior to release of larvae
Predators/Prey .....….....	• preyed upon by sea stars and some fishes • eats invertebrates (e.g., Crustacea) and fishes
Noteworthy Facts ……	• several Crustacea, including the candy stripe shrimp and other hippolytid shrimps, the stout coastal shrimp, and heart crabs, take shelter under it

9. Christmas Anemone, *Utricina crassicornis*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Order Actiniaria
Family Actiniidae
Genus *Utricina*

Occurrence	• Pribilof Islands, Alaska to southern California • low intertidal to shallow subtidal waters, up to 100 feet deep • attaches to rocks
Form/Function	• up to 12 inches tall and 10 inches wide (a large anemone) • column olive-green color with irregular blotches; other occasional column colors are cream, orange, red , or brown • possesses four to five rings/whorls of short, blunt tentacles which vary in color from reddish with pale cross bands to a single, broad, reddish band in the middle • nematocysts cause tentacles to stick to fingers
Reproduction	• sexual reproduction exclusively
Predators/Prey	• known to have been attacked in captivity by the mosshead sculpin • eats mollusks (e.g., snails, mussels, and chitons), Crustacea (e.g., crabs, barnacles), sea urchins, and fishes
Noteworthy Facts ……	• candy striped shrimp live as scavengers (consume scraps not ingested by the anemone) on the oral disc • may live at least 60 - 80 years • juveniles develop slowly; are rarely seen; likely

	indicates low reproduction rate • may feed on surprisingly large prey items, including jellyfish, chitons, tanner crabs, hermit crabs, sea urchins, and fishes

10. Sea Whip, *Balticina spp.*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Subclass Octocorallia
Order Pennatulacea
Family Virgulariidae
Genus *Balticina*

Occurrence	• in Alaskan waters • shallow subtidal or deep subtidal
Form/Function	• long, whiplike growth is actually a colony of polyps that grow upon one another in a continuous stem
Reproduction	• unknown
Predators/Prey .....….....	• unknown
Noteworthy Facts ……	• probably displays bioluminescence like most pennatulids • very little is known of species within this genus for Alaskan waters

11. Sea Pen, *Halipteris willemoesi*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Subclass Octocorallia
Order Pennatulacea
Family Halipteridae
Genus *Halipteris*

Occurrence	• southeast Bering Sea, Alaska • stem imbedded in sediment
Predators/Prey	• preyed upon by starfish and nudibranchs • feeding polyps capture small animal
Reproduction	• reproduction can occur annually or continuously throughout year • eggs and sperm released into water column where fertilization occurs • planula larvae will settle upon bottom after seven days if conditions favor this
Form/Function	• up to 5 feet tall
Noteworthy Facts ……	• "forests" of sea pens provide food and shelter for many organisms, including juvenile rockfish

12. **Sea Pen,** *Ptilosarcus gurneyi*

Kingdom Animalia
Phylum **Cnidaria**
Class Anthozoa
Subclass Octocorallia
Order Pennatulacea
Family Pennatulidae
Genus *Ptilosarcus*

Occurrence	• Prince William Sound to California • subtidal; common at depths of 30 – 80 feet; found in sand with central stalk lower portion functioning as an anchor
Form/Function	• fleshy stalk • has a short, internal rod support located in the lower, buried portion • polyps occur on leaf-like branches of on upper regions of stalk • orange color
Reproduction	• spawning occurs from March until April • egg size averages 0.5 – 0.6 mm • ciliated **planula larvae** generated through sexual reproduction • larvae are initially free-swimming; later settle to sea floor and there develop into a polyp which will eventually further develop into an adult
Noteworthy Facts ……	• a plankton feeder, it obtains nutrients by filtering minute organisms into the main axis; these are subsequently absorbed through specialized cells

- Jellyfish : Class Scyphozoa

    - medusa is predominant life stage
    - most bell diameters from 1 - 16 inches
        - one species, *Cyanea capillata*, may have a bell diameter of > 6 feet (!!)
    - often of striking coloration
    - gonads and other internal structures often brightly colored (e.g., orange) and visible through the largely transparent bell
    - 200 species described from Arctic to tropical oceans
    - most inhabit coastal waters, though a few are deep water
    - most are free swimming
    - tentacles occur at bell margin and vary from four to many; possess nematocysts, whose sting severity varies with species; in some species, the sting can be so severe as to cause death in humans (Australian sea wasp/box jellies are examples)
    - vertical movement results from contractions of circular muscle that surround the sub-umbrella margin (sub-umbrella is underside area of bell near its opening)
    - for most species, horizontal movement results from waves or currents
    - more primitive species have mouth open directly into stomach
    - feed on fishes and crustaceans
    - capture prey with tentacles and sting into submission with nematocysts on tentacles; tentacle then brings food to mouth for ingestion
    - nervous system arranged as a net; no central nervous system (hence, no brain)
    - have sensory pits that enable orientation with respect to light
    - sexes separate; thus often reproduce sexually
        - in polyp stage, Scyphozoans reproduce via asexual budding

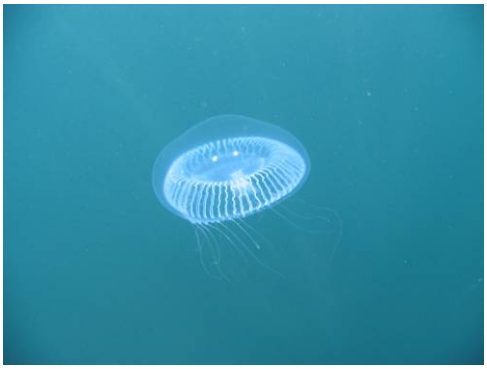


Fig. IX. 5. Jellyfish (Scyphozoan)

Class Scyphozoa Maintained at the Alaska sea Life Center

13. Moon Jelly, *Aurelia labiata*

Kingdom Animalia
Phylum **Cnidaria**
Class Scyphozoa
Order Semaeostomeae
Family Ulmaridae
Genus *Aurelia*

Occurrence	• Worldwide; can be very abundant in some areas
Form/Function	• free swimming, pelagic • bell may be up to 16 inches across • tentacles numerous and short • unlike other jellies, lack potent stinging tentacles • four horseshoe-shaped gonads are arranged symmetrically on bell surface
Reproduction	• sexual or asexual • sexes are separate; sexual reproduction in medusa stage
Predators/Prey .....….....	• mucus on bell surface ensnares prey items (zooplankton) ; prey is subsequently transferred via mucus to bell margin, from where it is transferred to the mouth
Noteworthy Facts ……	• most common jellyfish maintained in public aquaria • often wash ashore in large numbers • common name derived from half-moon shaped structures within bell • very difficult to distinguish from *A. aurelia*, which occurs in other parts of the world but has been unintentionally introduced into Alaskan waters

X. Flatworms: Kingdom Animalia, Phylum Platyhelminthes

Among bilateral organisms (meaning those that can be divided into an equal right and left side by a single cut), the flatworms, Phylum Platyhelminthes, are the simplest. In this short chapter, one species is described after a brief description of the Phylum.

Phylum Platyhelminthes, the Flatworms

- leaf or ribbonlike animals
- length ranges from 0.02 inches to 66 feet long (!!)
- digestive tract incomplete (lacks an anus)
- digestive cavity is only space within the body; otherwise lack an internal cavity
- three major groups

turbellarians: free living forms
- dense nervous tissue clusters form a primitive brain
- a nerve cord pair joins the brain to the rest of the nervous system, which extends throughout the body
- digestive system highly branched
- mouth on ventral side; a muscular tube projects from here during feeding
- use cilia located on ventral surface to move about

flukes: parasitic flatworms
- male is larger
- female invests much time located within a groove that traverses the male's length
- the thus mate readily and may produce more than 1000 eggs a day
- males and females possess suckers which attach to blood vessels in the host's intestine
- can cause severe diseases in humans; blood fluke disease occurs extensively throughout South America, Asia, and Africa
- most have a complex life that involves stages in more than one host

tapeworms
- live in digestive tracts of vertebrates (reptiles, birds, and mammals)
- body is a series of repeated segments (very unlike flukes and flatworms)
- lack a digestive tract (absorb nutrients across body integument)
- head, the smallest body segment, is equipped with teeth and sucking structures for attaching to grasp host tissues
- segment immediately behind head is youngest while posterior-most segment is oldest
- repeated segments contain male and female reproductive parts
- the posterior-most segment gets filled with ripe eggs and breaks off to be voided from the body in the feces
- life cycles are complex and generally utilize more than one host

- some species can reach 66 feet in the human intestine

1. **Flatworm,** *Kaburakia excelsa*

Kingdom Animalia
Phylum **Platyhelminthes**
Class Turbellaria
Order Polycladida
Family Stylochidae
Genus *Kaburakia*

Occurrence	• Alaska to southern California • low intertidal
Form/Function	• to 4 inches long and 2.8 inches wide when active and extended • **nuchal** tentacles large, retractile, and bearing eyes inside at the base • marginal eyes occurring around entire perimeter of body • tan color, heavily imprinted with uniformly distributed dark-brown, dash-like markings, which gives the entire body a bluish hue
Reproduction	• in Washington, gravid individuals have been identified in March
Predators/Prey	• 150 – 160 golden eggs are laid in capsules as a mono- or bilayer on rocks • carnivorous; feeds on ascidians, polychaete worms, crustaceans, and mollusks
Noteworthy Facts ……	• one of the largest coastal flatworms

XI. Segmented Worms and Tube Worms : Kingdom Animalia, Phylum Annelida

Earthworms are the members of the Phylum Annelida that are familiar to most people. Being bilaterally symmetrical and having a tube-shaped body, members of the Phylum Annelida possess up to 100 or more ring shaped segments. Important marine members of this Phylum make up components of ecosystems worldwide and that of Alaska is no exception. We now examine the general characteristics of thePhylum Annelida and describe two species maintained at the Alaska SeaLife Center.

Phylum Annelida

- includes earthworms, leeches, and many aquatic forms (both freshwater and marine example)
    - 8,700 described species
- trunk of body is divided into similar parts or segments
    - arranged as a linear series from the front to the rear of the animal
    - anterior-most trunk segments tend to fuse with head region
- head region unsegmented; contains brain
- anus located in terminal, unsegmented body region
- body changes shape as muscles contract against a hydraulic skeleton
- digestive tract runs straight from mouth to anus
- blood vessels usually well developed
- nervous system: possess a brain, nerve cells extending from brain towards posterior portion of body, and nerve cells extending from here to individual body segments
- are the major food of bottom feeding crabs, shrimps, some large gastropods, bottom fishes and some marine birds
- **Polychaete** worms are common marine examples
    - over 5,300 described species
    - most < 4 inches long
    - one species occasionally attains lengths of more than 10 feet long (!!)
    - are often brightly colored
    - cylindrical trunk segments bear paddle-like appendages (**parapodia**)
    - eyes present on head
    - mouth on underside
    - some forms free swimming, some forms burrowers, many forms capable of both swimming and burrowing
    - some polychaete species are tube dwellers
    - depending upon species, may be predators, herbivores, omnivores, browsers, deposit feeders, or scavengers
    - gas exchange (respiration) across gill structures as well as general body surface
    - eye present; may have from two to four pairs
        - some species are blind
    - can regenerate body parts (even heads!!)

- reproduction
  - sexual reproduction common, with most species having separate sexes
  - asexual reproduction in some species occurs by budding off of body segments
  - eggs shed directly into sea water
  - most live for more than two years
  - a few species brood their young within a tube or a brood chamber

1. **Red Tubeworm,** *Serpula vermicularis*

Kingdom Animalia
Phylum **Annelida**
Class Polychaeta
Order Sabellida
Family Serpulidae
Genus *Vermicularis*

Occurrence	• Alaska to San Diego; Pacific, Atlantic, and Indian Oceans • low intertidal to subtidal; to 330 feet
Form/Function	• tube to 4 inches long; chalky white and often coiled, cylindrical, smooth, or with longitudinal ridges • branchial crown red, pink, orange, or banded with white; contains 40 plume rows
Reproduction	• spawning animals observed during summer in England and California; on the French Mediterranean coast ripe individuals were most common in spring and least common in winter • pelagic stage of short duration
Predators/Prey	• uses tuft of plume-like gills on head to collect microscopic food from the water and pass it down to the mouth via cilia
Noteworthy Facts ……	• occur as worms that occupy a self-secreted calcareous tube that occurs on rock surfaces • have giant nerve fibers that enable them to rapidly pull into their tubes to avoid predators

2. **Sand Worm,** *Nereis vexillosa*

Kingdom Animalia
Phylum **Annelida**
Class Polychaeta
Subclass Errantia
Order Phyllodocida
Family Nereidae
Genus *Nereis*

Occurrence	• Alaska to San Diego, California • benthic mode of life about rocky shores, sandy or gravelly beaches, estuaries, mud flats, wharf pilings
Form/Function	• large crawling worms • gray body with iridescent greens, blues, and reds • possess four eyes • pharynx (throat) contains a pair of jaws
Reproduction	• spawning usually occurs 1 - 2 hours before midnight • mating occurs at favorable moon-tide as sexes leave benthic environment and swim in water column • the twisting male turns violently and releases sperm at this time • female follows and releases her eggs, which are then fertilized by the sperm; female only releases eggs in presence of male • worms die after mating
Predators/Prey .....….....	• preyed upon by crabs and fishes • when captured, squirm violently and protrude jaws in effort to bite predator • are omnivores; consume broad range of animal and plant tissues
Noteworthy Facts ……	• jaws can bite humans, but this rarely occurs in this species

	• can capture live prey or tear off algae with jaws • posterior segments in sexually mature individuals become red as they swell with sperm in males or swell with eggs in females

XII. The Moss Animals: Kingdom Animalia, Phylum Bryozoa/Ectoprocta

With more than 5000 species and several times that in fossil species, the Bryozoa (= Ectoprocta), or moss animals, nonetheless remain largely unknown to most people. All are aquatic and most live colonially, with individuals connected to one another. Such a colony may be comprised of from a few individuals to many millions. They can occur as rock encrustations or appear as branching colonies that look similar to species of algae. The size of a colony can range from less than 0.1 inch to several yards. The bryozoans are often misidentified as algae, hydroids, or corals.

Although bryozoans may encrust man-made structures to the extent that they foul piers, block water intakes, and cause tremendous drag on boats and ships, the diverse chemical compounds produced by them hold promise for medical applications. Certainly bryozoans, with their diverse colors and intriguing shapes, represent some of the most beautiful of the marine benthic fauna.

Bryozoa/Ectprocta Characteristics

- Ectoprocta means outside anus
- sessile animal organisms that live colonially in either freshwater or marine habitats
- generally, a single, sexually-derived individual gives rise to a colony through asexual reproduction
- there is much difference in colony form from one species to another
    - still, the bryozoan colony can be described as more or less plantlike (hence the original name for the Phylum was Bryozoa, meaning moss animals)
- occur at virtually all depths (a recently described Antarctic species forms jelly-like colonies on ice
- are suspension feeders that use many ciliated tentacles, these being part of a structure called a lophophore
- a limited number of species occur in fresh and brackish water
- some form coral-like colonies in shallow waters
- some encrusting forms occur on the exoskeletons or shells of various invertebrate species; some can even bore into the calcium carbonate substrate of a shell

The Three Recognized Classes of Bryozoa

a. Class Phylactolaemata
   - Freshwater
   - with chitinous or jelly-like coverings
   - body wall muscles well developed
   - most generate asexual bodies called **stomoblasts**
   - reproduction usually through formation stomoblasts

b. Class Stenolaemata
   - Marine
   - individual animals occur in tube-shaped, calcareous structures
   - individual animals are tube or trumpet shaped
   - inflexible body walls
   - muscles not well developed
   - pores connect one individual animal of a colony to an adjacent one
   - asexual reproduction of single embryos

c. Class Gymnolaemata
   - mostly marine
   - extremely diverse group
   - colony form highly variable; may be hard (calcified) or soft
   - muscles absent from body wall

1. **Stick Bryozoan,** *Microporina borealis*

Photograph Unavailable

Kingdom Animalia
Phylum **Ectoprocta**
Class Gymnolaemata
Order Cheilostomata
Family Microporidae
Genus *Microporina*

Occurrence	• Alaskan waters
Form/Function	• internodes of colony approximately 0.4 inches long • **zooecia** boxlike and embedded in a matrix of the colony • frontals of zooecia calcified and forming colony surface • aperture more or less semicircular, with an **operculum** • colony consisting of calcified units that are connected by flexible joints
Reproduction	• unknown
Predators/Prey .....….....	• preyed upon by some nudibranchs
Noteworthy Facts ……	• very little seems to be known of this species

2. **Fluted Bryozoan,** *Hippodiplosia insculpta*

Kingdom Animalia
Phylum **Ectoprocta**
Class Gymnolaemata
Order Cheilostomata
Family Schizoporellidae
Genus *Hippodiplosia*

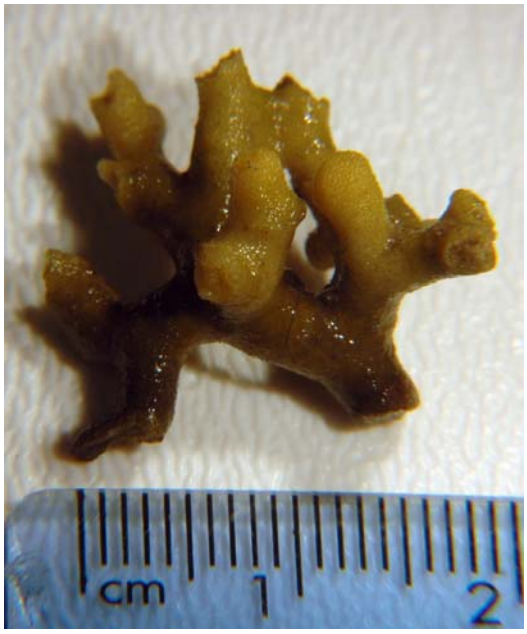
Occurrence	• Alaska to Gulf of California and Isla del Coco, Costa Rica • subtidal to 750 feet
Form/Function	• colony encrusting • to 2 inches or more in diameter and rising in double-layered frills or fan-like folds • color light yellow or pale tan, light orange when ova are present • individuals 0.02 – 0.027 inches long, 0.012 – 0.016 inches wide, rectangular to hexagonal in shape • bears large, globular **ovicells**
Reproduction	• unknown
Predators/Prey	• preyed upon by some nudibranch species
Noteworthy Facts ……	• common on lower middle and low intertidal rocky shores

3. **Purple Encrusting Bryozoan,** *Disporella separata*

Kingdom Animalia
Phylum **Ectoprocta**
Class Gymnolaemata
Order Cheilostomata
Family Lichenoporidae
Genus *Disporella*

Occurrence	• Alaskan waters
Form/Function	• colony large, encrusting and disk-shaped but not **stolon**like; up to 4 inches in diameter, complex, and made up of subcolonies bearing 8 – 12 bundles of tubules that are simple, calcified, and fused together • color commonly deep purple
Reproduction	• unknown
Predators/Prey	• unknown
Noteworthy Facts ……	• apparently very little is known of this attractive species

4. Northern Staghorn Bryozoan, *Heteropora magna*



Kingdom Animalia
Phylum **Ectoprocta**
Class Stenolaemata
Order Cyclostomata
Family Heteroporidae
Genus *Heteropora*

Occurrence	• Alaskan waters
Form/Function	• color often gray purple • zooecia, indistinct and embedded within a cylindrical matrix, protruding very slightly, if at all, above the colony surface; most of frontal zooecia calcified • zooecia apertures circular and lacking a sinus, usually tightly packed, and raised slightly above, or on level with, the branch surface • branches up to 0.2 inches in diameter, generally cylindrical, with apertures of zooecia distributed more or less evenly around branches • operculum absent • colony erect and solid; neither flexible nor jointed; not cuplike
Reproduction	• unknown
Predators/Prey	• unknown
Noteworthy Facts ……	• apparently very little is known of this species

XIII. Mussels, Clams, Oysters, Squid, Octopus, and Snails : Kingdom Animalia, Phylum Mollusca

Members of the Phylum Mollusca are familiar to us as bivalves (e.g., clams, oysters, and scallops), snails, and cephalopods (e.g., octopus an squids). Although outwardly different molluscan species may appear wholly unrelated to one another, we shall see that all mollusks share certain common traits. It is notable that the Phylum Mollusca is well represented in Alaskan waters and more than 40 species can sometimes be observed at the Alaska SeaLife Center.

Phylum Mollusca

- 100,000 described living species; 35,000 described fossil species
- marine, freshwater, and terrestrial forms
- generalized body plan body plan (obvious exceptions exist and will be noted later)
    - possess a muscular foot
    - possess a shield-shaped shell on the back (not present in all forms)
    - specialized tissue called a mantle secretes the shell
    - primitive molluscs possess gills
    - in many examples (except bivalves and some snails) feeding is made possible by a radula, a file-like structure that scrapes material off of surfaces or bore through a bivalve shell (not present in all examples)
    - stomach has capacity to process finely ground food
    - open circulatory system (no blood vessels)
    - heart present; has distinct upper and lower chamber
    - nervous system present; in the most primitive forms, it is comprised of a nerve ring around the esophagus, from which other components of the nervous system emerge
    - separate sexes in most a primitive trait; some with combined sexes (hermaphroditic)
- Mollusk Classes
    - **Snails** : Gastropoda
        - over 75,000 described living species
        - comprised of three subclasses
            1. Prosobranchia: most shelled snails
            2. Opistobranchia: sea slugs and kin
            3. Pulmonata: land snails and slugs and several marine, intertidal species (not represented at the Alaska SeaLife Center)
        - 15,000 fossil species described
        - can be considered as the most successful mollusks because of the wide variety of habitats they occupy as a group
            - many marine species adapted to different benthic environments
            - many freshwater examples
            - terrestrial examples

- Subclass Prosobranchia (snails and slugs) physical characteristics
  - head present
  - eyes present at the end of each of two head tentacles
  - creeping foot retained
  - shell has become a protective casing to retreat into rather than just an overlying shield
  - base of foot often contains a hard, horny or shelly disk called an **operculum;** this functions like a door to protect the animal when withdrawn into the shell)
  - shell usually an asymmetrical spiral
  - many shell varieties, including different shapes, colors, and modes of twisting (**torsion**) of the body (not to be confused with spiraling of the shell, which is a separate process) over evolutionary time has moved the anus and gills 180 degrees counterclockwise to just behind the head and therefore to the anterior portion of the body
  - in some species the shell is very reduced or lost altogether
  - different species collectively exhibit all possible modes of feeding (herbivores, carnivores, deposit feeders, suspension feeders, scavengers, etc.)
  - in many species sexes are separate; hence, reproduction in these is sexual
    - some species have both sex organs within one individual (hermaphroditic)

- Subclass Opisthobranchia (sea slugs and kin) physical characteristics
  - torsion lost to varying degrees
  - shell reduced and thin; can be external, internal, or lost altogether
  - mantle cavity reduced or lost altogether
  - head bears a pair of tentacles
  - hermaphroditic
  - primarily marine and benthic (some brackish and freshwater examples do exist)

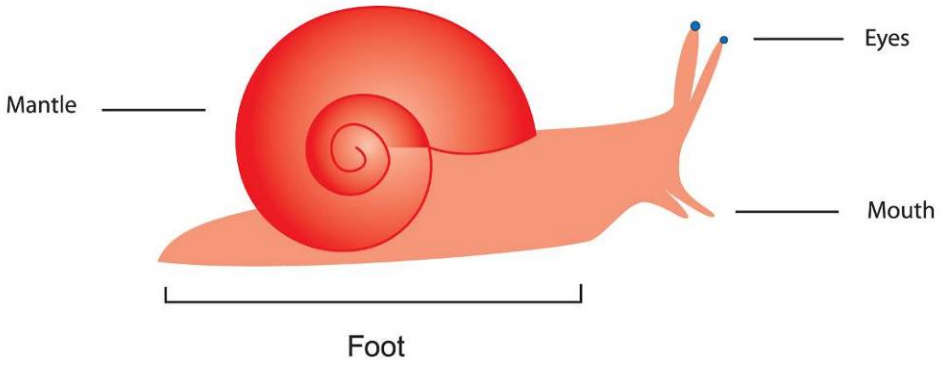


Fig. XIII.1. Snail (note structures)

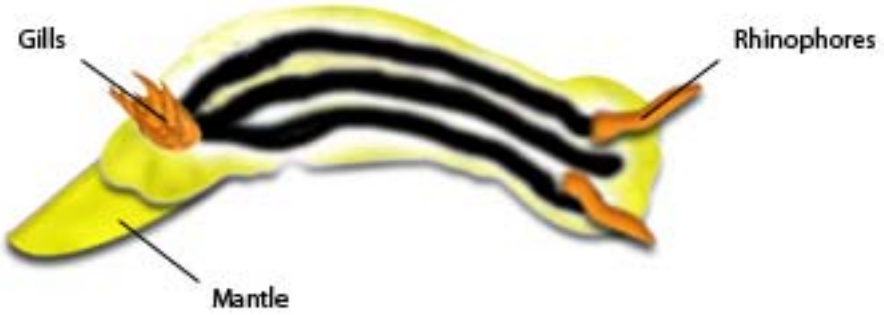


Fig. XIII.2. Nudibranch (note structures)

Snails (Gastropods) Featured at the Alaska sea Life Center

1. Whitecap Limpet, Acmaea mitra

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Patellogastropoda
Family Acmaeidae
Genus *Acmaea*

Occurrence	• Pribilof and Aleutian Islands, Alaska to Isla San Martin, Baja California • low intertidal and shallow subtidal zones in protected areas of heavy surf
Form/Function	• shell to 1.33 inches long • shell high, white, and conical; often covered by a growth of pink, corralline algae • apex of shell almost in center • shell surface sculptured with fine, concentric growth lines and radial **striations** • holdfasts and thalli of red coralline algae often grow all over the shell surface
Reproduction	• in California breeds in winter and spawns when temperature is at or near its minimum
Predators/Prey	• feeds upon detritus
Noteworthy Facts ……	• does not exhibit an escape response to sea stars • holdfasts and thalli of red coralline algae often grow all over the shell surface

2. **Keyhole Limpet,** *Diodora aspera*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Archaeogastropoda
Family Fissurellidae
Genus *Diodora*

Occurrence	• Alaska to Camalu, Baja California, Mexico • low intertidal to shallow subtidal
Form/Function	• oval cap-shaped shell with oval aperture that is 1/10th the shell's length at the apex • from 1 inch to 2.8 inches • **periostracum** rough with many radial ribs crossed by concentric threads and thus giving a lattice-like appearance • every fourth rib larger than the other • shell grayish-white and often having brownish-purple rays • shell interior white
Reproduction	• sexes separate • fertilization external • larvae planktonic
Predators/Prey .....….....	• an omnivore, this species feeds on algae, sponges, and bryozoans
Noteworthy Facts ……	• responds to predatory sea stars by extending the food and elevating the shell; it then extends the mantle such that it covers both the foot and the shell • this makes it difficult for the sea star to properly attach to this limpet to enable it to feed upon it • can also bite sea star tube feet to cause them to retreat • a **commensal** polychaete worm (*Arctonoe vittata*) is usually found in the mantle cavity

3. **Shield Limpet,** *Lottia pelta*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Patellogastropoda
Family Lottiidae
Genus *Lottia*

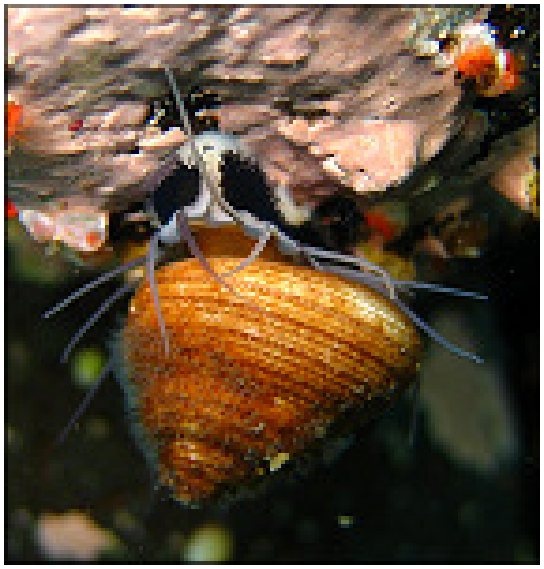
Occurrence	• Aleutian Islands, Alaska to Bahia del Rosario, Baja California • middle to low intertidal
Form/Function	• shell to 1.2 inches long • small specimens living in mussel beds occur on the stipes and holdfasts of algae (genus *Egregia*); usually black with weak ribbing on the shells
Reproduction	• in California populations, reproduction occurs throughout the year, with lowest rates occurring in summer • fertilization external • larvae planktonic
Noteworthy Facts ……	• consume a great variety of large and microscopic species of algae • animals on rocks have flatter shells than those in mussel beds • shell color highly variable: brown or green to nearly black, often checkered with white, or with peripheral rays and bands of white • this species is common in mussel beds • it is often associated with brown algae (*Egregia*, *Postelsia*, *Pelvetia*, *Laminaria*) when small • move on to nearby rocks when about 10 mm long • one of the most widely distributed limpets in the intertidal zone

4. Plate Limpet, *Tectura scutum*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Patellogastropoda
Family Lottiidae
Genus *Tectura*

Occurrence	• Southern Bering Sea and Aleutian Islands to Point Conception (north of Santa Barbara) • middle intertidal zone
Form/Function	• shell to 1.6 inches long • low, smooth, shield-like shell • shell often covered with tufts of green algae (these may function to hide the animal from would-be predators) • shell frequently green with irregular white spotting from the edge to the apex of the shell • has special chemical receptors that enable it to be very responsive to sea star predators • moves up and down rocks with rising and falling tide • like other limpets, it is most active at night
Reproduction	• unknown or information unavailable, though probably very similar to that of other limpet species
Predators/Prey .....….....	• preyed upon by crabs and sea stars
Noteworthy Facts ……	• feeds on microscopic algae

5. **Margarite Snail,** *Margarites pupillus*



Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Archaeogastropoda
Family Trochidae
Genus *Margarites*

Occurrence	• Nunivak Island and Bering Sea, Alaska to San Diego, California • low intertidal and subtidal waters to 330 feet
Form/Function	• conical shell to 0.6 inches wide • shell with spiral ribbing • color pink or orange, the aperture being brilliantly iridescent
Reproduction	• unknown or information unavailable
Predators/Prey	• in Puget Sound, Washington is preyed upon by the snail *Searlesia dira* and by the nudibranch *Dirona albolineata*, which crush these snails in its jaws
Noteworthy Facts ……	• though much is known of the biology of British *Margarites* species, little is known of this species, *Margarites pupillus*

6. Arctic Moon Snail, *Natica aleutica*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Mesogastropoda
Family Naticidae
Genus *Natica*

Occurrence	• Southern Bering Sea and Aleutian Islands to Point Conception (north of Santa Barbara) • shallow subtidal to 1650 feet
Form/Function	• shell medium, squat, and cream colored with brown periostracum • body color is a transluscent cream with brown spots and blotches • shells to 4 inches high as adults • in living examples there are mantle flaps from each side that cover the shell and thereby protect its lustrous finish
Reproduction	• eggs laid in capsules made of mucus-cemented sand grains
Predators/Prey .....….....	• preyed upon by juvenile and adult cod • feeds just below sediment upon other mollusks by drilling a neat, beveled hole with a rasp-like radula • secretes a non-acidic substance that softens the shells of mollusks it preys upon
Noteworthy Facts ……	• most common moon snail of Alaskan waters • name derived from shell opening (aperture), which is half moon shaped

7. Cancellate Hairy Snail, *Trichotropis cancellata*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Mesogastropoda
Family Trichotropididae
Genus *Trichotropis*

Occurrence	• Bering sea and Aleutian Islands, Alaska to Oregon • common shallow subtidal, occasionally intertidal
Form/Function	• shell to 1.0 inch diameter • shell high, white, and conical
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• suspension feeder, but also steals food from suspension-feeding polychaete worms (such stealing is termed **kleptoparasitism**); it uses its pseudoproboscis, an extended, ciliated portion of the lower lip to channel food from the mouth of the polychaete host

8. **Purple-ring Topsnail,** *Calliostoma annulatum*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Archaeogastropoda
Family Trochidae
Genus *Calliostoma*

Occurrence	• Forester Island, Alaska to Isla San Geronimo, Baja California • abundant subtidally but may occur at lowest tidal levels
Form/Function	• shell interior pearly • coumnella lacking nodes • spiral ridges beaded; brown on a cream or yellow background • anteriormost spiral ridge on each **whorl** is purple or violet • base of body whorl almost flat • animal pinkish-orange with brown dorsal spots • shell 0.8 – 1.2 inches wide • generally has eight flattened whorls • with death, the shell colors fade
Reproduction	• males generally spawn first • females produce green eggs, each contained in a clear envelope with a thick, gelatinous coat thick are shed in a soft gelatinous coating
Predators/Prey	• preyed upon by juvenile and adult cod • feeds on the kelp, or on kelp-encrusting diatoms, bryozoans, and hydroids • also consumes detritus and copepods • may scavenge dead fish or other sea creatures • possibly attacks anemones or nudibranchs
Noteworthy Facts ……	• mucus covering the shell makes it slippery and thus less prone to predation • although an algal feeder in the spring, this species switches largely to animal foods when they

	become available

9. Hal's Colus, *Colus halli*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Neptuneidae
Genus *Colus*

Occurrence	• Alaskan waters
Form/Function	• height slightly greater than 2X the diameter • **periostracum** chestnut brown or tan, particularly in younger specimens • height to 2.4 inches • spiral ridges faint but usually visible • without axial ribs • all whorl ridges approximately the same size
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• most common *Colus* species in northwestern Pacific region

10. **Leafy Hornmouth,** *Ceratostoma foliatum*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Muricidae
Genus *Ceratostoma*

Occurrence	• Sitka, Alaska to San Diego, California • low intertidal and subtidal to 200 feet
Form/Function	• to 3.2 inches long • shell to 4 inches high, but usually 3.2 inches high • shell ornamented with flanges that bear thorny projections
Reproduction	• spawning observed in Washington in late February and early March • previously scattered mature snails begin to form clusters • after mating, female deposits eggs in yellow egg cases, each about 0.5 inches long • eggs are attached to subtidal rocks and shells, usually at 15 – 80 feet • egg cases of females in a cluster are attached in a common mass on the substrate • a female produces, on average, 40 capsules/year, each containing 30 – 80 eggs • development occurs within egg capsules • veliger larvae are produced but undergo metamorphosis before release • after four months development time, juvenile snails emerge from egg cases and begin developing into adults (usually takes about 4 years)
Predators/Prey	• this snail is a predator, well equipped to bore through the calcareous shells of its prey; feeds mainly on barnacles, bivalves, and other snails
Noteworthy Facts ……	• the “fins” projecting from the shell may ward off would-be fish predators; these also perhaps assist the snail in landing upright when it falls more than

	20 body lengths

11. **Wrinkled Dove Snail,** *Amphissa columbiana*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Columbellidae
Genus *Amphissa*

Occurrence	• Sitka, Alaska to San Pedro (Los Angeles, California county) • low intertidal to more commonly subtidal below kelp beds
Form/Function	• shell to 1.2 inches high • shell thin with fine longitudinal ribs running from the apex to the middle body whorl and with uniform, close-set spiral threads • color highly variable; often orange or dull greenish yellow, sometimes pink, mauve or brown, often with brownish spots
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• an excellent climber, this snail can rear up, such that it is standing only on the back of the foot, and then change direction by swinging around to a new course

12. **Frilled Dogwinkle,** *Nucella lamellosa*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Nucellidae
Genus *Nucella*

Occurrence	• Bering Strait to central California • common on low intertidal rocks, especially below mussel beds
Form/Function	• shell to 2 inches long • shape highly variable • some shells smooth, others frilly with well developed ridges, projections, or spiral bands • color variable, ranging from white through orange to brown, either of a single color or banded
Reproduction	• sexually mature at 4 years • breeding occurs in winter or spring • animals aggregate in groups numbering from a few dozen to several hundred individuals; individuals tend to breed within the same group year after year • aggregations usually occur at low tide • eggs are deposited in vase-shaped, yellow egg capsules, each about 0.4 inches long; 95% of mature females in a breeding group deposit these capsules • egg capsules are attached in clusters to rock undersides • young snails develop within capsules and emerge in 140 days after deposition at lower temperatures (6 – 8 ^{o}C) and 67 – 91 days after deposition at higher temperatures (9.6 – 11 ^{o}C) • development occurs within egg capsules • more than half of the egg capsules are lost to

	predators; perhaps less that 10 of the approximately 1000 eggs produced by a female will survive to one year • young snails undergo considerable shell changes as they develop into adults
Predators/Prey	• this snail is a carnivore, feeding primarily upon acorn barnacles as well as mussels and other mollusks
Noteworthy Facts ……	• one of the most abundant intertidal whelks of the Pacific northwest

13. **Channeled Dogwinkle,** *Nucella canaliculata*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Nucellidae
Genus *Nucella*

Occurrence	• Aleutian Islands, Alaska to Cayucos (San Luis Obispo county, California) • middle intertidal
Form/Function	• shell to 1.6 inches long • shell sculptured with numerous spiral cords separated by narrow grooves that contain tiny scales • color white or dark orange with darker mottling on cords
Reproduction	• breeding occurs in spring and summer • after mating the female deposits eggs in a flask-shaped capsules (0.25 – 0.5 inch long) and attaches these to shaded areas of rocks • eggs develop within capsules and change (metamorphose) from **veligers** to juveniles and small snails, each about 0.04 inches long, emerge
Predators/Prey .....….....	• this snail is a predator and feeds mainly upon the mussel *Mytilus* and secondarily on barnacles
Noteworthy Facts ……	• common on rocks and mussel beds

14. Checkered Periwinkle, *Littorina scutulata*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Mesogastropoda
Family Littorinidae
Genus *Littorina*

Occurrence	• Kodiak Island, Alaska to Bahia de Tortuga, Baja California • high and upper middle intertidal zones on rocky shores
Form/Function ….....	• shell to 0.5 inches high, usually less • shell smooth and conical • shell brownish to nearly black, often with lighter bands or spots in a checkered pattern
Reproduction ….....	• in California breeds during all seasons except summer • females appear to lay their eggs at the waterline or under water in tide pools, usually in the evening or at night • eggs are individually contained within flattened capsules • capsules are themselves contained within a sausage-shaped gelatinous mass coiled in a spiral of 3 – 5 turns; each such mass may hold up to 2000 eggs • swimming veliger larvae hatch out in 7 – 8 days at 13 – 15 ^{o}C, but more detailed information is yet to be obtained for development in this species
Predators/Prey …..….…....	• preyed upon by carnivorous gastropods and small sea stars
Noteworthy Facts ……	• feeds mainly on films of diatoms, microscopic algae, diatoms, lichen etc. that occur upon rock which is otherwise barren • often intermediate hosts for a number of parasites, including fluke (a flatworm) larvae

15. Sitka Periwinkle, *Littorina sitkana*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Mesogastropoda
Family Littorinidae
Genus *Littorina*

Occurrence	• Kiska Island to Aleutian Islands, Alaska to Oregon, its southern limit • Intertidal
Form/Function	• shell height to 0.6 inches • shell globose and higher than wide • color variable; brown or gray, possible with light bands on upper sides of whorls; lighter colored areas may be yellow or orange
Reproduction	• unknown or information unavailable, but likely similar to that of other *Littorina* species
Predators/Prey .....….....	• unknown or information unavailable, but likely similar to the predators and prey of other *Littorina* species
Noteworthy Facts ……	• displays escape responses to sea stars

16. **Sinous/Lyre *Whelk,*** *Buccinum plectrum*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Buccinidae
Genus *Buccinum*

Occurrence	• occurs in all Alaskan seas • subtidal
Form/Function	• inside of shell opening with no dark lines • spiral shell ridges virtually microscopic • axial ribs extend to body whorl; often both irregular and oblique to shell long axis • height to 2.8 inches
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• fed upon by sea stars
Noteworthy Facts ……	• all *Buccinum* spp. respond to the presence of sea stars by rapid movements and violent twisting

17. **Hairy Triton,** *Fusitriton oregonensis*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Mesogastropoda
Family Cymatiidae
Genus *Fusitriton*

Occurrence	• Pribilof Islands and Aleutian Islands to San Diego, California • extreme low intertidal to 300 feet deep
Form/Function	• 6" high, 3" wide • very fragile shell: with thick, fibrous, brown periostracum adorned in brown, spirally-arranged bristles • shell opening is white • living tissue is pinkish yellow mottled with maroon or black
Reproduction	• female lays eggs in communal masses (up to 30 females may contribute to one such giant mass) • sometimes containing more than 2000 eggs, these masses are occasionally referred to as “sea corn” due to their resemblance to corn kernels; numerous developing eggs are in each capsule of “sea corn” • many of these eggs will function as “nurse eggs” and provide nutrients to the surviving embryos • planktonic larvae (called veligers) emerge from egg mass after 7-8 week development period and become part of the zooplankton for their next life stage
Predators/Prey .....….....	• feeds upon detritus, polychaete worms, chitons, bivalves, gastropods, sea urchins, sea stars, and tunicates
Noteworthy Facts ……	• often lays egg capsules within the “touch tank” at the Alaska SeaLife Center

18. Kennicott's Whelk, *Beringius kennicottii*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Neptuneidae
Genus *Beringius*

Occurrence	• South Central Alaska westward to Bering Sea
Form/Function	• shell length to 2.75"
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• predators unknown • preys upon small polychaetes; accomplishes this by inserting proboscis into the polychaete body and rasping off tissue
Noteworthy Facts ……	• relatively abundant in Bering Sea; a major component of large gastropod fauna there • despite this species' relative abundance in the Bering Sea, much of its basic biology remains unknown • overall, a rare northern species

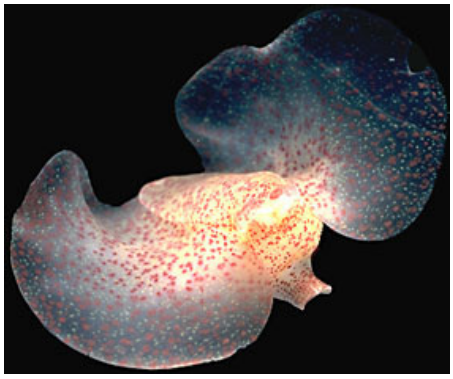
19. **Ridged Whelk/Northwest Neptune/Lyre Whelk**, *Neptunea lyrata*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Neogastropoda
Family Neptuneidae
Genus *Neptunea*

Occurrence	• Alaska to Monterey, California • Subtidal
Form/Function	• large shell reaching 4" in height • 5 robust **whorls** on shell, each adorned with evenly spaced ribs • shell opening (aperture) large • color reddish brown; sometimes darker on ribs
Reproduction	• sexual reproduction • female produces a capsule that may contain up to 5000 eggs each • groups of egg capsules are piled on one another and resemble an irregular corn cob • only 1 – 4 of the eggs in a capsule develop into embryos • remaining eggs function as "nurse eggs" by providing food for the 1 – 4 developing embryos • no planktonic stage; young hatch out in crawling stage with a tiny, hardened shell already present

Predators/Prey .....….....	• likely consumes polychaete worms and small clams and other small invertebrates • can be a scavenger and thus eat dead fish and crabs while feeding the proboscis can be extended to at least the length of the shell • this extending of the **proboscis** enables it to remove tissues of bivalve mollusks as well as soft parts of dead crab and fish tissues • proboscis also enables the lyre whelk to probe into tubular structures in search of different prey items
Noteworthy Facts ……	• salivary glands produce toxins that can cause illness in humans if ingested; this toxin is likely used during predation to paralyze prey

20. **Pacific Wingfoot Snail,** *Gastropteron pacificum*



Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Cephalaspidia
Genus *Gastropteron*
Family Gastropteridae

(Images courtesy of BioMEDIA Associates; http://www.ebiomedia.com)

Occurrence	• Aleutian Islands, Alaska to Point Loma, San Diego county, California • uncommonly on intertidal mud, more commonly subtidally to 500 feet
Form/Function	• shell to 1.33 inches long • with two large wing-like flaps extending from the lateral edges of the foot and capable of folding dorsally over the body • a light shell is hidden under the mantle • although it usually crawls along the bottom, the wingfoot snail can "take off" with its "wings" if the organism is threatened
Reproduction	• clear, gelatinous, almost globular egg mass contains widely separated, rounded capsules of spherical pink eggs
Predators/Prey	• preyed upon by carnivorous gastropods and small sea stars
Noteworthy Facts ……	• feeds mainly on films of diatoms, microscopic algae, diatoms, lichen etc. that occur upon rock which is otherwise barren

21. Yellow Edged Cadlina Nudibranch/Yellow Margin Dorid, *Cadlina luteomarginata*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Subclass Orthogastropoda
Order Opisthobranchia
Suborder Nudibranchia
Family Chromodoridae
Genus *Cadlina*

Occurrence	• Lynn Canal, Alaska to Point Eugenia, Mexico • intertidal to 100’
Form/Function	• to 2” long • body white with a yellow margin • large, low antennae are yellow-tipped
Reproduction	• specific reproductive information for this species unknown • in general, hermpaphroditic sea slugs lay ribbon-like egg clusters
Predators/Prey .....….....	• predators unknown or information unavailable • preys largely upon a number of different sponge species
Noteworthy Facts ……	• any of the yellow markings may be absent from some individuals

22. **Gold Dirona,** *Dirona aurantia*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Nudibranchia
Family Dironidae
Genus *Dirona*

Occurrence	• Southern Bering Sea, Alaska to Puget Sound • to 180 feet
Form/Function	• to 4.5 inches long • foot broad, rounded anteriorly, and tail bluntly pointed • basic color is orange throughout; body scattered with white, granular spots though none appear on the underside of the foot or the oral veil
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• feeds on algae, hydroids, bryozoans, gamarid, and caprellid amphipods
Noteworthy Facts ……	• divers remark that the bright colors of this nudibranch often contrast with the comparatively duller colors of other marine organisms inhabiting the same area

23. **Red Gilled Aeolid**, *Flabellina triophiona*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Nudibranchia
Family Flabellinidae
Genus *Flabellina*

Occurrence	• Aleutian Islands, Alaska to Oregon • subtidal to 200 feet
Form/Function	• to 4 inches long • cerrata color varies between pink and reddish brown • perfoliate **rhinophores**
Reproduction	• unknown or information unavailable
Predators/Prey	• feeds on a variety of hydroids, other aeolids, amphipods, crustaceans, polychaete worms
Noteworthy Facts ……	• very little is presently known of this attractive nudibranch • as a defense mechanism to elude predators, the related *F. iodinea* can lift off the substrate and undulate its body from side to side to remain in the water column where currents may carry it away to safety; perhaps a similar such evasion tactic is utilized by *F. triophiona*

24. Sea Lemon Nudibranch, *Anisodoris nobilis*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Nudibranchia
Family Discodorididae
Genus *Anisodoris*

Occurrence	• Kodiak Island and Washinton Bay, Kuiu Island, Alaska to Ensenada, Baja California, Mexico • intertidal to subtidal
Form/Function	• to 8 inches long • bright orange-yellow to light yellow color • gills, gill edge, and foot white • dorsal surface covered in tubercles that are somewhat inflated towards tips • dark spots on dorsal surface but not on tubercles
Reproduction	• produces a light yellow egg mass
Predators/Prey .....….....	• reported to feed upon at least 9 different sponge species
Noteworthy Facts ……	• when handled emits a sweet, lemon scent • apparently contains a toxic substance that deters predation by fishes

25. Giant White Dorid, *Archidoris odhneri*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Nudibranchia
Family Archidorididae
Genus *Archidoris*

Occurrence	• Kenai Peninsula, Alaska to Point Loma, California • subtidal to 75 feet, rarely intertidal
Form/Function	• pure white; a yellow phase has been reported from Puget Sound and British Columbia • rhinophores with 20 - 24 lamellae • gills with 7 fluffy plumes • 4 – 8 inches long
Reproduction	• reproductive information for this species not found, but other members of this genus are hermaphroditic and thus have both male and female reproductive organs • eggs of other species within this genus are deposited in ribbon-like clusters
Predators/Prey	• feeds on sponges
Noteworthy Facts ……	• extracts from this and other dorid species were found to be lethal when injected in crabs or mice; this property protects it from fish predation

26. The Shaggy Mouse Nudibranch, *Aeolidia papillosa*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Order Nudibranchia
Family Aeolidiidae
Genus *Aeolidia*

Occurrence	• North Atlantic, California to north Pacific; cosmopolitan • low intertidal to subtidal (to about 2500 feet)
Form/Function	• to 4 inches long • dorsal side is covered with cerata, which have the appearance of a shag rug • cerrata are flattened and lack conspicuous longitudinal membranes • conspicuous area between head tentacles and rhinophore base is distinctive (usually an opaque white) • basic color is white to brown
Reproduction	• eggs are laid in thin-walled egg capsules crowded into a large, untidy, pink or white egg string • examples living on mudflats often lay eggs on eel grass
Predators/Prey	• feeds mainly on sea anemones; shows a preference for eating anemones that have already been damaged • in order to avoid being stung by anemone nematocysts, this species first approaches the potential prey cautiously and covers it with a mucus; the gut is lined with a protective tissue layer that prevents the nematocysts from causing extensive damage there
Noteworthy Facts ……	• unexploded nematocysts obtained from food are stored in special compartments (cnidosacs) located at the tips of the cerata; these nematocysts are then extruded from the **cnidosacs** if the nudibranch is attacked by a fish predator • ;does not occur in Alaskan waters but included as this species is of interest and does occur in the northern Pacific

27. **Orange Peel Nudibranch,** *Tochuina tetraquetra*

Kingdom Animalia
Phylum **Mollusca**
Class **Gastropoda**
Subclass Orthogastropoda
Order Opisthobranchia
Suborder Dendronotina
Family Tritoniidae
Genus *Tochuina*

Occurrence	• Southern Bering Sea, Alaska to Los Angeles, California; benthic, shallow subtidal
Form/Function	• to 12” long • color ranges from pale yellow to orange to deep reddish orange • white-tipped tubercles covering dorsal mantle surface • mantle fringe adorned in branched, white gills
Reproduction	• specific reproductive information for this species unknown or unavailable • in general, this and other hermpahroditic sea slugs lay ribbon-like egg clusters
Predators/Prey .....….....	• predators unknown • preys upon hydroids, soft corals, and sea pens
Noteworthy Facts ……	• the largest nudibranch in the world • known there as “tochni”, it is eaten either raw or cooked in The Kuril Islands of Russia

- **Chitons** : Class Polyplacophora
  - 600 existing described species
  - 350 fossil species described
  - body ovoid and flattened
  - very adapted for adhering to rocks
  - bilaterally symmetrical
  - shell comprised of eight overlapping plates (called valves)
  - depending upon species, range in size from 1 to 12 inches
  - like snails, have a creeping foot
  - nervous system primitive and poorly developed
  - sexes are separate; hence, reproduction is sexual

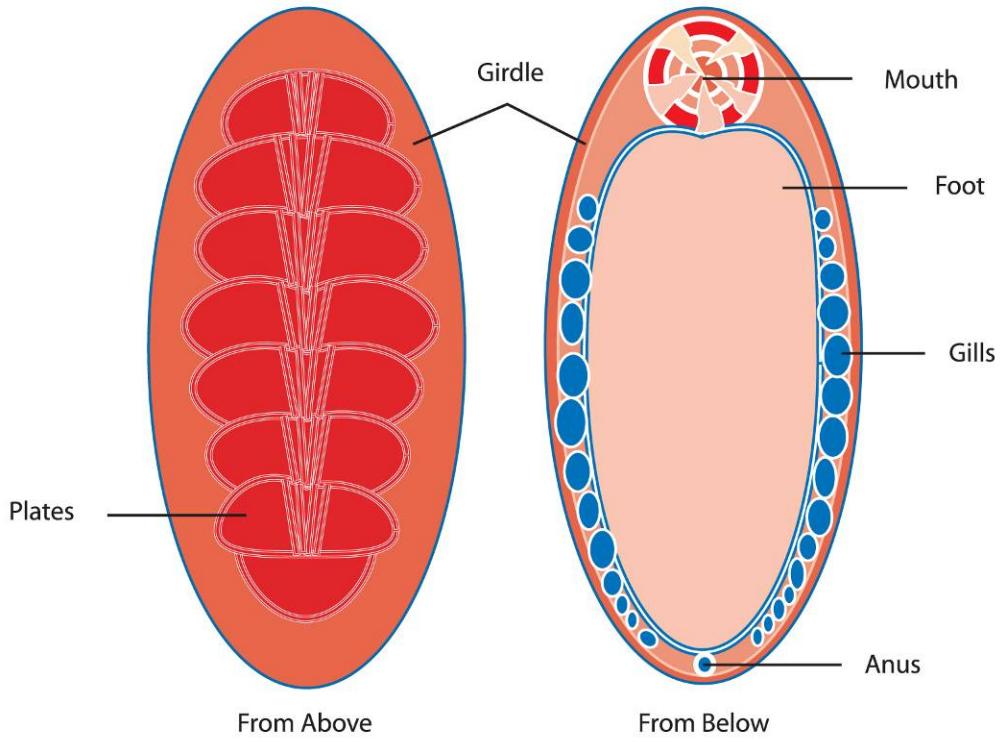


Fig. XIII. 3. Chiton External Anatomy (dorsal and ventral sides)

Chitons Maintained at the Alaska Sea Life Center

28. Lined Chiton, Tonicella lineata

Kingdom Animalia
Phylum **Mollusca**
Class Polyplacophora
Order Neoloricata
Family Lepidochitonidae
Genus *Tonicella*

Occurrence	• Adak Island, Aleutian Islands, Alaska, to Monterey, California • low intertidal and subtidal
Form/Function	• length approximately 1.8" • smaller (about 1") in Juneau area • bright red is basic shell color, interfused with white and maroon brown or black lines • dark, wavering lines found on head and tail regions of shell (used to identify this species)
Reproduction	• sexual • reddish eggs stream from posterior end of female
Predators/Prey .....….....	• consumed by harlequin ducks and river otters in Alaska • feeds on microorganisms which are on the surface of algae; occasionally eats small crustaceans
Noteworthy Facts ……	• most common *Tonicella* species in southeastern Alaska • other *Tonicella* species that occur alongside the lined chiton: • 1. white-line chiton, *Tonicella insignis* • 2. northern red chiton, *Tonicella* spp. • young live offshore and migrate inshore as they develop

29. **Red Veiled-Chiton,** *Placiphorella rufa*

Kingdom Animalia
Phylum **Mollusca**
Class Polyplacophora
Order Neoloricata
Family Mopaliidae
Genus *Placiphorella*

Occurrence	• Aleutian Islands, Alaska to Southern Oregon • low intertidal to 150 feet
Form/Function	• up to 2" long • oval shape • red dull color to shell • the girdle (i.e., the fleshy portion of the animal that extends out beyond the margins of the shell) is broad, tan colored (can also have green mottling), and contains many bristles at its margin • anterior (i.e., front) portion of girdle very enlarged and contains tentacles
Reproduction	• sexual
Predators/Prey .....….....	• only chiton known to be a predator • feeds by raising girdle at 45^{o} angle off of substrate and waiting for an invertebrate or a small fish to swim beneath, upon which the red veiled chiton smothers it and begins feeding • also feeds upon microalgae
Noteworthy Facts ……	• only chiton species to feed by trapping prey under girdle

30. Black Katy Chiton, *Katharina tunicata*

Kingdom Animalia
Phylum **Mollusca**
Class Polyplacophora
Order Neoloricata
Family Mopaliidae
Genus *Katharina*

Occurrence	• Cook Inlet, Alaska to Catalina Island, California • intertidal zones of wave-impacted rocky shores
Form/Function	• length to 5 inches • notable for black, leathery girdle that almost covers the entire shell • only a small portion of the dorsal area of each valve is exposed • clings to sides and upper surfaces of rocks exposed to strong wave action
Reproduction	• spawns March to July depending on latitude, with later spawning occurring further north • eggs are green
Predators/Prey .....….....	• feeds on brown and red algae and on benthic diatoms
Noteworthy Facts ……	• a variety of plants and animals, including coralline algae, hydroids, bryozoans, and barnacles, attach to the exposed portions of the valves • an important subsistence food in southcentral Alaska and the Aleutians; *Katharina* chiton valves are found in ancient shell middens in archaeological sites

31. **Mossy Chiton**, *Mopalia muscosa*

Kingdom Animalia
Phylum **Mollusca**
Class Polyplacophora
Order Neoloricata
Family Mopaliidae
Genus *Mopalia mucosa*

Occurrence	• Queen Charlotte Islands, British Columbia to Isla Cedros, Baja California, California • middle and low intertidal zones of in regions of low to moderate surf
Form/Function	• to 3.5 inches long • valve surfaces lusterless, sometimes sculptured with wavy riblets, but often eroded or overgrown by marine organisms • valves dull brown, blackish olive, or grayish, rarely tinted with red, orange, or green • girdle tan or cream colored and hairy in appearance
Reproduction	• spawning noted in April and May in Monterey Bay, California and July to September in central and northern California • eggs and sperm often shed in tide pools • eggs green or golden brown in color, 0.29 mm diameter • hatch in 24 hours • larvae swim freely for several days; mantle, foot, and eyes develop at this time • settlement occurs about 11.5 days after fertilization if an adequate substrate is present • first seven shell plates present at 13.5 days
Predators/Prey .....….....	• feeds primarily upon red and green algae • preyed upon by the sea star *Pisaster ochraceus*
Noteworthy Facts ……	• attain sexual maturity in two years • common on rocks and in tidepools

32. Giant Gumboot Chiton, *Cryptochiton stelleri*

Kingdom Animalia
Phylum **Mollusca**
Class Polyplacophora
Order Neoloricata
Family Acanthochitonidae
Genus *Cryptochiton*

Occurrence	• Japan through Aleutian Islands, Alaska, to Southern California • low intertidal to 65 feet
Form/Function	• largest chiton in world; reaches 13" long • in Alaska, intertidal examples are up to 6" long • mantle (fleshy portion of animal) completely covers the eight white plates beneath (thus, the genus name, *Cryptochiton*, means "hidden chiton") • all plates butterfly-shaped except first • lower surface a dirty yellow color
Reproduction	• sexual • small, green eggs laid in gelatinous strings; wave action breaks them up • two days of development at 11^{o} C allows juvenile forms (called trochophores) to become component of zooplankton, their next life stage
Predators/Prey	• in northern California the predaceous snail *Ocenebra lurida* rasps pits in the upper surface exposing the yellow flesh covering the white plates
Noteworthy Facts ……..	• although sometimes consumed by humans, it is very good conservation practice not to eat this slow-to-reproduce species

	• was traditionally used as food by coastal Indians

- Clams, Oysters, and Mussels : Class Bivalvia
  - a shell with two halves
    - great variety of shell shapes and sizes among different species
    - composed of calcium carbonate
  - muscles pull shell halves together
  - possess head very reduced in size
  - gills are very large and in many species are involved in both food collection (via filtering mechanisms) and gas exchange
  - most species of clams adapted as soft mud or sand burrowers
    - upon burrowing in mud, both an inhalent and an exhalent siphon extend to the overlying water; particulate organic material brought in via intake siphon is filtered for use as food
  - some species are surface dwellers, typically on rocky shores
  - certain species inhabit this realm by secreting tough cords (called byssal threads) that enable them to attach strongly to the surface of submerged items
  - other species cement one of their shell halves to the rocky substrate surface
  - some bivalves are able to bore into sedimentary rock and one species bores into wood; although it is not a worm, it is called a shipworm (*Teredo*)
  - scallops are surface dwellers that swim by rapidly opening and closing their shells on the sediment bottom to create a powerful current that enables them to swim
  - relatively simple nervous system
  - sexes separate in most species
    - some hermaphroditic (i.e., female and male reproductive systems in one individual) examples exist

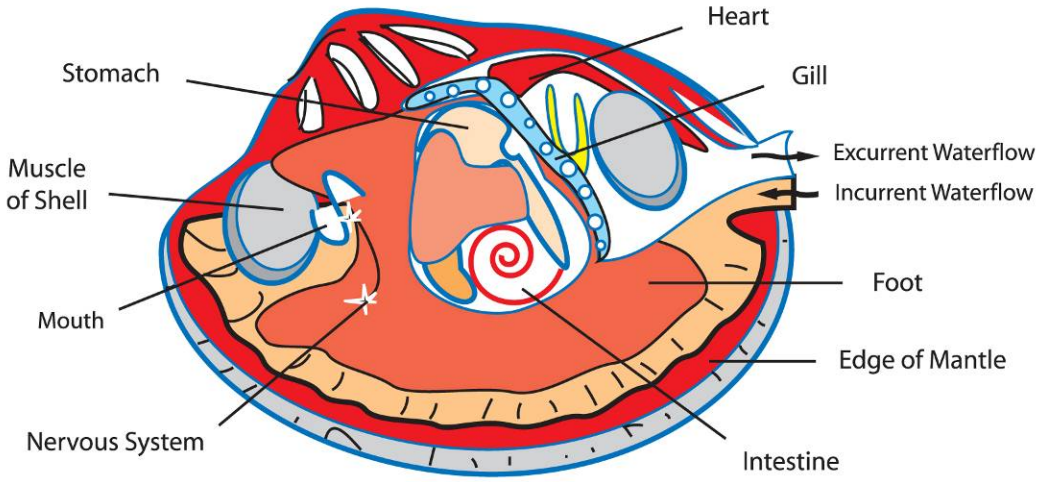


Fig. XIII. 4. Generalized Clam Anatomy: note Inhalent and Exhalent Siphon Tubes

Bivalves Maintained at the Alaska Sea Life Center

33. Pacific Weathervane Scallop, *Patinopecten caurinus*

Kingdom Animalia
Phylum **Mollusca**
Class **Bivalvia**
Subclass Pteriomorpha
Order Ostreoida
Family Pectinidae
Genus *Patinopecten*

Occurrence	• throughout eastern North Pacific Ocean; range in the northeastern Pacific Ocean from the Pribilof Islands, Alaska and the southern Bering Sea to Point Reyes, California • occurs on sand, gravel, and rocky bottoms at depths of 6 - 950 feet
Form/Function	• up to 8 inches across • shell of brownish color • has characteristic scallop “wings” at hinge area • prominent ribs on shell outside • the thin shell of scallops in general serves to lighten the animal and is therefore an adaptation to swimming • occur as aggregations of many individuals; called beds • swimming movements may enable it to reach distances of 20 feet; swimming can last for 15 - 20 seconds • rapid opening and closing of scallop shell produces power that enables scallop to swim • can detect movement with numerous eyes on mantle around opening of shell perimeter
Reproduction	• sexes are separate (**dioecious**) • spawn in June and July

	• sperm and ova released into water, whereupon ova become fertilized and descend to bottom • larvae drift after one month and drift as zooplankton • in two to three weeks sufficient shell mass has been formed and the settle upon substrate or seaweeds • in four to eight weeks juveniles have developed ability to swim
Predators/Prey .....….....	• preyed upon by sea stars, various fish species, birds, and marine mammals • filter feeders • feeds on many living components of the plankton, including both phyto- and zooplanktonic species
Noteworthy Facts ……	• may live up to 18 years • commercial harvest of Alaskan weathervane scallops is approximately 800,000 pounds (not including shells); fishery sporadic due to overexploitation; are sexually mature at three to four years of age • age can be determined by counting concentric rings on shell (much like tree rings); these rings form in response to yearly seasonal changes in phytoplankton availability as food related to warming and cooling of water summer to winter respectively

34. Bay/Blue Mussel, *Mytilus trossulus*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Mytiloida
Family Mytilidae
Genus *Mytilus*

Occurrence	• Chukchi Sea to northern California • occurs through the intertidal zone to a depth of 16 feet
Form/Function	• 2.5 to 4 inches long with a long, rounded triangular shape • shell shiny blue-black to brownish • attaches to the substrate via long, fine byssal threads
Reproduction	• while spawning occurs when temperatures reach 12^{o}C (May) along coastlines of temperate regions, in Alaskan waters spawning begins in late Spring at water temperatures ranging from 5^{o} to 10 ^{o}C • spawning in Alaska waters heaviest in May and June • females release three to six million eggs into the water column; males release sperm here • after a 3 – 4 week planktonic existence, larvae settle out onto algae-encrusted substrate and metamorphose into small mussels
Predators/Prey	• preyed upon by sea stars, gastropods, crabs, and sea otters • suspension feeders

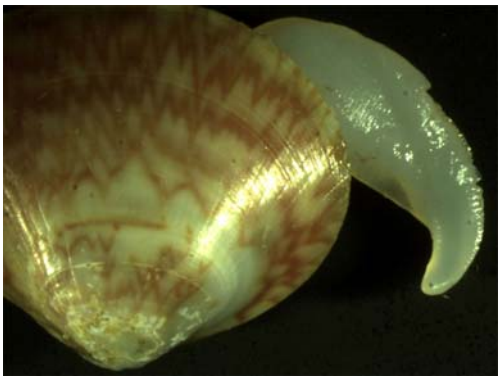
Noteworthy Facts ……	• tangled mass of mussels and their byssal threads form habitats for many other organisms

35. **Horse Mussel,** *Modiolus modiolus*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Mytiloida
Family Mytilidae
Genus *Modiolus*

Occurrence	• Vancouver island, British Columbia to Gulf of California; also occurs in the southeastern Bering Sea off of the Aleutian Islands
Form/Function	• normally 4.5 inches long but may reach 8.5 inches • shell thick, shiny, brown, heavily beaded on posterior end • shell bluish under periostracum and white internally • soft parts yellow-orange • attaches to the substrate via long, fine byssal threads
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• suspension feeders • normally lives embedded within mud, sand, or gravel with only the posterior tip of the shell and yellow mantle showing; attaches to buried rocks via strong byssal threads

36. **Greenland Cockle,** *Serripes groenlandicus*



Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Veneroida
Family Cardiidae
Genus *Serripes*

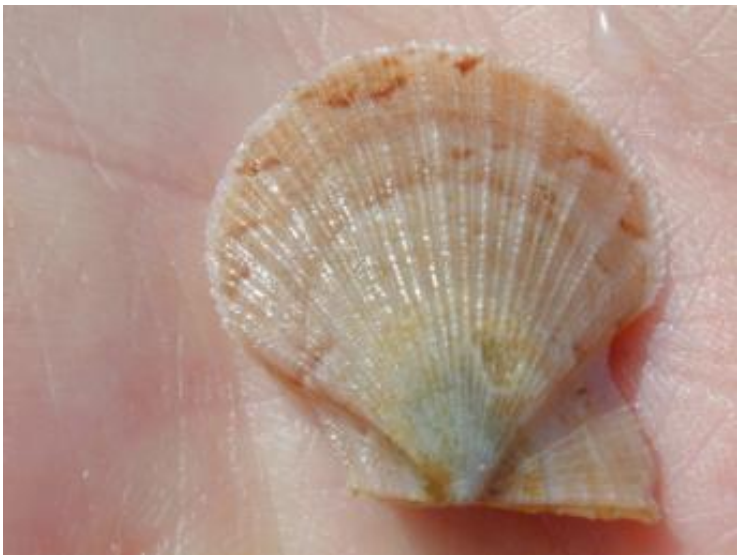
Occurrence	• Alaska to Puget Sound, Washington; Arctic Seas to Cape Cod, Massachusetts • intertidal to 268 feet
Form/Function	• shell to 4.5 inches diameter • shell length greater than height • ribs low and radial; often worn away at shell middle • posterior portion tapered • tan to light green or brown periostracum • interior color varies from white to pale yellow
Reproduction	• separate sexes, usually not apparent based upon shell structure • fertilization occurs within mantle cavity • young hatch as pelagic larvae
Feeding Method	• unknown but other cockles are suspension feeders • fed upon by sea stars, walrus, and bearded seals
Noteworthy Facts ……	• preyed upon by the giant pacific octopus • this cockle probably uses its mobile foot as an escape mechanism as in *Clinoardium*

37. **Cockle**, *Clinocardium nuttallii*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Veneroida
Family Cardiidae
Genus *Clinocardium*

Occurrence	• Bering Sea to San Diego, California • low intertidal to depths of 680 feet • lives on or just beneath the surface of fine sediments
Form/Function	• shell to 3.2 inch diameter • shell has 34 radial ribs crossed by growth concentric rings • ribs and grooves at edges of the two valves interlock • periostracum brown • shell buff mottled with brown or red • soft parts yellowish white
Reproduction	• are hermaphroditic (i.e., both sexes contained in a single individual) • breeding occurs in summer for individuals 2 years and older
Predators/Prey	• preyed upon by sea stars • suspension feeders
Noteworthy Facts ……	• the powerful, protruding foot of this species enables it to have a remarkable, leaping escape reaction to certain species of predatory sea stars

38. Spiny Pink Scallop, *Chlamys hastata*



Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Ostreoida
Family Pectinidae
Genus *Chlamys*

Occurrence	• Southern Alaska to Santa Barbara, California • subtidal to 500 feet deep
Form/Function	• shell 2.2 inches across • oval with upper valve slightly more convex than lower • approximately 50 ribs radiating from the hinge • wing-like hinges are called ears • front ears slightly more than twice as long as hind ears • cream colored mantle exposed when valves are agape and many small tentacles with small, dark eyes at the base • pink, pinkish-gray, or cream sometimes with dark patterns arranged concentrically around the shell
Reproduction	• free-spawning organisms, reproduction occurs through release of eggs and sperm into the water
Predators/Prey	• preyed upon by sea stars
Noteworthy Facts ……	• filter feeders • although it anchors itself via byssal threads, the spiny pink scallop is also an accomplished swimmer (thus called a swimming scallop) • often encrusted with sponges, which function to camouflage the scallop and thereby protect it from

	predators

39. **Smooth Pink Scallop**, *Chlamys rubida*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Ostreoida
Family Pectinidae
Genus *Chlamys*

Occurrence	• Southern Bering Sea, Alaska to Santa Barbara, California • subtidal to 660 feet deep
Form/Function	• shell to 4 inches across • oval with upper valve slightly more convex than lower • ribs radiate from the hinge • has wing-like hinges are called ears
Reproduction	• free-spawning organisms, reproduction occurs through release of eggs and sperm into the water
Predators/Prey .....….....	• preyed upon by sea stars • filter feeders
Noteworthy Facts ……	• opens and closes valves to swim away from predators (e.g., certain sea star species); while swimming, the scallop has the appearance that it is gulping water as it sucks in water by opening the valves and then ejects the water such that it is propelled through the water

40. **Rock Scallop**, *Crassadoma gigantea*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Ostreoida
Family Pectinidae
Genus *Crassadoma*

Occurrence	• Southern Alaska to Santa Barbara, California • subtidal to 500 feet deep
Form/Function	• shell to 10 inches across (maximum) • shell round and thick • orange mantle with sensory tentacles and blue eyes fringing the shell • juvenile life stage is free but adults are permanently attched to the substrate by one valve
Reproduction	• sexes separate, though hermaphrodites have been reported • because more large adults are females rather than males, it has been suggested protandry (i.e., functioning initially as males but later becoming females); alternatively, perhaps females simply have a greater survival rate in California, rock scallops spawn two times per year: first in late spring/early summer and later in mid fall
Predators/Prey .....….....	• preyed upon by sea stars, crustaceans, and sea otters
Noteworthy Facts ……	• filter feeders • one of the largest scallops in the world, it is much sought after as food by humans

*41. **Rock Jingle,** Pododesmus cepio, P. macrochisma*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Ostreoida
Family Anomiidae
Genus *Pododesmus*

Occurrence	• Chukchi Sea to Cabo San Lucas, Baja California; occurs in Prince William Sound • near low tide level and subtidal
Form/Function	• shell to approximately 1.75 inches across • shell rounded in outline, translucent, sculptured with irregular branching radial ribs • attach to one side of substratum by tissues projecting through opening near hinge of lower right valve • valves unequal, with lower valve thin and conforming to the substrate • upper valve convex above, its inner surface highly polished, irredescent green, and bearing two well-marked muscle scars • soft parts bright orange
Reproduction	• studies of reproduction in Tomales Bay (Marin County, California) revealed that gametes form in late November, gonads enlarged in the spring, and spawning occurred in July and August
Predators/Prey .....….....	• preyed upon by sea otters in Alaska
Noteworthy Facts ……	• a remarkable clam that is distantly related to mussels and scallops • although edible, rarely used for human consumption

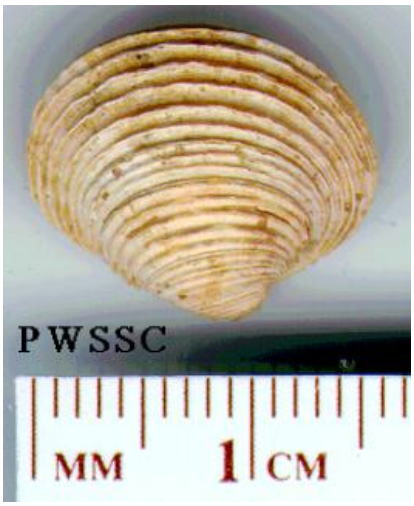
42. **Pacific Littleneck Clam,** *Protothaca staminea*

Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Veneroida
Family Veneridae
Genus *Protothaca*

Occurrence	• Aleutian Islands, Alaska to Cabo San Lucas, Baja California • middle to low intertidal
Form/Function	• shell 2.4 inches across • oval in outline with fine radial ribs crossed by many weak, concentric ridges • shell whitish or tan with angular pattern of chocolate brown
Reproduction	• sexes separate • studies in British Columbia revealed that the gonads enlarge in the winter, reach peak size in March, and release gametes from April through September • swimming larvae settle and develop rudimentary gonads at a shell length of 1 mm; later, at 15 – 30 mm shell lengths, sexual differentiation occurs • sexual maturity reached at 22 – 35 mm shell lengths • spawning in females in Prince William Sound, Alaska occurred from June to September with the major spawning effort in June • in British Columbia spawning occurs from April to October • a shortened spawning period is characteristic of clams at the northern and southern limits of their range; apparently a temperature-related effect
Predators/Prey …….	• preyed upon by drilling snails, the sea star *Pycnopodia*, sea ducks and sea otters

	• siphon growth is reduced by fishes nipping at them
Noteworthy Facts ……	• filter feeder • one of the most abundant west coast clams and prized as fine table fare everywhere; now supplanted in markets by the faster growing Japanese littleneck clam that is grown commercially along the Pacific coast • often contains large numbers of larval tapeworms, which are killed in cooking

43. **Kennerley's Venus,** *Humilaria kennerleyi*



Kingdom Animalia
Phylum **Mollusca**
Class Bivalvia
Order Veneroida
Family Veneridae
Genus *Humilaria*

Occurrence	• Cook Inlet, Alaska to Santa Rosa Island, California • intertidal to 140 feet
Form/Function	• shell 4 inches across • shell closes tightly at posterior end • concentric ridges bent in the direction of the umbones
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• filter feeders • the biology of this bivalve is poorly understood

- **Octopus, Squid**, and related organisms : Class Cephalopoda
  - includes octopuses, squids, cuttlefish, and *Nautilus*
  - certain species are the largest invertebrates
  - 720+ described living species
    - 7,500 different fossil forms described
  - class is adapted to an active, predatory existence on the bottom or in the water column
  - movement made possible by expulsion of a jet of water from a specially designed body cavity (called the mantle cavity); water is squeezed out via muscle contraction; or, in the case of the bottom dwelling octopus, the arms are used to move about on the substrate
  - squids live in the water column and have greatest swimming speed of any aquatic invertebrate
  - arms located at anterior region of body
  - the outside shell is only retained in nautili and is reduced or lost in adults
  - shell in squids and cuttlefish has been internalized
  - shell reduced or absent in all other cephalopods
  - great range in size: from very small species of squid (perhaps just over two inches long) to 60 feet long (giant squid)
  - circulation of water in mantle cavity oxygenates gills
  - all are adapted to a carnivorous feeding style and diet
  - circulatory system is closed in most taxa and therefore is the most sophisticated of this system to be found among mollusks
    - blood vessels extensively developed
  - nervous system most extensively developed of all invertebrates
    - brain well developed
      - cephalopods are most intelligent of invertebrates; display capacity to learn
  - along with a well-developed nervous system are found well-developed sensory structures
    - eyes are very well developed in squid, octopus, and cuttlefish
    - eyes present but reduced in deep sea taxa
  - rapid color changes in surface of squids, octopus, and cuttlefish made possible by nervous system causing contraction or relaxation of muscles surrounding bags of pigment in the skin; these bags are called **chromatophores**
  - cephalopods other than the *Nautilus* produce ink that is ejected from near the anus when the organism is threatened; this may function to confuse the would-be predator with a false image or perhaps it interferes with chemical perception (e.g., smell and taste capabilities) of potential predator
  - deep sea cephalopods that live in the dark eject luminescent ink, the function of which remains undetermined
  - cephalopods have separate sexes and therefore reproduce sexually
  - beaklike jaws and radula (both used for feeding) are present in all cephalopods

Cephalopods Maintained at the Alaska Sea Life Center

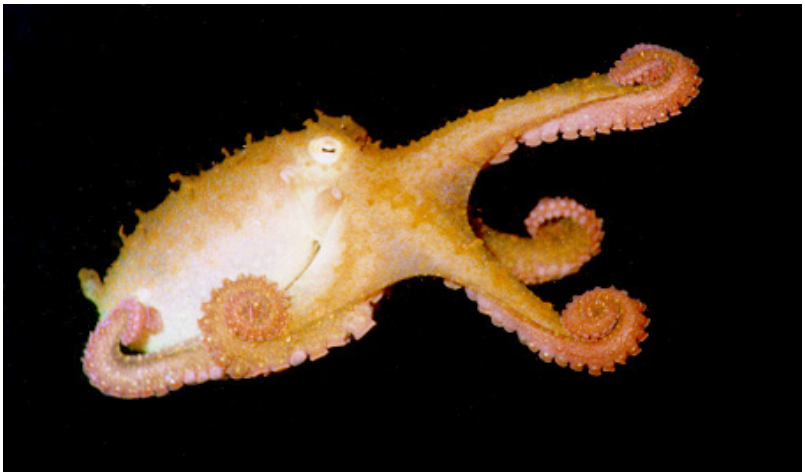
44. Robust Clubhook Squid (= Pacific Giant Squid), *Moroteuthis robustus*

Kingdom Animalia
Phylum **Mollusca**
Class **Cephalopoda**
Order Teuthoidea
Suborder Oegopsida
Family Onychoteuthidae
Genus *Moroteuthis*

Occurrence	• throughout North Pacific, including waters of Alaska, Japan, Kuril Islands, Vancouver Island, along Pacific coast to southern California • usually found at depths of 300 to 2000 feet deep and even deeper
Form/Function	• can reach lengths of over 12 feet • main body (i.e., minus tentacles and arms) up to 7 feet long • has eight arms and two tentacles, both longer than the arms • two rows of sharp hooks at terminals of the two tentacles
Reproduction	• separate sexes • sperm packaged in **spermatophores** and inserted into the mantle cavity of the female
Predators/Prey	• important prey item of sperm whales • stomach of a trawled individual found to contain a heart urchin and (*Brisaster latifrons*) a jellyfish (*Velella velella*); other prey items taken as yet unknown
Noteworthy Facts ……	• not largest squid in Pacific because the giant squid (genus *Architeuthis*, up to 57 feet long) also sometimes occurs in the North Pacific as well

	• occasionally captured in trawling nets or found washed up on the beach • the specimen at the Alaska Sea Life center is a preserved individual that was one of two found washed up in the Aleutian Islands in the year 2000 • squids, being highly mobile, rapid swimmers and yet soft-bodied • due to their soft bodies they do not live long in aquarium environments

45. **Red Octopus,** *Octopus rubescens*



Kingdom Animalia
Phylum **Mollusca**
Class **Cephalopoda**
Order Octopoda
Family Octopodidae
Genus *Octopus*

Occurrence	• Alaska to Scammon Lagoon (Baja California) and Gulf of California • low intertidal to subtidal at depths of 660 feet
Form/Function	• body mantle 2 to 4 inches across • body round to ovoid in shape • body dull red or reddish brown in color; often mottled with white • skin bearing papillae, often with cirri • arms approximately four times the body length
Reproduction	• females are found protecting their egg clusters from late spring through early winter in rocky intertidal and subtidal areas • peak breeding season August through September • young hatch in 6 - 8 weeks • after a brief period in the plankton, young metamorphose in surface waters and finally settle as juveniles in kelp beds • juveniles feed for a while near or at the kelp holdfasts and thereafter move farther offshore to the sandy mud areas • mating occurs in deep water during later winter and early spring • after mating, the red octopus adult population

	moves inshore (males moving first) to spawning grounds • as is the case with *Octopus bimaculoides*, which is present in California and Baja California waters, the female *Octopus rubescens* probably dies after eggs hatch
Predators/Prey .....….....	• consume crustaceans, mollusks, and fishes
Noteworthy Facts ……	• although the red octopus the most common octopus found in shallow subtidal waters from Alaska to Baja California, as of 2004 there has not yet been one collected for display at the ASLC as it has not yet been encountered on local dives • it is not recommended to handle a small octopus as a puncture wound may result from the beaklike jaws (used for feeding) and, for some species, such a wound may contain poison secreted from salivary glands

46. Giant Pacific Octopus, *Enteroctopus dofleini*

Kingdom Animalia
Phylum **Mollusca**
Class **Cephalopoda**
Order Octopoda
Family Octopodidae
Genus *Enteroctopus*

Occurrence	• coastal waters of northern California through Gulf of Alaska and around Pacific Rim to Japan and Korea • mostly subtidal to depths of 100 m; small individuals may be occasionally found in tide pools
Form/Function	• average adult weight is 50 lbs. • average arm-spread from tip to tip is 12 - 16 feet; may reach more than 30 feet in very large specimens • prefer soft sediment with intermittent boulders as the octopus will excavate a den beneath the boulder
Reproduction	• male has "reproductive arm" that inserts a sperm packet into the female near her egg tube (**oviduct**), thus fertilizing the eggs • female lays tens of thousands of eggs in her protective den • female remains with eggs, cleaning and aerating them by siphoning a jet of water over them • female dies after eggs hatch
Predators/Prey	• preyed upon by larger octopus of same species, dogfish (a shark), halibut and other flatfish species, sea lions, sea otters • voracious feeders, they consume crabs, clams, and other invertebrates

Noteworthy Facts ……	• largest octopus in the world • 5 year life span • it is suggested that giant pacific octopuses not be harvested from the Prince William Sound area as their numbers appear to have dwindled in the wake of the 1989 Exxon Valdez oil spill • one of the Alaska SeaLife Center's most fascinating exhibits (!!)

XIV. Sea Lilies, Sea Urchins, Sand Dollars, Sea Cucumbers, and Sea Stars: Kingdom Animalia, Phylum Echinodermata

The Echinoderms are familiar as sea stars/starfish, brittle stars, sea urchins, and sea cucumbers. Another group within this phylum, the chrinoids, have a very palm tree-like appearance but are, nonetheless, another example of Echinoderm. Exclusively marine, Echinoderms inhabit virtually all depths of the world's oceans and seas. Let's begin with a brief overview of this important invertebrate group, represented by no less than 42 different species at the Alaska SeaLife Center.

Echinoderm Characteristics:

- among most familiar invertebrates known
- 6000 known species
- exclusively marine (i.e., saltwater)
- **pentamerous** radial symmetry (i.e., the body may be divided into five segments about a central axis)
- this, however, does not place them in close relationship to other radially symmetrical animals, such as sponges and cnidarians; this is because the radial symmetry develops secondarily after an initial bilaterally symmetrical larval stage of development
- possess pedicellaria
- possess an internal skeleton made up of calcareous (i.e., made of calcium carbonate) **ossicles** (small, spiny structures which collectively form echinoderm skeleton)
    - ossicles may articulate with one another as in sea stars with mobile arms
    - ossicles may be linked to one another to form a rigid skeletal shell (**test**), such as in sea urchins and sand dollars
- projections on body surface typically give appearance of a bumpy, spiny skin (echinoderm means "spiny skin")
- possess an internal water vascular system
    - though originally used to transport food, it is believed that over time this vascular system has enabled more advanced forms to move
- respiratory structures vary
- possess a well-developed digestive tract, but this varies in structure as per the various echinoderm groups
- no excretory system present
- some non-predatory stars feed on mud while others are suspension feeders
- most species have separate sexes
    - fertilization of eggs takes place in sea water and planktonic larvae are produced; a number of species have direct development and brood young that are released as small versions of the adult (e.g., *Leptasterias* and *Henricia* spp.)

- **Sea Stars** : Class Stelleroidea; Subclasses Asteroidea and Ophiuroidea

- star-shaped, freely mobile echinoderms
- body comprised of rays or arms projecting from a central disc
- two subclasses

    1. Asteroidea : **sea stars**
    2. Ophiuroidea : **brittle stars**

Sea Stars; Subclass Asteroidea

- 1600 described species
- occur in coastal waters throughout the world
- greatest concentration in the world is found in northeast Pacific, especially Puget Sound to the Aleutians
- colors vary with different species from a more common drab yellow to many brightly colored, and even multi-colored, examples
- symmetry is usually pentamerous (five equal divisions about a central axis)
- some species, however, may have 7 to 40 arms (see sunflower and sun stars below)

Fig. XIV. 1. Pentamerous Symmetry Characteristic of Sea Stars (photograph is of the bat star, *Patiria miniata*)

- size usually about 3 - 6 inches
- one species of the northwestern U.S. may attain a diameter of more than three feet
- unlike brittle stars (see below), arms of sea stars are not sharply set off from the **central disc**
- width of arm usually increases with closer proximity to the central disc
- mouth positioned at center of central disc underside
- entire undersurface called the **oral surface**
- entire top surface called the **aboral surface**
- a radial furrow, called an **ambulacral groove**, extends from the mouth to through the arm undersurface

- 2 - 4 rows of projections called **tube feet** , or **podia**, extend from the ambulacral groove
- the sea star uses these tube feet to move about
    - tube feet are moved by the water vascular system
- moveable spines guard the ambulacral groove; these spines can even close the groove altogether
- the digestive system consists of an oral area, cardiac and pyloic stomach areas, and a diminutive intestine that ends in an anus

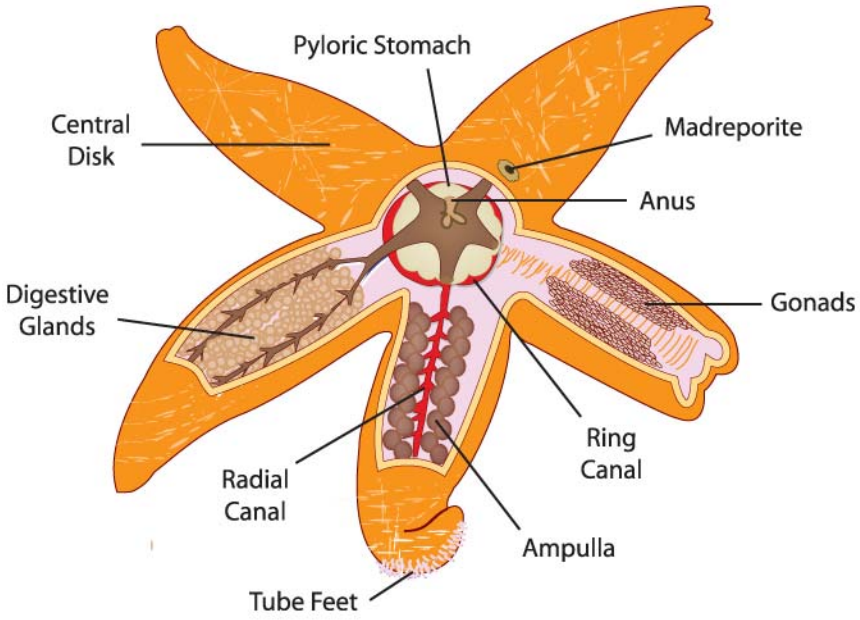


Fig. XIV. 2. Sea Star; note structures

- **madreporite**, a button-like structure that is an opening on the aboral surface toward the side of the central disc, allows water to enter the vascular system
- body surface typically spiny and rough
- body surface covered in a skin that secretes protective mucus
- nerve cells located immediately beneath the upper skin surface
- ossicle skeletal system contained in thicker, connective tissue below the upper skin layer
- skeletal system ossicles basically form a latticework that is held together by this connective tissue

- muscle tissue layers arranged in opposing directions located beneath the skin
- **pedicellariae** are very small, jaw-like appendages on the sea star skin surface of certain sea star species
    - these function to remove undesirable small animals
- the water vascular system is a series of internal canals through which water is pumped for opposing muscle contractions in movement of the animal
- asteroids have two stomachs, these being the cardiac and pyloric stomach; the anus projects out of the latter
- digestion primarily occurs in the cardiac stomach (which is attached to the mouth via a short esophagus) and this digested material then moves into the pyloric stomach; these two stomachs are located in central disc
- an anus leads from the pyloric stomach to deposit wastes on the aboral side, center of the central disc
- sea stars are carnivorous and feed on invertebrates (including polychaete worms, clams, snails, crustaceans, and other echinoderms) and even small fishes
    - will also scavenge dead animals
    - certain species are notorious feeders on oysters and will destroy whole oyster beds if left unchecked
- deep-water sea star species tend to be **omnivores**; some deep sea examples may also derive nutrients from ingested mud
- fluid-filled areas inside arms and central disc make up main circulatory system (an open system in that it lacks fluid transport vessels [e.g., veins and arteries])
- **papula** (raised, bulbous areas on the aboral surface) and tube feet are main areas of gas exchange (respiration)
- any part of a sea star arm may be regenerated
    - in one species, if at least one fifth of the central disc is still attached to an arm, an entire, new starfish will be generated
- sexes are usually separate in all sea star species
- eggs and sperm are freely released into sea water
- some species of sea stars (e.g., *Leptasterias* species) brood their eggs under the oral area until young individuals emerge
- **embryo** becomes free-swimming as part of the zooplankton at some point in its development
- at first bilaterally symmetrical, the developing larva eventually assumes the pentarameous symmetry in its development
- a baby starfish (less than 1/25th of an inch and having very stubby arms) eventually settles down to the bottom to assume a benthic lifestyle
- growth rates are variable
- average life span of a sea star is ten years but some species can live to at least 50 years
- under starvation conditions, sea stars can reduce metabolism and resorb part of the body; this will cause them to become smaller after long periods without feeding

Fig. XIV. 3. Sea Star

Sea Stars Maintained at the ASLC

1. Leather Star/Garlic Star, *Dermasterias imbricata*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Asteropseidae
Genus *Dermasterias*

Occurrence	• Gulf of Alaska to Baja California, Mexico • low intertidal rocks and sandy areas to 300 feet deep
Form/Function	• reaches 12 inches in diameter; arms are short, tapering rays; webbed at base • smooth top (aboral) surface • upper (aboral) surface color gray with splotches of red, purple, and brown • respiratory structures (papulae) appear as feathery outgrowths on upper surface
Reproduction	• spawns from April to August; separate sexes release sperm and eggs into open ocean • fertile eggs develop into larvae and, now as zooplankton, begin feeding upon other zooplankton • further development of larvae leads to juvenile stage, at which time the pentamerous symmetry develops
Predators/Prey .....….....	• not known if anything preys upon this sea star • consumes prey items whole rather than extruding stomach as in many other Asteroidea • a generally carnivorous species, consumes encrusting sponges, sea pens, sea anemones, **bryozoans**, sea cucumbers, and sea urchins

Noteworthy Facts ……	• scale worms often found living within ambulacral grooves • emits odor of rotting garlic • slippery to the touch as a result of the mucus it exudes • contact with leather star causes some species of sea anemones to detach from substrate and swim away

2. **Blood Star,** *Henricia leviuscula*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Echinasteridae
Genus *Henricia*

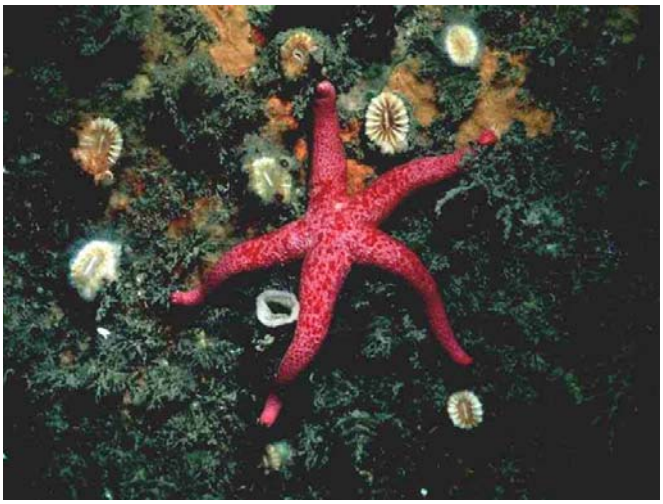
Occurrence	• Aleutian Islands, Alaska to Baja California, Mexico, and Japan • low intertidal rocky surfaces to intertidal waters of 1435 feet deep
Form/Function	• top (aboral) side bright red or reddish orange, but may be tan, purple, or mottled • disk more or less flattened • arms emerge from disc as five, hard rays
Reproduction	• female broods eggs, often while taking shelter between rocks • planktonic developing larvae become juveniles which then settle down to bottom
Predators/Prey .....….....	• predators unknown • extrudes stomach to feed upon encrusting sponges and bryozoans and may also suspension feed • uses streams of sticky mucus that it produces to entrap very minute living organisms and bring these, via cilia, to mouth for ingestion
Noteworthy Facts ……	• an attractive sea star species

3. **Ridged Blood Star,** *Henricia aspera*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Echinasteridae
Genus *Henricia*

Occurrence	• Sea of Japan to Bering sea to Oregon Coast to Santa Barbara Channel, California • 20 to 2000 feet
Form/Function	• aboral spines single, set sparsely along the skeletal trabeculae around strongly depressed spaces • spines stout, conical, short and coarse, enclosed in a very thick membrane • no **paxillae**
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• apparently very little is known of this sea star

4. Fat Henricia Star, *Henricia sanguinolenta*



Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Echinasteridae
Genus *Henricia*

Occurrence	• Circumpolar to Cape hatteras in the Atlantic and to Washington in the Pacific • low intertidal to 7920 feet
Form/Function	• 6 – 8 inches across • disk small • five tapering, thin, rigid arms; to 5 inches long • texture sandpaper-like • dorsal spines possessing 3 – 6 sharp, glassy points • spines terminate in a cluster of long spikes that are devoid of skin • commonly white to pale orange in the Pacific (Atlantic form is red)
Reproduction	• sexes separate • brood their young
Noteworthy Facts ……	• feeds on organic matter and dissolved nutrients • the taxonomy of this species in the Pacific is disputed and therefore requires revision

5. Ochre Star/Purple Star, *Pisaster ochraceus*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Asteriidae
Genus *Pisaster*

Occurrence	• Prince William Sound, Alaska to Baja California, Mexico • intertidal rocky shores to 280 feet deep
Form/Function	• up to 13 inch diameter • arms are five stout rays • top (aboral) surface is bright purple or ochre (dusky orange) in color • thin epidermal covering appears worn away in areas • spines on top surface are short and blunt but grow continuously; in calm waters the spines may be elongated
Reproduction	• males and females release sperm and eggs into ocean • fertilized eggs develop into planktonic larvae • juveniles settle on bottom and develop into adults
Predators/Prey .....….....	• consumed by sea otters and occasionally by sea gulls of several species; presumably the gulls remove loosely attached stars or ones washed ashore after a storm • a carnivorous species, this sea star displays a

	predilection for molluscs, including mussels, limpets, chitons, and snails; it also eats barnacles • feeds by everting its pyloric stomach into and around prey • can insert its stomach into snail shells or into slits as small as 0.1 mm between bivalve shells
Noteworthy Facts ……	• prefers cold, oxygenated water • only occurs in water of full salinity • more prevalent on exposed, rocky coastal areas • prefers rocky habitats; can cling to rocks with great tenacity during times of receding tides and heavy wave impact during high tide • in more northern limits of its range, the ochre star will feed primarily in summer and move to deeper waters during the winter • has enormous gripping force with tube feet; utilizes this to open bivalves and to pry barnacles off of rocks before ingesting them • species that are preyed upon by the ochre star often display avoidance responses to this voracious predator • scale worms often found in the ambulacral grooves and/or aboral surface

6. **Mottled/True Star,** *Evasterias troschelii*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Evasterias*

Occurrence	• Pribilof and Aleutian Islands, Alaska to Monterey, California; a related species, *Evasterias echinosoma*, occurs in the southeastern Chukchi Sea • low intertidal to 230 feet deep
Form/Function	• up to 22 inches in diameter • five arms that appear somewhat tapered in comparison to the ochre star • top (aboral) surface pinkish, orange, pale or dark green, bluish, brown, and occasionally purple • spines on top surface less pronounced but more variable in comparison to those of ochre star
Reproduction	• massive release of eggs and sperm into ocean by females and males • females and males often aggregate in spring and summer • fertilized eggs become free-swimming larvae as part of the zooplankton • juveniles settle to bottom and develop adult characteristics
Predators/Prey	• occasionally consumed by sunflower stars, large king crabs, and, in winter, glaucous-winged sea gulls • a carnivorous species • consumes many molluscs, including mussels,

	clams, chitons, limpets, and snails; also consumes barnacles and sea squirts • can pull open bivalves but can also insert its stomach between clam shells • various gastropods elicit escape responses upon coming in contact with the true star
Noteworthy Facts ……	• prefers rocky areas along coast • can tolerate somewhat lowered salinities • scale worms often found in ambulacral grooves and/or on body surface

7. Red Banded Star/Long-armed Star, *Orthasterias koehleri*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Orthasterias*

Occurrence	• Gulf of Alaska to Channel Islands, California • sandy, broken shell, and rocky bottomed low intertidal areas to 770 feet deep
Form/Function	• to 20 inches in diameter • relative to central disc, the five arms appear rather long • top (aboral) surface rosy pink to displaying reddish bands between white cream patches • prominent, chalky spines white to purple in color (0.1 to 0.2 inches long) extending along arm lateral margins
Reproduction	• males release sperm in response to female-produced pheromone • sperm and eggs released by sexes into ocean • fertilization occurs in open ocean • in five days, fertilized eggs develop into free swimming larvae (part of zooplankton) • larvae develop into juveniles, which settle on bottom to further develop into adults • breeding season extends from June to August
Predators/Prey	• predators unknown • feeds on a wide variety of invertebrate organisms, including snails, limpets, mussels, clams, rock oysters, chitons, abalone, squid, barnacles, crabs, tunicates, and occasionally even fishes

Noteworthy Facts ……	• often host to commensal worms on ray undersides • lives to at least 9 years (probably longer)

8. Flat Bottom Star, *Asterias amurensis*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Asterias*

Occurrence	• Sea of Japan and Tatar Strait, in Aniva Bay and off the north Japanese coasts; abundant north and locally south of the Alaska Peninsula; to British Columbia; in Australian waters; also occurs in the Chukchi Sea • sublittoral to subtidal; to 700 feet
Form/Function	• an extremely variable species; thus, a generalized description is difficult; small specimens differ greatly from large specimens • body very dorsoventrally flattened • disk broad • arms long and flat with a broad base that tapers evenly to a pointed tip • oral surface very flat • intermarginal areas broad • aboral spines small and short
Reproduction	• capable of reproducing at 10 cm • in Australia, spawning occurs during winter (July to October) at temperatures of 10 – 12 oC when females may carry up to 20 million eggs per adult • eggs and sperm are released and larval sea stars develop as part of the plankton until, in approximately 90 days, they settle down to the substrate as juveniles
Predators/Prey .....….....	• prefers to prey upon shellfish and has thus a threat to this industry; will feed on other invertebrates in the northeastern Bering and Chukchi Seas
Noteworthy Facts ……	• juvenile red king crab take refuge among the arms

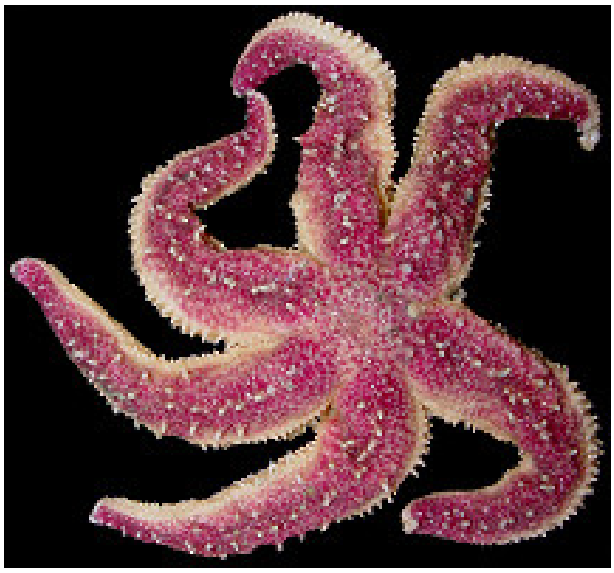
	of this species, presumably for protection and/or to feed upon food associated with the host • native to Japan, Korea, China, and Russia, this sea star has spread to Alaska and western coastal waters of the U.S. as well as to Australia; it is a threat to marine organisms such as bivalves

9. **Brooding Star,** *Leptasterias hexactis*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Leptasterias*

Occurrence	• Sea of Okhotsk (vicinity of Shantar Islands) to Puget Sound, Alaska to Santa Catalina Island, California • mid intertidal
Form/Function	• with six rays • drab color, often mottled • rays fairly long but thick, scarcely tapering • aboral spines single and very sparse • aboral skeleton compact and coarse • crossed pedicellariae forming fairly dense tufts at aboral spine bases • grows to 4 inches in diameter
Reproduction	• female broods eggs for six to eight weeks by hunching over a rock upon which the eggs have been placed • hence the name brooding star
Predators/Prey .....….....	• preys on limpets, snails, barnacles, and other invertebrates
Noteworthy Facts ……	• best known for its ability to brood by the female attaching eggs to the substrate and remaining over them until the eggs hatch some 6 – 8 weeks later

10. **Polar Star,** *Leptasterias polaris*



Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Leptasterias*

Occurrence	• Sea of Okhotsk to Pribilof Islands to Bering Sea to as far north as the Chukchi Sea • low intertidal to 500 feet
Form/Function	• aboral spines of varying length and thickness • very uneven spiny dorsal side • rays relatively long and slender; six rays total
Reproduction	• female incubates eggs by holding them in her arms/rays; the characteristic form for holding is that of a spiral • no larval stage
Predators/Prey	• consumes polychaetes, barnacles, barnacles, mollusks, echinoderms, and ascidians • preyed upon by purple sea stars and probably by certain fishes as well
Noteworthy Facts ……	• certain whelk species have strong escape responses to this predatory sea star

11. **Six-armed Sea Star**, *Leptasterias epichlora*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Leptasterias*

Occurrence	• Aleutian islands, Alaska to Vancouver island, British Columbia • mid and low intertidal waters to 150 feet deep
Form/Function	• up to 4 inches diameter • six short, stout arms • variable color on top (aboral) surface; usually a mottled blue gray, indigo, dark green, or black
Reproduction	• a brooding species of sea star • some 500, large (1 mm diameter), orange, yolky eggs are maintained at the females oral surface until hatching • female assumes a hunched position, her central disk held above the substrate, while brooding • appears not to feed at this time
Noteworthy Facts ……	• can tolerate lower salinities that sometimes occur along coast lines

12. **Black Spined Star,** *Lethasterias nanimensis*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulitida
Family Asteriidae
Genus *Lethasterias*

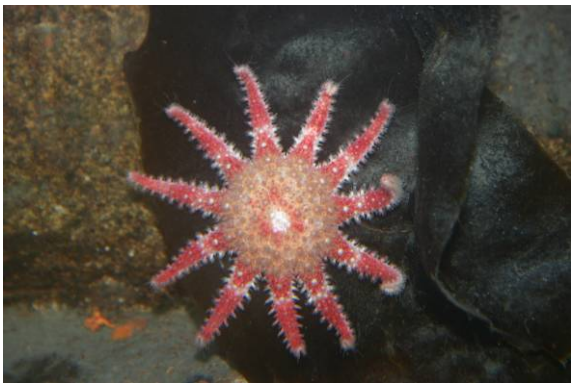
Occurrence	• Sea of Japan, east coast of Kamchatka, Sea of Okhotsk, Bering Sea up to Bering Strait, south to Kodiak Island, Aleutian Islands, and British Columbia; also occurs in th Chukchi Sea, and abundantly so in some areas • sublittoral; 70 to 780 feet
Form/Function	• disk small • rays long and flexible; five in number • spines on aboral side singly and evenly spaced • aboral side brownish gray with black spines; orally paler
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• in the Chukchi Sea it feeds on gastropods, bivalves, sand dollars, and probably other invertebrates as well
Noteworthy Facts ……	• a large star reaching 24 inches in diameter

13. Mud Star, *Ctenodiscus crispatus*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Goniopectinidae
Genus *Ctenodiscus*

Occurrence	• occurs in, but may not be restricted to, Alaskan waters • subtidal, 35 – 6,200 feet
Form/Function	• a small sea star • aboral surface color gray or yellowish • five (rarely four or six) short arms, each reaching a length of up to 2.1 inches • oral side is lighter, with shades of light orange • ambulacrals possess an oblique series of three to five sharp furrow spines • tube feet large and pointed • prominent mouth plates
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• obtains nutrients from organic matter (including small worms and bivalves residing in the mud) • a small sea star

14. **Rose Star,** *Crossaster papposus*



Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valatida
Family Solasteridae
Genus *Crossaster*

Occurrence	• circumpolar distribution • in eastern Pacific, it ranges from the Chukchi Sea to Puget Sound, Washington • rocky areas of extreme low intertidal to muddy gravel bottoms down to 1080 feet deep
Form/Function	• 12 inch diameter • top (aboral) surface has concentric wings colored red and white, sometimes yellow or orange • 8 to 16 rather short arms • have a stiff, prickly appearance as a result of columnar erectile structures (called **paxillae**), each of which contains up to 50 slender, small spines
Reproduction	• females and males release eggs and sperm into ocean • yolky, fertilized eggs maintain developing larvae for about 20 days until larvae become juveniles and settle on bottom to further develop into adults
Predators/Prey	• preyed upon by sunflower star and morning sun star • feeds upon sea anemones, sea pens, sea slugs, bryozoans, tunicates, nudibranchs, bivalves, and occasionally small sea stars
Noteworthy Facts ……	• can move at a rate of 28 inches/minute in pursuit of prey • lives up to at least 20 years

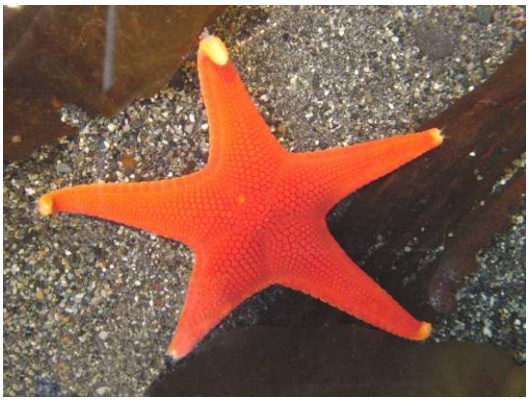
15. **Sunflower Star,** *Pycnopodia helianthoides*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Pycnopodia*

Occurrence	• from Unalaska Island, Alaska to Baja California, Mexico • low intertidal to 1435 feet deep
Form/Function	• to 3 feet in diameter • adults have up to 24 soft, flabby arms • juveniles begin with five arms • central disk is soft and floppy • much larger than in other sea stars • color is orange with tufts of purple papulae (respiratory structures on top surface); some papulae may be yellowish, reddish, or reddish brown
Reproduction	• spawn March to July • females and males release eggs and sperm into ocean • fertilized eggs maintain developing larvae until larvae become juveniles and settle on bottom to further develop into adults
Predators/Prey	• preyed upon by red king crabs, and graceful rock crabs • also preyed upon by glaucous-winged gulls during

	winter months • feeds upon chitons, bivalves, snails, barnacles, various crabs (including hermit crabs), sea urchins, other sea stars, sea cucumbers, and sand dollars • consumes prey items whole
Noteworthy Facts ……	• among north Pacific sea stars, the sunflower star is the heaviest, softest, and fastest • can move 5 to 10 feet/minute (!) • populations of sunflower stars can be very mobile • when two of this species encounter one another, they can show intolerance by flailing one another with their tube feet • such confrontations end by the two individuals moving away from one another • will attack and take prey items away from other sea star species • abalones, cockles, scallops, sea cucumbers and other sunflower sea star prey species have developed vigorous escape responses to encounters with sunflower sea stars

16. **Vermilion Star,** *Mediaster aequalis*



Kindom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Goniasteridae
Genus *Mediaster*

Occurrence	• Chignik Bay (Alaskan Peninsula), Alaska to southern California • low intertidal waters to 960 feet deep; common on rocks, shells, sand, gravel, pebbles, and mud
Form/Function	• up to 8 inches diameter • top (aboral) surface bright reddish orange, oral side lighter in color • tube feet red to pinkish • the five arms have distinct marginal plates that lack spines
Reproduction	• spawning occurs in spring • females and males release eggs and sperm into ocean • bright orange, yolky, fertilized eggs maintain developing larvae until larvae become juveniles and settle on bottom to further develop into adults
Predators/Prey .....….....	• preyed upon by morning sun star • an omnivorous sea star • consumes detritus from mud, dead animals, algae, encrusting sponges, bryozoans, sea pens, and sea squirts

Noteworthy Facts ……	• barnacles of genus *Dendrogaster* parasitize internal tissues of this sea star

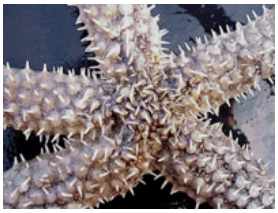
17. **Bat Star,** *Patiria miniata*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Ateroidea
Order Valvatida
Family Asterinidae
Genus *Patiria*

Occurrence	• Sitka, Alaska to Baja California, Mexico • low intertidal to almost 1000 feet deep
Form/Function	• five arms broadly joined to a wide central disc • top (aboral) side of bat star has sandpaper-like structure • bright orange to deep red in color • some mottled, yellowish, brown, gray, and black forms occur as well • lacks spines
Reproduction	• spawning occurs May through July • spawn when exposed to air for one to several hours • females and males shed gametes directly into the sea when covered by tide • eggs hatch and become zooplanktonic larvae • planktonic larvae develop into juveniles, which settle on bottom and further develop into adults
Predators/Prey .....….....	• preyed upon by sea gulls and sea otters • an omnivore, it consumes surf grasses, various algal species, sponges, and sea urchins
Noteworthy Facts ……	• bat star lacks ability to open clams and other bivalves; instead it everts the stomach directly onto the prey to consume it • competes for space by pushing other *Patiria* with arms • a small polychaete, *Ophiodromus*, lives in the oral

	surface, especially in the ambulacral grooves

18. Fish-eating Star, *Stylasterias forreri*



Aboral View

Oral View

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Forcipulatida
Family Asteriidae
Genus *Stylasterias*

Occurrence	• Southeastern Alaska to southern California • subtidal (50 to 1500 feet deep); never found intertidally
Form/Function	• up to 15 inches diameter • common form has black epidermis and white spines • some forms of a grayish black color • body spiny and fragile • each spine surrounded by many pedicellariae • the five, small, and slender arms extend from a relatively small central disc
Reproduction	• unknown
Predators/Prey .....….....	• predators unknown • primarily feeds on gastrpopods and chitons • can trap small fishes by means of pedicellariae on aboral surface
Noteworthy Facts ……	• can eat small fishes • a **commensal** scale worm occurs on the body and in the ambulacral groove

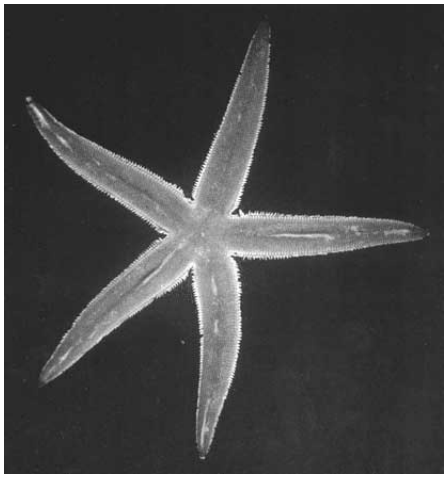
19. Cushion Star, *Pteraster tesselatus*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Pterasteridae
Genus *Pteraster*

Occurrence	• Japan through Bering Sea to California • low intertidal
Form/Function	• thickness approximately equal to one third the diameter • aboral surface without a conspicuous and elevated central opening • madreporite not visible • color of aboral surface generally pale orange or brownish yellow • when first collected secretes a great amount of gelatinous mucus • disk more or less flattened • rays merge with one another such that the entire animal's shape is pentagonal
Reproduction	• reproduction occurs continuously as females pump eggs out of the body and males release sperm in response • fertilized eggs (1.5 mm diameter) are bright orange or yellow and float to the surface • each egg is coated in a jelly-like substance • larvae hatch out and become part of the plankton for thirty days, during which time the five arms develop • after thirty days the planktonic larvae become juveniles as they settle down to the substrate and begin moving about
Predators/Prey .....….....	• feed primarily upon sponges

Noteworthy Facts ……	• when threatened these stars exude a mucus over their body which apparently contains an irritant that wards off would-be predators

20. **Sand Star,** *Luidia foliolata*



Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Platyasterida
Family Luidiidae
Genus *Luidia*

Occurrence	• occurs in, but perhaps not limited to, Alaskan waters • intertidal or subtidal to 660 feet
Form/Function	• with five rays; ray diameter often greater than 4 inches • rays bordered by plates along the sides that are not apparent when viewed from directly above • tube feet pointed and without suckers
Reproduction	• in British Columbia spawning occurs in spring • transparent ova are approximately 0.15 mm diameter • metamorphosis from larva to juvenile occurs four months after fertilization • juveniles are about 0.73 mm diameter, have five complete arms, and a pair of tube feet on each arm
Predators/Prey .....….....	• unknown or information unavailable • studies on a related species, *L. sarsi*, in European waters found that the diet is dominated by echinoderms (i.e., brittle stars, a species of *Asterias*, and a sea urchin); in addition, they also consumed polychaetes, some mollusks, some mollusks, and crustaceans (probably amphipods); it is reasonable to assume that *L. foliolata* has a characteristically similar diet
Noteworthy Facts ……..…	• found on muddy or sandy habitats

21. Arctic Cookie Star, *Ceramaster arcticus*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Goniasteridae
Genus *Ceramaster*

Occurrence	• Bering Sea to Kodiak, Alaska to British Columbia • intertidal to 600 feet deep • resides among rocks in shallow waters and on mud in deeper parts of range
Form/Function	• up to 4.5 inches diameter • pale orange color with red patches • small and pentagonal • stiff, firm to touch • top (aboral) surface covered in plates of hexagonal shape • margins of arm contain granules of variable sizes
Reproduction	• unknown
Predators/Prey .....….....	• unknown
Noteworthy Facts ……	• a small but attractive star

22. Cookie Star, *Ceramaster patagonicus*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Goniastridae
Genus *Ceramaster*

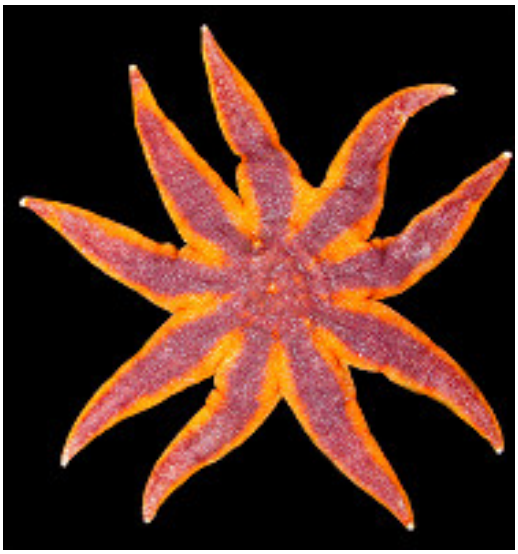
Occurrence	• Bering Sea to Cape Horn, South America • intertidal to 800 feet deep • occurs on rocks or mud
Form/Function	• up to 3.5 inch diameter • top (aboral) surface often swollen and soft to touch in living example • hexagonal plates on top (aboral) arm side • creamy-orange to red-orange on top (aboral) side • pale yellow on bottom (oral) side
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• differs from *Ceramaster arcticus* in being larger and having more granules on aboral plates

23. **Gunpowder Star,** *Gephyreaster swifti*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Valvatida
Family Radiasteridae
Genus *Gephyreaster*

Occurrence	• Bering Sea to Aleutian Islands to Washington • 200 to 1200 feet
Form/Function	• a very large star (12 inch diameter) with an exceptionally broad disk • aboral surface with numerous paxillae that consist of numerous, granule-like spines • five stout, very blunt rays • large granules on entire aboral surface
Reproduction	• unknown or information unavailable
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• an apparently rare species

24. **Purple Sun Star/Smooth Sun Star,** *Solaster endeca*



Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Solasteridae
Genus *Solaster*

Occurrence	• Widespread circumboreal species; in North Atlantic (extending from Norwegian coast to Atlantic coast of North America) and north Pacific (Commander Islands southeast of the Bering Sea, to Chukchi Sea, south to Vancouver and Puget Sound) • low intertidal to 900 feet
Form/Function	• to 12 inch diameter • 9 – 13 rays, but typically has 10 • disk very broad • ray length variable, but generally short, basally very broad, and thick
Reproduction	• development direct without a free living larval stage
Predators/Prey	• diet appears to be largely restricted to that of eating other echinoderms, but will consume some mollusks
Noteworthy Facts ……	• has been known to eat out the fleshy viscera of sea urchins

25. **Morning Sun Star,** *Solaster dawsoni*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Solasteridae
Genus *Solaster*

Occurrence	• Point Franklin (Chuckchi Sea, Alaska) to Monterey Bay, California • intertidal to 1200 feet • occurs on rocky substrates
Form/Function	• up to 12 inches in diameter • 12 to 13 arms • aboral coloration brown, gray, or yellow; less often bright red or orange or dull yellow • sometimes area around the disk is darker • disc is slightly raised
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• a carnivore that preys mainly on other sea stars but also feeds on sea cucumbers and occasionally nudibranchs • all sea star species preyed upon have escape responses when contacted by the morning sun star; they bend their arms back and push the attacker off while rapidly moving away
Noteworthy Facts ……	• a very multi-armed attractive species

26. Stimpson's Sun Star, *Solaster stimpsoni*

Kingdom Animalia
Physlum **Echinodermata**
Subclass Asteroidea
Order Spinulosida
Family Solasteridae
Genus *Solaster*

Occurrence	• southern Bering sea to Sonoma County, California, and Japan • found on rocks and other surfaces of low intertidal waters to 2000 feet deep
Form/Function	• up to 20 inches in diameter • 9 to 12 long, slender tapering arms; usually 10 present • top (aboral) surface red, orange, pink, or blue, always containing a dark, purple-blue stripe running from a patch on the central disk to down each arm
Reproduction	• spawning occurs in spring • females and males release eggs and sperm into ocean • greenish-yellow, yolky, fertilized eggs maintain developing larvae until larvae become juveniles and settle on bottom to further develop into adults
Predators/Prey	• preyed upon by morning sun star • eats sea cucumbers, sea squirts, and sea pens • not known to eat other sea stars
Noteworthy Facts ……	• scaleworms reside within ambulacral grooves • a barnacle, genus *Dendrogaster*, can live parasitically within Simpson's sun star tissues

Subclass **Ophiuroidea**

- this subclass contains those echinoderms referred to as basket stars and brittle stars
- 2000 described species; largest Echinoderm group
- inhabit practically all marine habitats
- often found in soft-bottomed areas
- compared to subclass Asteroidea (the sea stars), Ophiuroidean arms are more distinctly set off from central disc
- lack ambulacral grooves (these are present in the Asteroidea)
- lack pedicellariae and papulae
- central disc about 0.5 to slightly over 1 inch in diameter in the brittle stars; up to 5 inch diameter in the basket stars
    - is flattened; has pentagonal shape
- many different colors; often arms are banded in different colors
- typically only five arms present
- in basket stars the arms branch at base or farther from the central disc
- mouth (on bottom, or oral, side) is surrounded by a complex series of plates
    - these form jaws that bear tooth-like structures
    - plates facilitate chewing
- the esophagus connects the mouth with a large, saclike stomach which fills most of the interior disc
- in most ophiuroids the stomach margins are are extended into ten pouches
- skeleton comprised of calcium carbonate plates called ossicles
- these are overlain and connected by muscle bands, which are in turn covered by a thin epidermis (skin)

Top (aboral) Bottom (oral)

Fig. XIV. 4. Top (aboral) and Bottom (oral) Sides of a Brittle Star

- bottom (oral) side has tube feet
- are among the most mobile of all Echinoderms
- some species form mucus-lined burrows

- are scavengers, predators, deposit feeders, or **suspension feeders**
- nervous system developed such that each arm contains a nervous center; these centers coordinate with one another to realize movements
- no specialized sense organs present
- can lose an arm if seized by a predator (hence the popular name *brittle stars*); arms are regenerated later
- sexes separate in most species
    - however, some hermaphroditic (both sexes in one individual) species do exist
- usually eggs and sperm are released into ocean and fertilization occurs there
- larvae then become part of zooplankton until they develop into juveniles that will settle down on the bottom to further develop into adults
- brooding occurs in some genera
    - in this case, some of the larvae develop within the central disc of the female until they become juveniles, at which time they leave female and settle down upon the bottom to further develop into adults
- gas exchange made possible by 10 internal sacs called **bursae**
    - internally, each **bursa** (singular) is lodged between two stomach pouches
    - bursae are connected to outside by means of a slit extending from the oral side of the disc arm margins
    - the two sides of the slit typically join in the middle to form two openings
    - cilia in the bursae create a water current that enters the peripheral slit end, passes through the bursa, and exits out of the oral slit end
        - this ensures that oxygen-rich water enters the bursae so that gas exchange (respiration) can occur

27. **Gray Brittle Star,** *Ophiura lutkeni*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Ophiuroidea
Order Chilophiurina
Family Ophiuridae
Genus *Ophiura*

Occurrence	• Alaska to Mexico • intertidal and subtidal sandy to muddy environments
Form/Function	• spines of arm combs contiguous with truncate tip • oral shields widest near their middle portions • spines of arm combs generally not more than three times as long as wide, having blunt or truncate tips aboral surface color usually gray, a shade of gray, bluish gray, greenish gray, or, rarely, reddish • aboral surface of disk having apparent marginal notches into which the arms are inserted • an arm comb borders each such notch
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey .....….....	• flexibility of arms enables prey capture via a lassoing-type gesticulations • probably feeds like the European *Ophiura ophiura* (=*texturata*) that is an omnivore that feeds on any small benthic organisms including polychaetes, crustaceans, bivalves, gastropods and ophiuroids • preyed upn by Dover Sole (*Microstomus pacificus)*, copper rockfish (*Sebastes caurinus)*,

	and the sand star (*Luidia foliata*)
Noteworthy Facts ……	• called brittle stars because they rather readily shed an arm if seized by a would-be predator; arm will be regenerated • this brittle star responds to the presence of *L. foliata* by creating a rowing motion with its arms that enables it to escape

28. **Daisy Brittle Star,** *Ophiopholis aculeata*

Kingdom Animalia
Phylum **Echinodermata**
Subclass Ophiuroidea
Order Ophiurida
Family Ophiactidae
Genus *Ophiopholis*

Occurrence	• Southern Bering Sea to Santa Barbara, California; in Arctic Ocean and North Atlantic as well • intertidal waters to 5435 feet deep • prefers strong currents
Form/Function	• central disc diameter may reach almost one inch long • disc appears fat and scalloped with bulges between ray bases • relatively broad, spiny arms • extremely variable color patterns; top (aboral) side frequently pink, red, orange, blue, green, gray, or black with mottled patterns; streaks also common • bottom whitish
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• its food is mainly detrital material; however, it may occasionally use the arm-loop capture method characteristic of *Ophiura* species • preyed upon by various ground fish species, which nip off arms but will consume entire brittle star if the opportunity to do so presents itself

Noteworthy Facts ……	• suspension feed by capturing particulate matter with tube feet; also scavenge organic matter off of bottom with tube feet • it has been suggested that the variance in color may confuse would-be predators such as gulls, which may be cued in on a color search pattern while scanning shallow waters for food • at low tides, daisy brittle stars are typically found beneath rocks and boulders • tolerates wide range of water temperatures and bottom types • during spawning it raises the disc off the substrate and pushes other brittle stars away

29. **Basket Star,** *Gorgonocephalus caryi (= G. eucnemis)*

Kingdom Animalia
Phylum **Echinodermata**
Class Ophiuroidea
Order Phrynophiurida
Family Gorgonocephalidae
Genus *Gorgonocephalus*

Occurrence	• west coast of North America from Alaska to California, the Bering and Chukchi Seas to the Sea of Japan, Okhotsk Sea, Laptev Sea, across the Arctic to Greenland, Finmark, Spitzbergen, south to Cape Cod • subtidal, rocky areas with strong currents to 6600 feet deep, typically 45 to 450 feet
Form/Function	• inclusive of arms, up to 18 inches in diameter • the five arms branch profusely to cause the animal to take on an appearance that can be described as a flattened, leafless bush • color is white to tan or beige with mottled pattern of orange-red or pink • very flexible arms (even more so than in brittle stars) can be coiled very tightly to capture prey items in a lasso-like manner
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• not known what organisms prey upon basket stars folding/coiling • attach to the substrate with some of their arms and extend the others facing the water current; plankton caught on the hooks of the arms are rolled up in strings of mucus and transferred to the mouth via arm folding and coiling

	• mainly traps small crustaceans, arrow worms, and occasionally small medusae and fish larvae
Noteworthy Facts ……	• arms easily broken through rough handling; this is an escape mechanism from would-be predators • young basket stars often found in association with soft corals

Class Echinoidea

- sea urchins, heart urchins, and sand dollars
- 900 described species
- name means “like a hedgehog”
- outside of body adorned with in spines
- lacks arms of asteroids and ophiuroids
- body shape circular to oval, spherical to greatly compressed along the oral-aboral axis
- ossicles (calcium carbonate structures forming skeletons of Echinoderms) are flattened and sutured together to form a solid case

Fig. XIV. 5. Sea Urchin Internal and External Anatomy (note spines)

- sea urchins characteristics
  - are called regular echinoids
  - body approximately spherical in shape

- colors range from brown to black to purple to green to white to red; some examples are multicolored
- diameter typically 2.5 to 5 inches
- body divides into two hemispheres

1. **Oral Pole**: the "underneath" hemisphere, this hemisphere contains the mouth, from which protrude five calcium carbonate teeth

2. **Aboral Pole**: the top pole region is anal area

- spherical body divides into ten radial sections
  - five of these sections, called ambulacral areas, contain tube feet
  - interambulacral areas occur between ambulacral areas and lack tube feet
  - these five ambulacral and interambulacral areas converge at both poles
  - ambulacral and interambulacral areas both bear moveable spines; these are distributed more or less equally among the two areas
- spines longest at equatorial region and shortest at poles
- muscle fibers encircling the spherical "shell" (test) of the animal enable the spines to be moved
- spines typically taper to a point
- both spines and tube feet enable sea urchins to move
- pedicellariae, small jaw-like structures, are located over the general body surface; these structures are used primarily for defense and cleaning the body
  - muscles at the base of the pedicallariae stalks direct their elevation and direction of movement

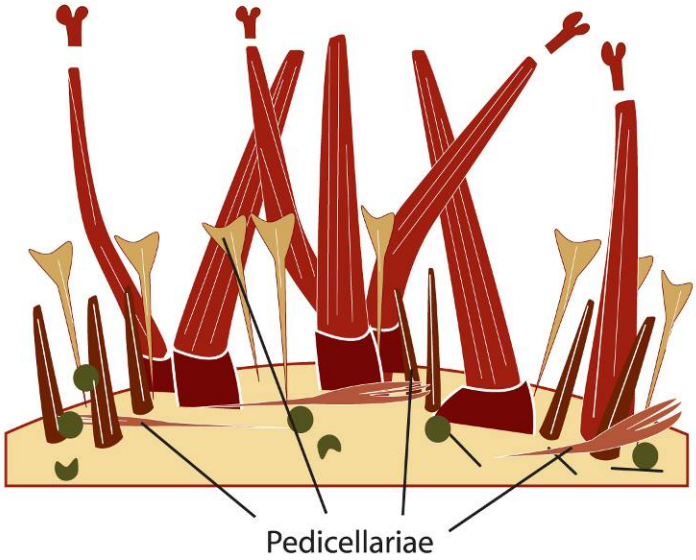


Fig. XIV. 6. Magnified View of a section of Sea Urchin Spines and Pedicellariae

- sea urchin movement is closely related to feeding
- most urchins are adapted to live on hard bottoms or rocks
- burrowing is a behavior that seems to counteract excessive wave action
- possess a water vascular system very similar to that already described for sea stars
- sea urchins feed with a specialized scraping apparatus called Aristotle's lantern

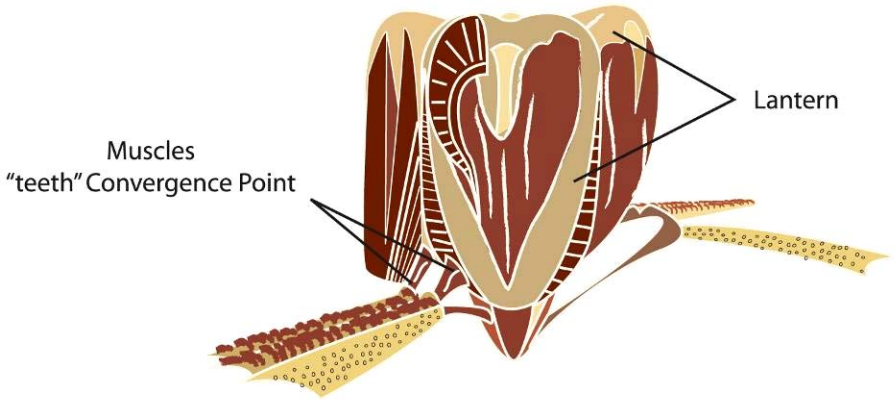


Fig. XIV. 7. Aristotle's lantern

- located immediately around the aboral to oral pole, this internal structure, Aristotle's lantern, consists of five large calcareous "teeth" arranged into a cylindrical-like structure that tapers towards the oral pole end of the animal

    - the teeth protrude through the mouth and their movements are controlled by muscles
- most sea urchins are grazers and use their "teeth" to consume organic matter (e.g., algae) from the surface of the substrate
- nervous system basically similar to that already described for Asteroids
- sexes are separate, although indistinguishable through examination of external **morphology**
- sperm and eggs are released into ocean where fertilization occurs
- some species brood eggs
    - fertilized eggs become zooplankton that develop into juveniles which live on the bottom and subsequently develop into adults

Regular Echinoids/Sea Urchins Maintained at the AlaskaSea Life Center

30. Green sea Urchin, *Strongylocentrotus droebachiensis*

Kingdom Animalia
Phylum **Echinodermata**
Class Echinoidea
Order Echinoida
Family Strongylocentrotidae
Genus *Strongylocentrotus*

Occurrence	• Arctic Alaska to Washington State; circumpolar distribution in northern hemisphere • low intertidal rocky shores, kelp bed waters, down to 3800 feet
Form/Function	• "shell" (test) up to 3.5 inches wide and 1.5 inches high • spines short and slender • color of spines and "shell" (test) usually green • flesh appears dark purple to reddish
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• preyed upon by sunflower and morning sun stars, otters, ducks, crows, ravens, various gulls, large sea anemones, various crabs, humans • grazes upon algae (especially kelp) but also consumes detritus; can scavenge and absorb organic substances from sea water • under starvation conditions, can reduce metabolism and reabsorb portions of body
Noteworthy Facts ……	• smallest intertidal sea urchin of Alaskan coastal waters • large numbers of these urchins can entirely strip rocky areas of their algae and offshore areas of their kelp; this urchin has thus earned a notorious reputation for such activity

	• use chemical cues to avoid predators and locate food sources • sea otters predation can greatly reduce the number of green sea urchins residing in kelp beds

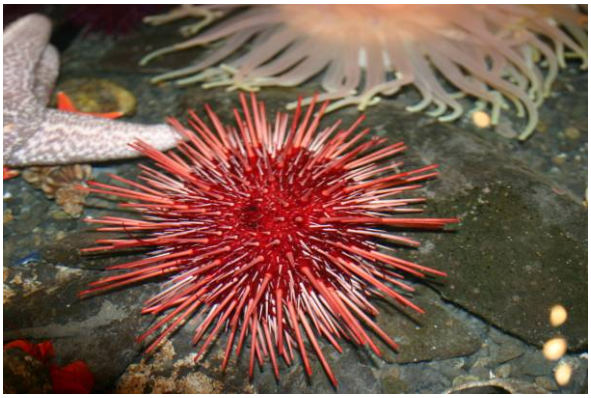
31. **Purple Sea Urchin,** *Strongylocentrotus purpuratus*

Kingdom Animalia
Phylum **Echinodermata**
Class Echinoidea
Order Echinoida
Family Strongylocentrotidae
Genus *Strongylocentrotus*

Occurrence	• Vancouver island (only Alaska occurrence), British Columbia to Isla Cedros, Baja California • lower intertidal to subtidal; to 500 feet
Form/Function	• "shell" (test) up to 4 inches in diameter (more typically 2 inches) • in life the body and spines are a typically bright purple or, occasionally, pale green or greenish tinged with purple
Reproduction	• become sexually mature during second year • from Washington to Baja California, spawning occurs during the first 3 months of the year(however, some ripe females are still found into July) • sexes are separate, though occasionally hermaphrodites are found • eggs and sperm are released and fertilized eggs develop into larvae • after larval metamorphosis into juvenile stage, growth is slow • large specimens may be from 10 to 30 years old
Predators/Prey	• feed upon brown and red algae and kelp • pedicellaria used to collect food (algal fragments) • preyed upon by sea stars (*Dermasterias, Pycnopodia*, *Pisaster ochraceus*, *Astrometis*), some bottom fishes (mainly *Pimelometon* on the sheepshead), and the sea otter
Noteworthy Facts ……	• one of the best studied sea urchins in the world, the gametes have been widely studied and used in demonstrations of fertilization and cleavage in the classroom • teeth are completely renewed every 75 days; this is

	necessary as individuals are capable of “forming burrows and depressions in rocks with these teeth • pedicellaria used as protection from predators

32. **Red Sea Urchin,** *Strongylocentrotus franciscanus*



Kingdom Animalia
Phylum **Echinodermata**
Class Echinoidea
Order Echinoida
Family Strongylocentrotidae
Genus *Strongylocentrotus*

Occurrence	• Kodiak Island, Alaska to Baja California, Mexico; also northern Japan • low intertidal to 300 feet deep
Form/Function	• "shell" (test) up to 6 inches in diameter and 2 inches high • dark red to maroon color • spines pinkish, reddish, orange, or reddish purple • tube feet are long and darkly colored
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• preyed upon by sunflower, leather, and bat stars, sea otters, various crabs, and humans • sea otter predation has reduced their numbers in recent years so as to make commercial harvesting impractical • feeds on brown and red algae, particularly kelp of the genus *Macrocystis*; can thus decimate kelp beds
Noteworthy Facts ……	• largest sea urchin of North America's west coast • when under attack by the sunflower star, smaller red sea urchins attempt to shuffle away by using their spines • larger specimens (2 inches or larger) lose this ability as they are too large to be consumed • large numbers of red sea urchins will decimate offshore kelp beds; sea stars, mainly genus *Pycnopodia*, can lower urchin population levels

- has numerous pedicellaria

Class Echinoidea (continued)

- sand dollars, heart urchins, and cake urchins
- called irregular echinoids
- symmetry bilateral or irregular
- most are adapted as burrowers and thus live within the sandy substrate
    - sand dollars typically burrow just beneath sand surface
- spines are much smaller but more numerous than in regular urchins
- mouth on oral (bottom) surface at front end of the animal
- anus on upper (aboral) surface at posterior end
- functional podia ("feet", similar to tube feet) occur on top (aboral) and bottom (oral) surfaces; margins of body lack podia
- petal-shaped areas on top (aboral) surface are called **petaloids**
    - these are respiratory structures
    - **phyllodes** are the petaloid equivalent occurring on the oral side of the animal
    - function as areas for obtaining food
- very specialized tiny ciliated spines called clavules occur in tracts along the irregular urchin surface and are believed to produce water currents that aid in secreting large amounts of mucus to maintain burrow
- some species feed upon organic matter found in the sand while burrowing; other species **suspension feed**
- Aristotle's lantern lacking
- nervous system, water vascular system, and reproduction similar to that already described above for regular urchins

Fig. XIV. 8. Sand Dollar

Irregular Echinoids/Sand Dollars Maintained at the Alaska Sea Life Center

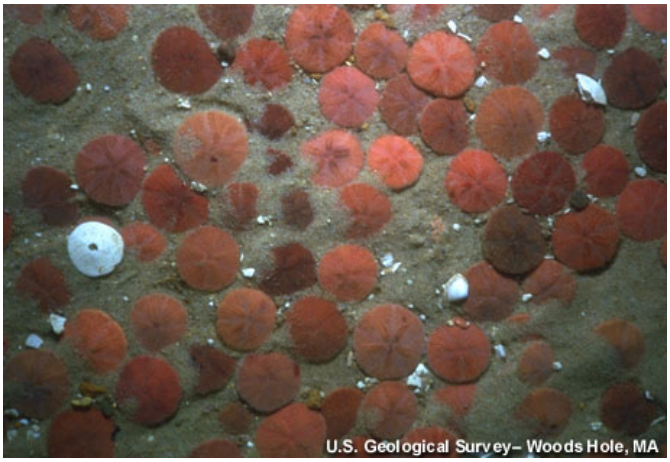
33. Eccentric Sand Dollar, *Dendraster excentricus*

Kingdom Animalia
Phylum **Echinodermata**
Class Echinoidea
Order Clypeasteroida
Family Dendrasteridae
Genus *Dendraster*

Occurrence	• Juneau, Alaska to Baja California, Mexico • usually subtidal, but occasionally in sheltered and open habitats of intertidal waters
Form/Function	• up to 4 inches in diameter and 0.25 inch high • "shell" (test) almost circular; very flattened • five "petals" (petaloids) on upper (aboral) surface form a star/flower-like pattern
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• preyed upon by starry flounder and probably other flatfish species as well • a suspension feeder, it consumes organic material present in water currents
Noteworthy Facts ……	• "shell" (test) commonly found washed up on beach • typically buries itself in the substrate by piling up sand into a mound by means of tube feet and then moves into the • mound with its spines • can also move on top of sand surface • though not maintained as a live specimen at the

	ASLC, this species is only present in southeastern Alaska waters to Juneau

32. **Common Sand Dollar**, *Echinarachnius parma*



Kingdom Animalia
Phylum **Echinodermata**
Class Echinoidea
Order Clypeasteroida
Family Echinarachniidae
Genus *Echinarachnius*

Occurrence	• circumpolar: in Pacific Alaska to Siberia to Japan; in Atlantic, New Jersey to north along east coast of North America • intertidal to subtidal
Form/Function	• adults from 2 to 4 inches in diameter • "shell" (test) almost circular; very flattened • five "petals" (petaloids) on upper (aboral) surface form a star/flower-like pattern
Reproduction	• females and males release eggs and sperm into ocean; fertilized eggs become zooplanktonic larvae, which develop into juveniles • juveniles live on bottom and develop into adults
Predators/Prey	• preyed upon by some bony fishes (notably eel pouts) and sea stars
Noteworthy Facts ……	• feed upon organic material encountered within sediment in which this sand dollar burrows • "shell" (test) commonly found washed up on beach • typically buries itself in the substrate by piling up sand into a mound by means of tube feet and then moves into the mound with its spines • can also move on top of sand surface • a very common sand dollar of Alaskan waters

Phylum Echinodermata (continued)

Class **Holothuroidea**, the sea cucumbers

- 900 described species
- features in common with sea urchins and sand dollars
- lack arms
- anus and mouth at opposite poles of animal
- unlike other Echinoderms, the sea cucumbers are greatly lengthened along their polar axis
- also unlike other Echinoderms in that the ossicles (calcium carbonate skeletal structures) of most genera have been reduced to microscopic size
- a few genera have a protective armor of calcareous plates embedded in the body wall

Fig. XIV. 9. Sea Cucumber (note tube feet)

- animal lies upon substrate with one side of body
- most are colored black, brown, or olive green; some are rose, orange, or violet and may be striped
- smallest species about 1 inch long, largest species over three feet long
- body shape varies from practically spherical to wormlike
- body surface usually leathery
    - ventral area contains three grooved (ambulacral) regions and form what is called the sole
    - dorsal surface has two ambulacral areas
    - podia (tube feet) may be present on both dorsal and ventral ambulacral regions, but functional podia are usually found only on the creeping sole
- mouth is surrounded by 10 to 30 tentacles
- as part of the water vascular system, these can be completely retracted
- the thick skin, itself filled with many, many microscopic ossicles, is covered in a thin cuticle
- circular and longitudinal muscle tissues occur beneath the skin
- are generally sluggish animals living on bottom surface or burrowing
- are chiefly deposit or suspension feeders
    - mucus on tentacles traps organic matter as the tentacles are swept over the bottom or hold them out in the water

    - each tentacle is then individually brought into the mouth and "wiped off" so that the trapped organic matter may be digested
- water vascular system and nervous system similar to those already described for Echinoderms in general
- gas exchange (respiration) occurs via a system of two **respiratory trees** located within the coelom and on the right and left sides of the digestive tract; each such tree is comprised of a main truck and many branches; sea water is pumped into the body and directed through the respiratory trees; this enables oxygen to diffuse into oxygen-poor body fluids while carbon dioxide diffuses into the respiratory tree water from those oxygen-poor fluids; the carbon dioxide-enriched water is then expelled from the respiratory tree and out of the animal
- sexes are separate in most species, though some hermaphroditic forms exist
- a gonad (believed to be a primitive feature of Echinoderms) produces sperm (males) or eggs (females)
- some 30 brooding species are known
    - fertilized eggs may be brooded beneath the sole or, in some species, actually within the body cavity itself (!)
- some species evade predation by ejecting their internal organs, thus leaving these structures to the predator while the remainder of the sea cucumber body moves off out of danger to regenerate the lost organs

Sea Cucumber Maintained at the Alaska Sea Life Center

34. California Sea Cucumber, *Parastichopus californicus*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Aspidochirotida
Family Stichopodidae
Genus *Parastichopus*

Occurrence	• Gulf of Alaska to Baja California, Mexico • low intertidal waters to 270 feet deep, it prefers protected bays and other areas protected from strong wave action • occurs on pilings or on sea bottom
Form/Function	• up to 20 inches long in their relaxed state (shorter if disturbed) • large conical projections (papillae) on surface of organism • mottled brown-red body on upper and lateral surfaces with a lighter, cream-colored underside
Reproduction	• separate sexes reach maturity at 4 years • gametes (sperm or eggs) are released by raising front one third of the body and waving it from side to side • a form of "pseudocopulation" occurs in which the spawning adults wrap around one another and release gametes into the ocean • fertilized eggs develop into larvae and become part

	of the zooplankton; larvae develop into juveniles, which live on the bottom and develop into adults
Predators/Prey .....….....	• preyed upon by various species of sea stars (*Pycnopodia* and *Solaster*), fishes, sea otters, and humans • deposit feed on organic matter or very small organisms that occur in the substratum
Noteworthy Facts ……	• largest sea cucumber of the northwest Pacific • commercially harvested to obtain muscle strips from body • gives characteristic escape response to sea star predators, "looping" short distances on the bottom by flexing its body like an oversized inchworm • a scale worm sometimes resides in the body wall

35. **Armored Sea Cucumber,** *Psolus chitonoides*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Dendrochirotida
Family Psolidae
Genus *Psolus*

Occurrence	• Aleutian islands, Alaska to Baja California, Mexico • low intertidal waters to 850 feet
Form/Function	• oval body up to 5 inches long and 2.3 inches wide • dorsal portion domed and covered in rigid, shingle-like scales • ventral portion a flexible sole • 8 – 10 equal sized tentacles or 8 large with two smaller tentacles • rows of tube feet run body's length
Reproduction	• spawning typically occurs in the morning hours from March through late May • sperm are dispersed by the male wiping its genetalia with its tentacles and then lifting these so that the sperm may be broadcast into the open sea • females release long, ropy sections of brick red eggs • eggs develop as plankton into larvae; larvae eventually metamorphose into juveniles and settle down to the substrate
Predators/Prey .....….....	• preyed upon by seastars and fishes
Noteworthy Facts ……	• suspension feeder • the soft and flat ventral sole enables it to attach firmly to smooth, rocky surfaces • a related species, *Psolus japonicus*, occurs in the Chukchi Sea

36. Sea Football, *Cucumaria frondosa*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Dendrochirotida
Family Cucumariidae
Genus *Cucumaria*

Occurrence	• Peter the Great Bay to the Kuril and Commander Islands to the Aleutian Islands, Alaska to the west coast of Canada • intertidal to 1000 feet; most common at 100 to 300 feet
Form/Function	• dense, cylindrical, barrel-shaped, and slightly curved dorsally; body dark brown to bluish • body almost appears globose when animal is retracted • tube feet large and retractile • occur ventrally in 2 – 4 rows • occur dorsally as reduced in size or a spapillae • tube feet location varies greatly from one specimen to the next; some examples lack tube feet in the middle of the body section, for example • 10 tentacles, all large and similar in size • maximum length is 20 inches
Reproduction	• reach sexual maturity at age three • in spring males broadcast sperm into the water to stimulate females to spawn • eggs released by females are fertilized as they float through the milt (sperm) already released by the males • larvae remain in the plankton for up to 70 days before settling down as juveniles
Predators/Prey .....….....	• preyed upon by a few species of sea stars
Noteworthy Facts ……	• suspension feed by using mucus-covered tentacles to trap organic matter which is then transferred to the gut

	• have been commercially harvested, as a food, in Canada since 1999; the Canadian government is working to ensure that this sea cucumber is not overfished as the animal requires three years to reach reproductive age

37. Orange Sea Cucumber/Red Sea Cucumber, *Cucumaria miniata*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Dendrochirotida
Family Cucumariidae
Genus *Cucumaria*

Occurrence	• Sitka, Alaska along the coast to southeastern Alaska to Monterey County, California • low intertidal to subtidal
Form/Function	• body wall thick and tough • usually brick red in color, but also ranging from pinkish white to purple • tube feet arranged in definite rows • other podia may occur between these rows • 10 bright orange, branched tentacles, all of equal size • 4 to 10.5 inches long
Reproduction	• reach sexual maturity at age three • eggs, embryos, and larvae are orange in color • larvae appear as components of Puget Sound Plankton during March and April
Predators/Prey	• preyed upon by the sun star, *Solaster stimpsoni* • suspension feed by using mucus-covered tentacles to trap small organisms and detritus from the water
Noteworthy Facts ……	• research conducted on this species has focused on red cells and the hemoglobin contained in them; the function of this sea cucumber's retractor muscles and the animal's ability physiologically to respond to changes in salinity have been examined as well

38. **Black Sea Cucumber,** *Cucumaria vegae*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Dendochirotida
Family Cucumariidae
Genus *Cucumaria*

Occurrence	• Commander Islands, at the western end of the Aleutian Islands south to the Queen Charlotte Islands, British Columbia; also south to Hokkaido, Japan in the western Pacific • rocky intertidal to low intertidal
Form/Function	• a small species that grows to an average of 3 inches • dorsal side brownish black to light brown to yellowish gray • ventral side white • five bands of tube feet arranged in single or zigzag rows; three ventral rows are more prominent • no tube feet occur between the rows • generally possesses eight equal-sized tentacles and two smaller, ventral tentacles • some populations have been identified in which many individuals have all the tentacles of equal size (perhaps a result of misidentification?) • tips of tentacles are usually darkly pigmented • genital papillae located between the two dorsal papillae
Reproduction	• all that is known is that it broods its young in late winter
Predators/Prey	• likely preyed upon by a few species of sea stars, including six armed stars (*Leptasterias polaris*) and the sunflower star (*Pycnopodia helianthoides*) • suspension feed by using mucus-covered tentacles

	to trap organic matter which is then transferred to the gut
Noteworthy Facts ……	• is virtually identical to the spot sea cucumber (*Cucumaria pseudocurata*) except that the black sea cucumber is a bit larger

39. White Sea Cucumber, *Eupentacta quinquesemita*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Dendrochirotida
Family Sclerodactylidae
Genus *Eupentacta*

Occurrence	• Aleutian Islands, Alaska to Puget Sound • intertidal to 660 feet
Form/Function	• five rows of nonretractile tube feet and smooth spaces between • to 4 inches long • skin soft and pliable • general skin color is creamy white with the tentacles being of a faint peachy color • characteristically has bits of shell and other debris attached to the tube feet • eight tentacles are of equal size but there are two smaller, ventral ones as well • when collected, the tentacles tend to be retracted
Reproduction	• In Puget Sound, Washington spawning occurs in the spring and larvae occur in the plankton from March to May
Predators/Prey .....….....	• preyed upon by a few species of sea stars • examination of gut contents has detected mixture of filamentous algae and diatoms as well as detritus and inorganic materials
Noteworthy Facts …….....……	• 38% of specimens examined in Puget Sound were found to have parasites, especially the gastropod *Thyonicola Americana*

40. **Sea Sweet Potato,** *Caudina (= Molpadia) intermedia*

Kingdom Animalia
Phylum **Echinodermata**
Class Holothuroidea
Order Molpadiida
Family Molpadiidae
Genus *Caudina* (= *Molpadia)*

Occurrence	• Kodiak Island, Alaska to Gulf of Panama • subtidal
Form/Function	• body smooth and sausage shaped • tail is 20 – 25% of total body length • dark purplish-brown to purplish-gray with rusty brown patches • up to 17.5 inches long • 15 tentacles arranged in a tight ring about the mouth • these very short tentacles are branched just below the tip • when collected, the tentacles tend to be retracted
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• detritus feeder • occurs in the mud

Class Crinoidea

- sea lillies and feather stars
- most ancient and primitive of living Echinoderms
- flourished more than 250 million years ago (before dinosaur age)
- most sea lillies are stalked Crinoids that live attached to the bottom
- 80 known species still exist today
- not commonly encountered as most modern examples tend to live at depths in excess of 300 feet

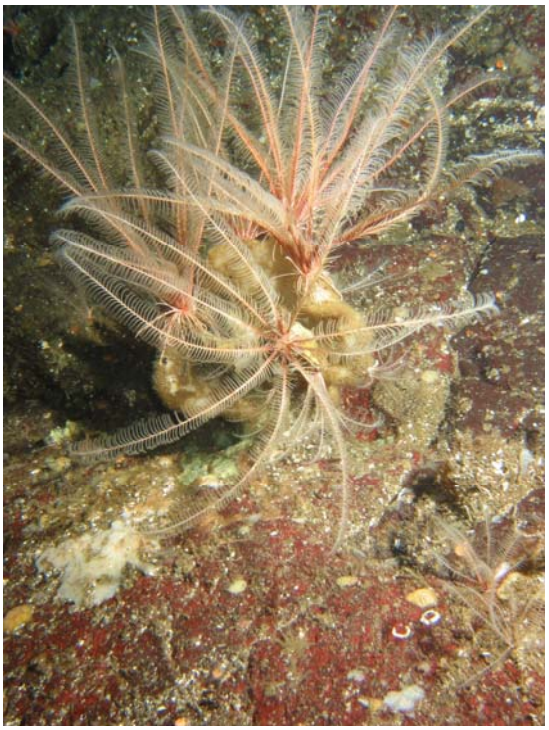


Fig. XIV. 10. Sea Lilies

- most modern Crinoids are members of the suborder Comatulida, the feather stars
- Comatulid characteristics
  - 550 species
  - free swimming crinoids
  - nonsessile (i.e., live not attached to the bottom as are the sea lillies)
  - occur from intertidal zones to great depths
  - comatulids have long attaching structures by which they can cling to rocks or creep over them slowly
    - if conditions are unfavorable, they can detach and by waving their arms swim to a new location

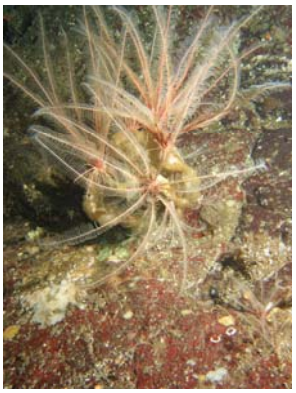


Fig. XIV. 11. Feather Stars (note structures)

- Crinoid body is a basal attachment stalk joined to a pentamerous body proper called a crown
  - sea lillies have a well developed stalk but this structure is mostly lacking in the feather stars
  - ossicles give stalk a joint-like appearance
  - many crinoids stalks bear structures called cirri, which are small, slender jointed appendages
  - in feather stars, these **cirri** are used for grasping the substrate when the organism comes to rest
- pentamerous body bears arms
  - **pinnules** are plume-like structures attached to the arms
- crown attaches to stalk by its aboral side, thus making the oral side face upwards
- mouth is near center of the oral surface
- five ambulacral grooves extend from the mouth to the arms
- most cold water Crinoids are brown in color
- most Crinoids have 10 arms (more primitive forms have only 5)
  - some feather star species have 80 to 200 arms
  - arms are 4 to 14 inches in length
  - arms have muscle tissue and can thus be moved
- movement made possible by a muscular system functioning in opposition to a water vascular system
  - the sessile sea lillies are limited to movement of only the arms and stalk
- feather stars swim and/or crawl through alternate raising/lowering of arm sets
- Crinoids are suspension feeders
  - mucus is secreted on arm structures; cilia in the ambulacral grooves direct the organic matter that becomes stuck to this mucus on towards the mouth
  - food is mostly zooplankton
- the outstretched arms form a filter-fan which is held perpendicular to current flow
- nervous system regulates muscle, and therefore arm and stalk, movements

- sexes are separate
- depending upon species, sperm and eggs may be released into ocean for fertilization to occur there or brooding may occur
- brooding is more typical of cold water species, especially those from Antarctica

41. **Feather Star,** *Florometra serratissima*

Kingdom Animalia
Phylum **Echinodermata**
Class Crinoidea
Order Comatulida
Family Antedonidae
Genus *Florometra*

Occurrence	• Alaska to California • subtidal
Form/Function	• corona, resembling a handful of feathers joined at the base, is main structure • a stalk maintains the corona well above the sea floor • cirri, anchor-like structures at the animal's base, anchor it to the substrate • like other echinoderms, feather stars have a vascular system and tube feet • neurosensors enable the animal to retract from light and touch
Reproduction	• brood young
Predators/Prey	• attacked by crabs, perhaps also by fish
Noteworthy Facts ……	• by everting its tentacles while moving through the mud it ingests sand and mud and ingests and feeds on the detrital particles in the substrate • the only crinoid commonly collected in our region • commensal crabs (mainly *Opisthopus transversus, Pinnixa faba*) are found in the cloaca of this cucumber

XV. Crabs, Shrimps, Lobsters, Krill, and Other Crustaceans : Kingdom Animalia, Phylum Arthropoda, Subphylum Crustacea

The crustaceans include some of the best known marine organisms, including crabs, lobsters, and shrimps. Although there are other important marine arthropods (e.g., the insects), we focus here on the Subphylum Crustacea as it is this group that is represented by living examples featured at the Alaska SeaLife Center. Nonetheless, in order to present the place of the Subphylum Crustacea within the Phylum Arthropoda, we must first present the general features common to this Phylum. We then examine the characteristics of the Crustacea.

Phylum **Arthropoda**

- world arthropod population, including insects, crustaceans, and spiders, is estimated to be 10^{18} individuals (that's 1,000,000,000,000,000,000, or one million trillion, individuals!!).
- about two of every three living organisms (not just animal organisms) is an arthropod
- arthropod Characteristics
    - the name *arthropod* means jointed foot; hence, arthropod legs are jointed
    - hard exoskeleton; strong and relatively impermeable to water
    - to grow, the old exoskeleton must be cast off (i.e., **molted**)
    - well developed sense organs, mostly located at front of body; includes:
        - compound eyes
        - olfactory (smell) receptors (**chemoreceptors**)
        - generally have an open circulatory system (largely lacks specialized vessels such as veins and arteries; there are some exceptions to this)

Subphylum **Crustacea**: crabs, lobsters, and shrimps

- more than 67,800 described living species
    - it is likely that another 120,000 species remain to be described
- great variety of form and habitat among different Arthropod groups
    - examples of diversity include plankton (which is partly comprised of microscopic, juvenile crustaceans) to crabs with leg spreads in excess of 12 feet
- marine, freshwater, brackish, brine, and terrestrial (e.g., pill bugs) forms
- shallow waters to deepest areas of oceans
- most diverse marine arthropod group
- head is relatively uniform across the entire crustacean subphylum
- five pairs of head appendages
    - two pairs of **antennae**
    - three pairs of mouth parts (including **mandibles**)
- among different species, trunk portion (i.e., the **thorax** and **abdomen** portions) of crustaceans is much less uniform than the head


Figs. XV. 1. Representative Crustaceans, a Crab (left) and a Shrimp (right)

- thorax and abdomen usually present
- depending upon the species, the trunk segments show varying degrees of specialization
- anterior trunk segments (collectively form the thorax) are covered by a dorsal (back) shield (carapace)
- anus typically present at the end of the thorax
- appendages are jointed (as in other arthropods)
- feeding methods vary among crustacean species; examples include:
    - biting predators
    - filter feeders
    - suspension feeders
- sexes separate in most species, but barnacles are hermaphroditic (i.e., have both sexes within one individual)
- copulation is a general rule among crustaceans
- male usually has specialized appendages which are modified to grasp female
- sperm usually transferred to female in a packet called a spermatophore
- most crustaceans brood their eggs
- earliest hatching stage is a nauplius larva, a free-swimming, zooplanktonic stage
    - the larva appearance can be very different from that of the adults
    - successive molts lead to various post-larval life stages, depending upon crustacean group

Although there are some eight different classes within the subphylum Crustacea, for our purposes we need be only concerned with the following two:

- Class **Cirripedia**, the barnacles
- Class **Malacostraca**, the crabs, lobsters, and shrimp

Class **Cirripedia**, the barnacles

- barnacles have been described by Louis Agassiz as "nothing more than a little shrimp-like animal, standing on its head in a limestone house and kicking food into its mouth"
- compared with other members of the Crustacea, body is greatly modified, depending upon species and/or life stage, to a free living, attached, or parasitic life
- basic crustacean body plan practically unrecognizable in the attached or parasitic forms
- up until the earlier part of the 19th century, barnacles were classified as mollusks

Fig. XV. 2. Thatched Barnacles

- thorax made up of six segments with paired appendages
- eyes reduced or absent in adults
- 1,000 or so described species
- locomotion confined to larval stages
- use feathery structures called cirri to filter feed
- parasitic forms may live on whales, turtles, or crustaceans
- most species are hermaphrodites (i.e., contain both sexes)
- as the barnacle develops from larval stage to adult, at some point (depending on species) its carapace becomes covered in a calcareous (i.e., limestone) excretion that forms plates
- the opening is directed upwards where the long, thoracic appendages can be used to scoop plankton from the water
- free living barnacles are called *thoracian* barnacles
- include stalked forms (such as goose neck barnacles) and sessile forms
- cement glands produce excretions that effectively affix barnacles to the substrate

Barnacles Maintained at the Alaska Sea Life Center

1. Common Acorn Barnacle, *Balanus glandula*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Cirripedia
Order Thoracica
Family Balanidae
Genus *Balanus*

Occurrence	• Aleutian Islands, Alaska to Baja California, Mexico • establishes dense assemblages on upper mid intertidal zone to 600 feet on both exposed and protected shores
Form/Function	• volcano-shaped shells of white to gray color; often a reddish- brown coating of diatoms in shell crevices • shells smooth to deeply ribbed • shells made up of six plates that fit tightly together while also leaving an opening at the top • opening is closed at low tides by pulling, via muscle contractions, down on the two pairs of plates and thereby protecting the internal tissues from desiccation • six leg pairs make sweeping motions for filter feeding
Reproduction	• although individuals contain both male and female sex organs, they do not fertilize their own eggs; thus, genetic variation introduced through sex is maximized through reproduction with another individual

	• very long penis (relative to the size of the organism it is the largest in entire animal kingdom) enables a barnacle to fertilize eggs of another individual that may be up to seven barnacles away • fertilized eggs are brooded within interior cavity of animal until the hatching larval stage (the naupilus), which becomes planktonic, is attained • the larva goes through six molts in the plankton, each of which represents a considerable change in form; this is followed by a nonfeeding cypris larva which is the settling stage that attaches to a suitable substrate • as juveniles, they cement themselves down to substrate and there develop into adults
Predators/Prey .....….....	• fed upon by whelks, limpets, sea stars, fishes (nip off cirri), and birds • feed, as filter feeders, upon phytoplankton and zooplankton
Noteworthy Facts ……	• abundant intertidal barnacle genus of Alaska; ability to close at low tide enables the organism to resist desiccation for long periods

2. Giant Acorn Barnacle, *Balanus nubilus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Cirripedia
Order Thoracica
Family Balanidae
Genus *Balanus*

Occurrence	• Southern Alaska to La Jolla, California (San Diego) • low intertidal to 300 feet; common on rocks, pier pilings, and hard-shelled animals
Form/Function	• up to 4.5 inch diameter and not easily confused with other barnacle species • volcano-shaped shells of white to gray color; often a reddish- brown coating of diatoms in shell crevices • shells smooth and lacking striation on the scutal pair of plates of the carapace • shells made up of six plates that fit tightly together while also leaving an opening at the top • opening is closed at low tides by pulling, via muscle contractions, down on the two pairs of plates and thereby protecting the internal tissues from desiccating • six leg pairs make sweeping motions for filter feeding
Reproduction	• individuals are hermaphrodites (i.e., contain both sexes in one individual) • produces up to six broods in the spring with 1,000 to 30,000 larvae produced per brood • very long penis (relative to the size of the organism is the largest in entire animal kingdom)

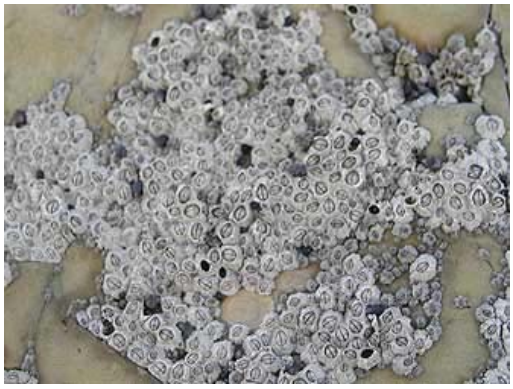
	enables a barnacle to fertilize eggs of another individual that may be up to seven barnacles away • fertilized eggs are brooded within interior cavity of animal until first larval stage is attained • larvae (called naupilus larvae) are planktonic and go through successive molts, each of which represents a considerable change in form • as juveniles, they cement themselves down to substrate and there secrete their carapace and develop into adults
Predators/Prey	• preyed upon by whelks, limpets, sea stars, fishes (nip off cirri), and birds • feed, as filter feeders, upon phytoplankton and zooplankton
Noteworthy Facts ……	• reportedly eaten by natives of northwestern North America, the barnacles were cooked over open fires • has been used for muscle physiology studies because it contains the largest individual muscle fibers known to science

3. Thatched Barnacle, *Semibalanus cariosus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Cirripedia
Order Thoracica
Family Archaeobalanidae
Genus *Semibalanus*

Occurrence	• Bering Sea to Morrow Bay (San Luis Obispo County, California); Japan • low intertidal on rocks to 180 feet, along exposed shores
Form/Function	• to 2.4 inches diameter • have a white or gray thatched wall permeated by many rows of longitudinal tubes • this thatched wall appearance results from a series of basal, rib-like buttresses that detach from time to time to allow for upward growth of the organism; this is more characteristic of California individuals as those from the Pacific northwest form more crowded communities and the thatched appearance
Reproduction	• broods in winter • larvae settle out in spring
Predators/Prey	• feed, as filter feeders, upon phytoplankton and zooplankton
Noteworthy Facts ……	• individuals may grow large enough to prevent their being attacked by predators

4. Little Brown Barnacle, *Chthamalus dalli*



Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Cirripedia
Order Thoracica
Family Chthamalidae
Genus *Chthamalus*

Occurrence	• Alaska to San Diego; northern Japan • high and upper middle tidal zones
Form/Function	• small; to about 1/3rd inch diameter • shells made up of plates that fit tightly together while also leaving an opening at the top • opening is closed at low tides by pulling, via muscle contractions, down on the two pairs of plates and thereby protecting the internal tissues from desiccating • six leg pairs make sweeping motions for filter feeding
Reproduction	• as hermaphrodites, when separated by more than 2 inches from neighbors of the same species, these barnacles self fertilize, though cross fertilization is more common • fertilized eggs are brooded within interior cavity of animal until first larval stage is attained • larvae go through successive molts, each of which represents a considerable change in form • as juveniles, they cement themselves down to substrate and there develop into adults
Predators/Prey	• feed, as filter feeders, upon phytoplankton and zooplankton
Noteworthy Facts ……	• occupy higher intertidal areas than acorn barnacles and thus spend much of their lives out of water; survival rate is higher in the high intertidal as compared to the low intertidal

Class Malacostraca

- the crabs, lobsters, and shrimps

- this class contains about 75% of the world's crustaceans
- structure
    - trunk usually made up of 14 segments
    - first eight make up the thorax
    - remaining six make up the abdomen
    - legs, present on thoracic region, are similar in structure to one another
    - may have paired appendages on anterior region of tail
    - these are used to generate currents for assistance in swimming, burrowing, aerating eggs, or food gathering
    - pelagic, shrimp-like crustaceans reaching about 3 cm. length
- 90 species
- exclusively marine
- many are filter feeders; feed by using the first six thoracic appendages to effectively sieve water
- some are predators
- appendages on abdomen (**pleopods**) are used for swimming
- many display luminescence
    - have specialized light-producing cells called **photophores**
- sperm are transferred to female in form of a sperm packet (spermatophore)
- eggs are liberated into the sea water or are retained briefly by the female by being attached to her undersurface
- blue whales can eat up to a ton of euphausiids in one feeding
- some species live in very shallow waters, others at great depth, and others migrate from one depth to another
- from the air, a swarm of surface-dwelling euphausids may cover several square blocks and appear like a giant, slow moving amoeba
- concentrations may reach 63,000 individuals/cubic meter
- most individuals in such surface swarms are concentrated in the first few yards nearest the water surface

Fig. XV. 3. Euphausiid

Order **Decapoda**, crabs, lobsters, and shrimps

- some of the largest and most highly specialized crustaceans
- 8,500 described species
- roughly one third of all known crustaceans
- mostly marine, although a few freshwater forms exist (e.g., crayfish/crawdads)
- distinguished from other Malacostracans by having first three pairs of thoracic appendages are modified into specialized mouthparts called maxillipeds
- remaining five pairs of thoracic appendages form legs; hence the name *decapod*
    - first pair of these leg appendages is often heavier than the others; when this is the case, the leg is called a cheliped (e.g., a lobster or crab claw is a type of cheliped)
- range in size from very small crabs that live commensally (i.e., symbiotically with benefit to the symbiont but neither help nor typically harm the host; occurs within some bivalves and sand dollars) to giant Japanese spider crabs with 13 foot leg spreads
- **shrimps**
    - most are bottom dwellers that swim only occasionally
- **crabs and lobsters**
    - **chelipeds** typically modified into powerful claws
- many modes of decapod feeding, but most are predators and/or scavengers
- some herbivorous forms feed upon algae
- some of these are also detritus feeders, and scavengers such as hermit crabs
- respiration in decapods occurs via gills
- a heart maintains flow of blood throughout body; the circulatory system is partially closed as blood vessels carry blood throughout numerous areas of the body before directing the blood into a large sinus area near the gills
- reproduction
    - sperm or eggs are produced in thoracic testes or ovaries, respectively
    - sperm may be transferred as a sperm packet (spermatophore)
    - many decapod species display courtship behaviors, such as special walking or stretching movements
- males and females often show marked differences in form (**sexual dimorphism**)
- pheromones often used as important sexual attractants
- mating varies among species, but males often hold females during copulation
- depending upon species, fertile eggs may be released into open ocean or brooded
- at a particular larval stage of development unique to a given species, the eggs hatch and the

emerging larvae become part of the zooplankton

- decapods living in cold or very deep waters tend to have shorter larval life stages
- larvae develop into juveniles which settle onto the bottom and, in turn develop into adults

Fig. XV. 4. Mating Tanner Crabs (female is smaller individual)

Decapods Maintained at the Alaska Sea Life Center

5. Spot Shrimp, *Pandalus platyceros*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Pandalidae
Genus *Pandalus*

Occurrence	• Unalaska Island, Alaska to San Diego, California; also waters near Sea of Japan • occur over rocky bottom from intertidal to over 1500 feet deep
Form/Function	• to 10 inches long • long, well developed spiny rostrum • five pairs of "**swimmerets**" underneath tail • three to four lateral white stripes on lateral surface of the carapace and two large white spots just behind the head on the anterior end of the abdomen, just in front of the tail • light to dark translucent orange body
Reproduction	• are protandric hermaphrodites; each individual initially mature as a male and then later develops into a female • breed in Autumn after female has molted • eggs are carried by females throughout winter months • hatching occurs in spring; larvae are zooplanktonic • larvae pass through several stages before becoming juveniles in late summer • females usually die after eggs hatch
Predators/Prey .....….....	• preyed upon by numerous fish species, marine mammals, birds, humans • as bottom foragers, spot shrimp prey upon other shrimp, plankton, small mollusks, worms, sponges,

	and fish carcasses
Noteworthy Facts ……	• most spot prawns are commercially harvested via traps or pots deployed on a long-line

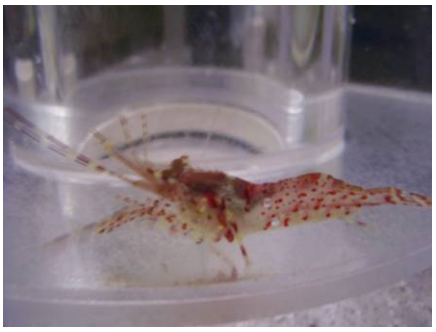
6. **Coon-Stripe Shrimp,** *Pandalus danae*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Pandalidae
Genus *Pandalus*

Occurrence	• Alaska Peninsula to Bahia San Quintin, Baja, California, Mexico • low intertidal on gravel/sand to 600 feet deep
Form/Function	• to 2.8 inches long • pale red color with irregular blue stripes • sometimes with white spots on the body • rostrum long and slender and curved upward • rostrum is continued as a ridge along the carapace top • legs striped in brown and white • six spines located on each side of tail
Reproduction	• are protandric hermaphrodites; each individual initially matures as a male and then later develops into a female • male uses first two swimming pairs of leg to transfer a • spermatophore (a “sperm packet”) to the female and thereby fertilize her eggs • females become egg-bearing in fall or early winter and carry these eggs until they hatch as larvae in the spring • larvae remain in water column for 2 to 3 months • larvae settle on to substrate as juveniles and occupy a different habitat (generally, this means shallower water) than adults
Predators/Prey .....….....	• preyed upon by octopus, other crustaceans, and fishes (notably cod, pollock, and rockfishes) • forage upon copepods, amphipods, euphausiids, mysids, polychaetes, etc.

Noteworthy Facts ……	• although the coon-stripe shrimp can be produced through aquaculture, it has thus far proved uneconomical to do so

7. **Rough Patch Shrimp**, *Pandalus stenolepis*



Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Pandalidae
Genus *Pandalus*

Occurrence	• Unalaska Island, Alaska to Hecata Bank, Oregon • low intertidal to 600 feet deep
Form/Function	• to 3.2 inches long • very similar to Pandulus danae • large brown spots on abdomen side rather than stripes, which is characteristic of *P. danae* • further distinguished from *Pandulus danae* by having narrow antennal scale, with the spine being wider than the blade at the tip • more conspicuously marked with bright blue spots than *P. danae*
Reproduction	• unknown, but may be similar to that of P. danae (see above), to which this species is closely related
Predators/Prey .....….....	• unknown or information unavailable (see *P. danae* (above) for possible prey and food items)
Noteworthy Facts ……	• although adults are easily misidentified as *Pandulus danae*, larvae of this species are markedly distinct from *P. danae*

8. **Bay Shrimp,** *Crangon stylirostris*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Crangonidae
Genus *Crangon*

Occurrence	• Chirikof Island, Alaska to San Luis Obispo Bay • generally shallow subtidal on sandy/rocky bottom to 170 feet
Form/Function	• to 2.2 inches long • rostrum short, dorsally flattened, lacking dorsal teeth, curving strongly downward, and tapering to an acute tip • carapace lacking a mid-dorsal spine
Reproduction	• unknown or information unavailable • like other crangonids, this species likely broods its eggs and releases larvae
Predators/Prey .....….....	• are food generalists that feed on small, benthic organisms, including bivalves, crustaceans, and ophiuroids • preyed upon by crabs, bottom fishes, and benthic-feeding marine mammals
Noteworthy Facts ……	• trawled commercially in San Francisco Bay for use as bait

9. Stout Coastal Shrimp/Shortspine Shrimp, *Heptacarpus brevirostris*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Hippolytidae
Genus *Heptacarpus*

Occurrence	• Attu (Aleutian Islands, Alaska) to south of Carmel (Monterey County, California) • intertidal pools and subtidal waters to 240 feet
Form/Function	• to 2 inches long • long, well developed spiny rostrum, reaching very little, if at all, beyond the eyes, and directed obliquely downward • no spines present above eyes on each side near the base of the rostrum • body color variable
Reproduction	• likely brood their eggs and release larvae like other shrimp species
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• very little is known concerning the biology of this shrimp

10. Graceful Kelp Crab, *Pugettia gracilis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Brachyura
Family Majidae
Genus *Pugettia*

Occurrence	• from Aleutian Islands to Monterey Bay, California • abundant in rocky shorelines and eelgrass beds of southeast Alaska • low intertidal to 460 feet in eel grass, kelp, and rocky substrate
Form/Function	• carapace up to 1.7 inches long • width 39.2 mm in males, 28.0 mm in females • abdomen not long but tucked underneath thorax • rostrum less than one third carapace length; carapace longer than wide • dorsal surface of carapace mostly smooth with a few spines on medial area • rear half of carapace with two lateral spines • long, thin claws; fingers of claws grayish or blue with orange tips • walking legs end in sharp points
Reproduction	• male and female copulate, and hence mate, throughout the year • eggs are carried by female for 28 – 31 days • larvae planktonic; settle down to bottom as juveniles
Predators/Prey	• preyed upon by numerous fish species and octopus • mainly an herbivore on brown algae but will feed

	on hydroids, bryozoans, and barnacles when algae not available
Noteworthy Facts ……	• large piles of graceful kelp crabs are often found about the dens of the giant octopus, *Enteroctopus dofleini*, a major predator of this crab species

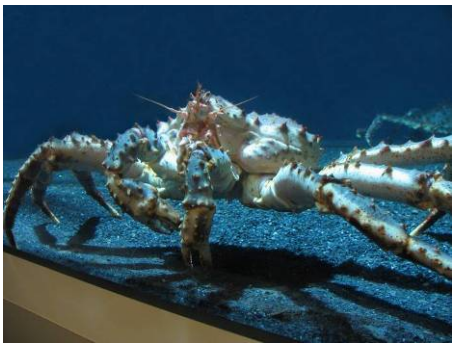
11. Northern Kelp Crab, *Pugettia producta*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Brachyura
Family Majidae
Genus *Pugettia*

Occurrence	• from Southeastern Alaska coastal waters to Baja California, Mexico • abundant in rocky shorelines and eelgrass beds of southeast Alaska • low intertidal waters to 318 feet deep • commonly occur under rocks, on brown algae, or in the kelp canopy
Form/Function	• abdomen not long but tucked underneath thorax • carapace width up to 73 mm in males and 78 mm in females • relatively smooth, brown to reddish, shield-shaped carapace • rostrum less than one third carapace length; carapace longer than wide • dorsal surface of carapace mostly smooth with a few spines on medial area • rear half of carapace with two lateral spines • long, thin pincers • walking legs end in sharp points
Reproduction	• pairs copulate and reproduce throughout the year • eggs carried by female for 28 – 31 days • larvae planktonic; settle down to bottom as juveniles
Predators/Prey	• preyed upon by numerous fish species • initially feeds on algae but, as it grows larger,

	assumes a more carnivorous diet, including hydroids. Bryozoans, and barnacles
Noteworthy Facts ……	• adults occur in kelp beds • young occur in low tide line on rocks or inshore brown algae • cannot survive in brackish estuarine waters • many egg-bearing females have egg masses infested with small ribbon worms (genus *Carcinonemertes*) • some are parasitized by a highly modified barnacle

12. **Red King Crab,** *Paralithodes camtschaticus*



Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Anomura
Family Lithodidae
Genus *Paralithodes*

Note: *There are two other species of king crabs indigenous to Alaska. These are the blue king crab, Paralithodes platypus, and the golden king crab, Lithodes aequispinus.*

Occurrence	• from the Chukchi Sea to the Bering Sea to Queen Charlotte Islands and along Aleutian Islands to Japan; though rare in the Chuckchi Sea, it is abundant in the Norton Sound of the northeastern Bering Sea; afterward, there is a considerable gap where few red king crabs are encountered until the southeast Bering Sea, where the crab is again abundant and harvested commercially • adults prefer sand or mud bottoms ranging in depth from 10 to 1200 feet
Form/Function	• males attain carapace sizes of about 9 inches x 11 inches • carapace reddish brown to purple in color • entire body covered in spines • rostrum less than one third carapace length; carapace longer than wide • dorsal surface of carapace mostly smooth with a few spines on medial area • rear half of carapace with two lateral spines • first pair of legs has long, thin pincers at terminals • remaining four leg pairs, walking legs, end in sharp points

Reproduction	• sexes separate, copulation occurs • females brood thousands of embryos beneath their tail flap for approximately one year • larvae hatch and become zooplankton in spring • subsequent mating also occurs in spring • larvae feed upon plankton and undergo successive molts until reaching juvenile stage • juveniles settle on bottom and develop into adults
Predators/Prey .....….....	• as pelagic larvae red king crab are consumed by numerous organisms, especially pelagic fishes; juveniles preyed upon by sculpins; as adults red king crabs are preyed upon by large fishes such as halibut; also preyed upon by sea otters, and humans • feeds on sea stars, sea urchins, clams, barnacles, and other benthic invertebrates
Noteworthy Facts ……	• very important commercially, it is the largest crab of the United States • most are taken from the Bering Sea and southeastern Alaska • juveniles often stay in shallow waters where they aggregate into very large balls of crab called pods • have been introduced to the Atlantic coast of Russia and Norway

13. Golden King Crab/Brown King Crab, *Lithodes aequispinus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Lithodidae
Genus *Lithodes*

Occurrence	• Japan, Sea of Okhotsk, Aleutian Islands, Alaska to Vancouver Island, British Columbia • subtidal, 300 to 3000 feet
Form/Function	• abdomen mostly or completely covered by calcified plates and pressed tightly against the underside of the thorax; most of abdominal integument calcified; median plates of abdominal segments 3 – 5 replaced by membraneous areas containing calcareous nodules; plates of abdominal segment 2 totally or partially fused • carapace lacking lateral expansions of the carapace that conceal the legs when viewed from above • dorsal view of carapace rounded posteriorly and lacking the appearance of an equilateral triangle; posterior half of the dorsal carapace also lacking a semicircular depression • carapace shiny and lacking large tubercles • legs 2 – 4 longer than carapace width • rostrum ending in two diverging spines or in a spine flanked by two other spines • length of rostrum approximately twice its width at the base; rostrum with some dorsal spines as well as lateral spines flanking the terminal projection
Reproduction	• adult females brood eggs under the tail flap for up to one year • fully developed embryos hatch out and become

	planktonic, free swimming larvae • over several months, larvae undergo several molts until they develop into juveniles and settle out on the bottom • juveniles have the appearance of adults but are smaller in size than a dime
Predators/Prey	• an important commercially harvested crab species
Noteworthy Facts ……	• less is known of golden king crab migrations that those of blue and red king crabs; however, as golden king crabs migrate vertically as they inhabit steep sloped areas of the ocean

14. Puget Sound King Crab, *Lopholithodes mandtii*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Anomura
Family Lithodidae
Genus *Lopholithodes*

Occurrence	• Sitka, Alaska to Monterey, California • subtidal to 450 feet in areas with strong currents
Form/Function	• abdomen mostly or entirely covered with calcified plates that are tightly pressed against the thorax underside • carapace lacking lateral expansions that obscure the legs when viewed from above • lateral dorsal carapace outline rounded posteriorly; entire carapace lacking the appearance of an equilateral triangle • carapace bumpy because of large tubercles being present • legs 2 – 4 stout and not longer than carapace width • tubercles on legs and claws are spinelike
Reproduction	• in late winter to spring move to shallower waters to breed
Predators/Prey .....….....	• feeds on sea urchins, other echinoderms, and sea anemones
Noteworthy Facts ……	• one of the largest crabs of the Pacific coast

15. **Dungeness Crab,** *Cancer magister*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Suborder Pleocyemata
Infraorder Brachyura
Section Cancridae
Genus *Cancer*

Occurrence	• from Pribilof Islands, Bering Sea, Alaska, south to Magdalena Bay, Mexico • widely distributed subtidally, preferring sandy or muddy bottom ranging from less than 45 feet deep down to 750 feet deep
Form/Function	• adult crabs have a carapace width of 6.5 inches on average; may reach 10 inches • broad, oval carapace has no spines • legs much shorter and more slender than king and tanner crab legs
Reproduction	• sexes separate • mating occurs from spring through fall • males only mate with a recently-molted (i.e., has just shed its old exoskeleton) female • females maintains sperm in reserve until eggs are fully developed; she then uses the sperm to fertilize the eggs • females carry eggs beneath abdomen; a large female may carry up to 2.5 million eggs • fertilized eggs hatch and larval crabs thus become zooplankton • several molts have larvae develop into juveniles, which settle upon bottom • juveniles develop into adults, which may be sexually mature at three years
Predators/Prey .....….....	• preyed upon by numerous fish species and humans • scavenge along sea floor; as carnivores they

	consume barnacles, shrimp, mussels, small crabs, clams, worms, and fish
Noteworthy Facts ……	• internal organs should not be eaten as these have been associated with paralytic shellfish poisoning • this crab is named after one of its habitats, a sandy bay inside the Dungeness Spit on the south shore of the Straits of Juan de Fuca

16. Tanner Crab and Snow Crab, *Chionoecetes bairdi and Chionoecetes opilio*

Tanner Crab

Snow Crab

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Brachyura
Family Calappidae
Genus *Chionoecetes*

Occurrence	• *C. bairdi*: southern region of the southeastern Bering Sea; mainly south of Unimak Pass to Winchester Bay, Oregon, but slightly overlap in southeast Bering Sea where *C. opilio* is found • shallow water to 1500 feet • *C. opilio*: Chuckchi Sea, Bering Sea, Arctic Ocean, North Atlantic Ocean from Greenland to Maine: 45 to 500 feet
Form/Function	• reach 1 to 2 pounds for *C. opilio* and 2 to 4 pounds for *C. bairdi* • carapace narrows towards the front into a rostrum • body shape roughly triangular

	• a pincer located at each leg terminus of the first leg pair • walking legs end in sharp points
Reproduction	• female undergoes terminal molt into adulthood and mates for first time • females attract males with pheromones (chemical attractants) • male grasps female and mating occurs • female will use sperm stored from the previous year's mating if no males are available for future mating • female broods up to almost half a million eggs on underside; such brooding lasts for almost one year • eggs develop into larvae, which usually hatch out in June to become part of zooplankton • larvae undergo successive molts to become juveniles, which settle on the bottom • juveniles undergo successive molts to develop into adults • adults sexually mature: females 5 years, males 6 years
Predators/Prey .....….....	• preyed upon by king crabs, numerous fish species, walrus and bearded seals, and humans • consume worms, crabs, mussels, snails, crabs and other crustaceans, and components of fishes
Noteworthy Facts ……	• may live up to 14 years • can be cannibalistic and consume smaller individuals

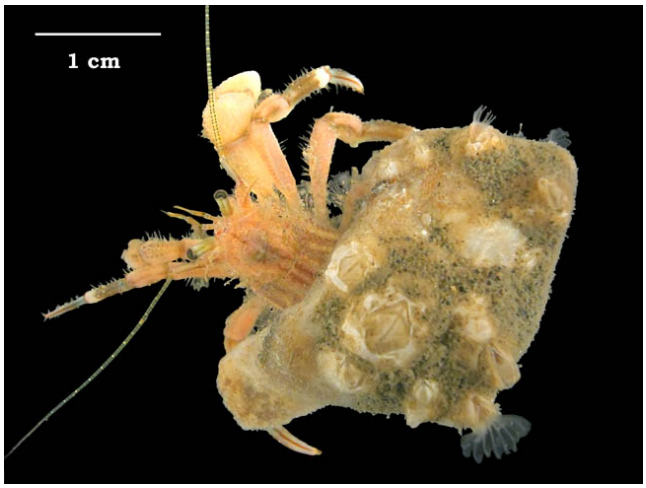
17. **Alaskan Hermit Crab,** *Pagurus ochotensis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Pribilof Islands, Alaska to Point Arena, California and to Southern Japan • a low intertidal species, preferring sandy to muddy bottoms and depths as great as 1275 feet
Form/Function	• up to 1.75 inches long • eyes green-yellow in color • claws and legs bear an iridescent sheen and grainy appearance; claws have a dark red stripe near the fingers • inner claw surfaces deep red
Reproduction	• prior to mating and egg extrusion, the male will hold the female's shell with his smaller claw and fend off other males with his larger claw • both male and female emerge about half way out of their shells during mating; the male attaches the sperm about the female's genital openings at this time • as female extrudes eggs to attach to her small legs (located inside the shell), the eggs are fertilized • female broods the eggs; females average 2.5 broods/year • larvae hatch out of eggs to become zooplankton; these undergo successive molts to become juveniles, which settle upon bottom to further develop into adults

Predators/Prey .....….....	• preyed upon by a few fish species, including gunnels, snailfish, and clingfish • primarily scavenges upon dead organic matter, but may also prey upon small invertebrates such as recently settled Pacific blue mussel
Noteworthy Facts …….……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of a dead snail and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • up to 50% of this species that had been examined in the northern Gulf of Alaska had **commensals** (mainly polychaetes) in their shells and 25% had commensals in the southeast Bering Sea

18. **Hairy Hermit Crab**, *Pagurus hirsutiusculus*



Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Pribilof Islands, Alaska to Monterey Bay, California and in the northwest Pacific, Bering Strait to Northern Japan • common tidepool species, found in mid to upper intertidal zones often seeking shelter beneath small rocks or under algae blades; have been found at depths as great as 365 feet
Form/Function	• up to 0.75 inches long • body olive green to black in color • noticeable white band along walking legs' outer segments and a blue spot on each dactyl • claw-bearing legs shorter than walking legs; right claw larger than left claw
Reproduction	• prior to mating and egg extrusion, the male will hold the female's shell with his smaller claw and fend off other males with his larger claw • both male and female emerge about half way out of their shells during mating; the male attaches the sperm about the female's genital openings at this time • as female extrudes eggs to attach to her small legs (located inside the shell), the eggs are fertilized • female broods the eggs; females average 5 broods/year during spring and summer

	• larvae hatch out of eggs to become zooplankton; these undergo successive molts to become juveniles, which settle upon bottom to further develop into adults
Predators/Prey .....….....	• preyed upon by a few fish species, including the tidepool sculpin • primarily scavenges upon dead organic matter or preys upon small invertebrates
Noteworthy Facts ……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of some dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth

19. **Bluespine Hermit,** *Pagurus kennerlyi*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Aleutian Islands, Alaska to Puget Sound and contiguous inland waters • primarily subtidal but occasionally intertidal on a wide range of substrate types (rock to mud) to 898 feet deep
Form/Function	• fourth claw appendage with a white band • eyestalks about five times as long as wide
Reproduction	• unknown or information unavailable, though probably similar to that of other hermit crabs
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of a dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • occasionally uses the hermit crab sponge, *Suberites* sp. (in the picture above, the view of the crab is largely obscured by the sponge)

20. Bering Hermit Crab, Pagurus beringanus

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Bering Sea and Aleutian Islands to Monterey Bay, California • low intertidal to 1193 feet
Form/Function	• walking legs colored pale blue with red spots and bands • claws reddish and thickly covered with spines • carapace length to 1 inch
Reproduction	unknown or information unavailable, though probably similar to that of other hermit crabs
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of a dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • will typically use the heavy shell of the frilled dogwinkle

21. Steven's Hermit Crab, *Pagurus stevensae*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Akun Bay, Akun Island (Aleutian Islands) to Puget Sound and contiguous inland waters • primarily subtidal but occasionally intertidal from 15 – 650 feet on mud, sand, or gravel substrate
Form/Function	• left claw more nearly triangular than elongate-ellipsoidal, and with a double row of divergent spines on the eminence near the midline of the dorsal surface of the spine • right claw is long and slender, with claws/legs a reddish brown color • rostrum not pronounced and possessing a blunt tip • distal claw part without a white band
Reproduction	• unknown or information unavailable, though probably similar to that of other hermit crabs
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of a dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • usually recognized by its shell being adorned in the sponge, *Suberites* sp.

22. Blackeyed Hermit Crab, *Pagurus armatus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Pagurus*

Occurrence	• Dutch Harbor, Unalaska Island, Alaska to San Diego, California low intertidal, preferring sandy bottoms, but also inhabits mud, shell, and gravel; may be found at depths as great as 479 feet
Form/Function	• up to 1.7 inches long • large, erect oval black eyes • claws bearing closely-packed spines on dorsal side
Reproduction	• prior to mating and egg extrusion, the male will hold the female's shell with his smaller claw and fend off other males with his larger claw • both male and female emerge about half way out of their shells during mating; the male attaches the sperm about the female's genital openings at this time • as female extrudes eggs to attach to her small legs (located inside the shell), the eggs are fertilized • female broods the eggs • larvae hatch out of eggs to become zooplankton; these undergo • successive molts to become juveniles, which settle upon bottom to further develop into adults
Predators/Prey	• preyed upon by a few fish species
Noteworthy Facts ……	• primarily scavenges upon dead organic matter • one of the largest and most commonly observed

	hermit crabs of the Pacific coast • hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of some dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • almost always found inhabiting moon snail shells (*Polinices* spp.)

23. **Pacific Red Hermit Crab,** *Elassochirus gilli*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Elassochirus*

Occurrence	• from Bering Sea and Alaska to Puget Sound, Washington, and northwest Pacific • inhabits rocky areas with considerable water movement, in low intertidal to 656 feet deep
Form/Function	• up to 1.5 inches long • right claw larger than left • body surface smooth • recognized by bright red-orange coloration
Reproduction	• prior to mating and egg extrusion, the male will hold the female's shell with his smaller claw and fend off other males with his larger claw • both male and female emerge about half way out of their shells during mating; the male attaches the sperm about the female's genital openings at this time • as female extrudes eggs to attach to her small legs (located inside the shell), the eggs are fertilized • female broods the eggs; females broods once/year • larvae hatch out of eggs to become zooplankton in April and May; these undergo successive molts to become juveniles, which settle upon bottom to further develop into adults
Predators/Prey .....….....	• preyed upon by a few fish species, including gunnels, snailfish, and clingfish
Noteworthy Facts ……	• primarily scavenges upon dead organic matter

	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of some dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • hermit crabs in the northeast Gulf of Alaska and a few in the northeast Bering Sea and Chukchi Sea had commensals (mainly polychaetes but some amphipods) in shells

24. **Widehand Hermit Crab,** *Elassochirus tenuimanus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Paguridae
Genus *Elassochirus*

Occurrence	• from Bering Sea and Aleutian Islands, Alaska to Puget Sound, Washington, and northwest Pacific • inhabits muddy, sandy, gravelly, or shell-ridden bottoms in intertidal zone to 1275 feet deep
Form/Function	• up to 1.5 inches long • right claw larger than left; is also considerably flattened into a "wide hand"; helps block entrance when animal has retreated into shell • body surface has grainy appearance; reddish brown and purplish blue patches on legs/claws
Reproduction	• prior to mating and egg extrusion, the male will hold the female's shell with his smaller claw and fend off other males with his larger claw • both male and female emerge about half way out of their shells during mating; the male attaches the sperm about the female's genital openings at this time • as female extrudes eggs to attach to her small legs (located inside the shell), the eggs are fertilized • female broods the eggs; females broods once/year • larvae hatch out of eggs to become zooplankton in March to May; these undergo successive molts to become juveniles, which settle upon bottom to further develop into adults
Predators/Prey .....….....	• preyed upon by a few fish species, including

	gunnels, snailfish, and clingfish • primarily scavenges upon dead organic matter; may prey upon small invertebrates such as the pacific blue mussel
Noteworthy Facts ……	• hermit crabs do not secrete their own shells; rather, they take the remaining empty shell of some dead mollusk and insert their strong, muscular abdomen into this; the abdomen then holds the shell firmly while the crab moves about by using its protruding claws and front-most pairs of legs • hermit crabs frequently abandon a smaller shell in exchange for a larger one; this accommodates the animal's growth • probably have polychaete and amphipod commensals in their shells

25. **Spiny Lithoid Crab,** *Acantholithodes hispidus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Lithodidae
Genus *Acantholithodes*

Occurrence	• Northeast Pacific off Moorovsky Bay, Alaska to St. Nicholas Island (Channel Islands), California • intertidal to 540 feet
Form/Function	• carapace to 5 inches across • rostrum studded with stout spines from base to tip • abdomen mostly soft and not tightly applied to thorax underside; abdomen also thick • claws unequal in size
Reproduction	unknown or information unavailable
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• apparently little is known of this crab's biology

26. **Butterfly Crab,** *Cryptolithodes typicus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Lithodidae
Genus *Cryptolithodes*

Occurrence	• Amchitka Island (Aleutian Islands), Alaska to Santa Rosa Island (Channel Islands), California • low intertidal and subtidal in crevices or on encrusted rock areas hidden by seaweed to 147 feet
Form/Function	• carapace to 2 inches long and 2.8 inches wide • color extremely variable • rostrum narrows towards distal end
Reproduction	• in the laboratory a 24 day larval planktonic stage was followed by a juvenile stage in which the crab was settled on the bottom
Predators/Prey	• feeds on bryozoans, coralline algae, and other encrusting organisms
Noteworthy Facts ……	• very little is known of the biology of this crab, however it has been observed blending in among accumulations of bivalvia shells

27. **Umbrella Crab,** *Cryptolithodes sitchensis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Lithodidae
Genus *Cryptolithodes*

Occurrence	• Sitka, Alaska to Point Loma, California • intertidal to 55 feet on wave-washed, seaweed-covered bedrock in sheltered crevices
Form/Function	• carapace smooth; half again as wide as long; to 3.6 inches wide • medially convex with a central longitudinal crest • anterior margins of carapace undulated and expanded practically as far forward as the rostrum • distal rostrum portion expanded • cone shaped eye stalk, cornea small • antenna scales have leafy appearance • chelipeds of unequal size • female abdomen wider than that of male • color highly variable; small examples are white while adults range from orange, pink, red-brown, green, grey, purple, or white; may be several of these colors with one of them being predominant
Reproduction	• unknown or information unavailable
Noteworthy Facts ……	• feed upon calcareous algae • this crab's capacity to lie motionless enables it to evade would-be predators • it is slow moving and clings tightly to rocks in a manner similar to that of the related *Cryptolithodes typicus* • because of its color, and like *C. typicus ,* it is well camouflaged and difficult to see

28. Hairy Lithoid Crab, *Hapalogaster mertensii*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Oreder Decapoda
Family Lithodidae
Genus *Hapalogaster*

Occurrence	• Atka, Alaska to Puget Sound, Washington • low intertidal to 180 feet
Form/Function	• body brown to red and brown • body entirely covered in golden brown bristles • fifth leg pair small and maintained folded up in gill chamber • attains a carapace width of 1.2 inches • rostrum length equal to twice its width at the base • upper palm surface of right claw with three rows of spines running lengthwise
Reproduction	• in Puget Sound, Washington practically all females carry eggs in November, December, January, and April but none in June or July • brood sizes varied from 600 to 2,076 eggs for animals with a carapace of 0.6 – 0.8 inches width • eggs hatch and larvae are free swimming for 44 days • at a later stage the larvae are capable of swimming but generally remain on the bottom • in the first juvenile stage (carapace width is 0.05 inches) the crab does not swim; it tucks its abdomen beneath the carapace like an adult and seeks shelter under pebbles
Predators/Prey	• an omnivore; it fans the water to obtain small particles and small organisms • can scrape algae off of substrate and thereby obtains brown, red, and green algae • also obtains barnacles by crushing

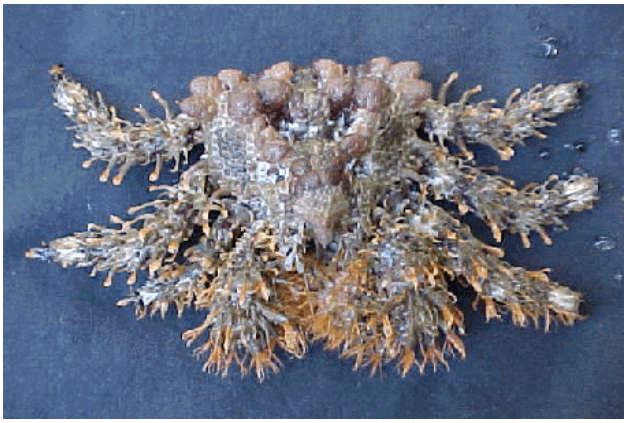
Noteworthy Facts ……	• the larval development stages described above for this species were obtained in a laboratory setting

29. Hairy Crab, *Hapalogaster cavicauda*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Oreder Decapoda
Family Lithodidae
Genus *Hapalogaster*

Occurrence ……..	• Cape Mendocino, California to Baja California, Mexico • low intertidal to 50 feet
Form/Function	• thick, velvet-like hair covers carapace legs, and claws • appendages flattened and having a fringe of golden hair along edge • abdomen soft and sac-like; loosely folded beneath body • attains a carapace width of 0.8 inches
Reproduction	• nearly all mature females carry 600 to 2000 eggs November-January and in April • eggs hatch as prezoea larvae and then go through four zoeal stages • the last stage is followed by a glaucothoe larva that can swim with pleopods but generally remains on the bottom where it feeds on small algae and material scraped from rocks
Noteworthy Facts ……	• a grazer on plants and animals, this species can also filter feed • cling tightly to underside of rocks • the larval development stages described above for this species were obtained in a laboratory setting

30. **Heart Crab**, *Phyllolithodes papillosus*



Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Suborder Pleocyemata
Infraorder Anomura
Family Lithodidae
Genus *Phyllolithodes*

Occurrence	Dutch Harbor, Aleutian Islands, Alaska to San Miguel Island, California • Low intertidal to subtidal in rocky areas with moderate to strong currents up to 600 feet
Form/Function	• carapace to three inches wide • abdomen mostly or entirely covered with calcified plates that are tightly pressed against the thorax underside • carapace lacking lateral expansions that obscure the legs when viewed from above • lateral dorsal carapace outline has appearance of an equilateral triangle; does, however, have blunt or sharp-tipped spines on lateral margins; posterior portion of dorsal surface has a semicircular depression • rostrum divided to form two blunt lobes • leg spines mostly blunt • semicircular depression in carapace bordered by large tubercles
Reproduction	• unknown or information unavailable

Predators/Prey .....….....	• observed feeding on small sea urchins and sponges
Noteworthy Facts ……	• easily identified by heart shaped markings on back

31. Scaled Crab, *Placetron wosnessenskii*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Anomura
Family Lithodidae
Genus *Placetron*

Occurrence	• Aleutian Islands, Alaska to Puget Sound, Washington; occurring in at least some Alaskan coastal waters; possible occurrence in Pribilof Islands • Shallow subtidal to 360 feet
Form/Function	• abdomen mostly soft (although the telson may be calcified and a few other calcified plates may be present); abdomen also thin and flat • carapace and legs with scale-like protuberances
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• feeds on shrimp, amphipods, crabs, and brachipods (this based upon stomach/fecal analysis) and brittle stars
Noteworthy Facts ……	• clawed appendages notable for their wide range of movement

32. Rhinoceros Crab, *Rhinolithodes wosnessenskii*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Anomura
Family Lithodidae
Genus *Rhinolithodes*

Occurrence	• Kodiak, Alaska to Crescent City, California • Shallow subtidal to 240 feet on gravel and rock substrate, often in crevices
Form/Function	• abdomen mostly or entirely covered with calcified plates that are tightly pressed against the thorax underside • carapace lacking lateral expansions that obscure the legs when viewed from above • dorsal view of carapace has appearance of an equilateral triangle; blunt or sharp-tipped spines along carapace lateral margin • rear portion of carapace surface containing an obvious, semicircular depression that is not bordered by prominent tubercles • rostrum not divided into two blunt lobes • leg spines sharp-tipped; lateral margins of carapace also with sharp spines
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• rostrum having one point like a rhinoceros, hence the common name

33. **Longhorn Decorator Crab,** *Chorilia longipes*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Infraorder Brachyura
Family Majidae
Genus *Chorilia*

Occurrence	• Japan, Shumagin Bank and Kodiak Island, Alaska to Cortez Bank, Mexico • subtidal to 3900 feet on mud, sand, gravel, shell, and rock substrates
Form/Function	• rostrum approximately half the length of the remainder of the Carapace and comprised of two, slender spinelike processes (these processes may be fused for much of their length); these processes diverge both proximally and distally • the otherwise spiny dorsal surface of the carapace lacks a tooth like structure behind each eye
Reproduction	• unknown or information unavailable
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• has a spider-like appearance

34. **Pacific Lyre Crab,** *Hyas lyratus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Majidae
Genus *Hyas*

Occurrence	• Chukchi and Bering Seas to Puget Sound, Washington • 30 to 200 feet on mixed sediment substrate
Form/Function	• males larger than females • rostrum not more than one third or two fifths the length of the remainder of the carapace; rostrum also bearing two broad, flattened processes • carapace, including the rostrum, is obviously longer than wide; length is 1.2 X the width • carapace without a prominent, sharp projection occurring on both body sides near or behind the middle (any such projections will occur on the anterior body half) • dorsal body outline lyre-shaped as a result of a toothed expansion of the carapace on both anterior half sides • rostral processes widest at their base
Reproduction	• mating aggregations of 2000 individuals (including 200 “grasping pairs”) have been observed
Predators/Prey .....….....	• unknown or information unavailable; probably feeds on food items similar to those used by *Chionoecetes*
Noteworthy Facts ……	• carapace may be covered with barnacle growth as well as that of other invertebrates

35. Graceful Decorator Crab, *Oregonia gracilis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Majidae
Genus *Oregonia*

Occurrence	• Bering Sea to Monterey Bay, California; Japan • intertidal and subtidal to 1500 feet on mixed sediment substrate
Form/Function	• rostrum approximately half carapace length and comprised of two slender, spinelike processes (may be fused medially for much of their length) • for at least the proximal half, the rostrum spinelike processes are almost parallel • the otherwise smooth dorsal surface of the carapace bears a large, sharp, tooth-like structure behind each eye
Reproduction	• male uses pleopods (specially modified appendages) to transfer spermatophore to female • fertilized eggs are carried by female on her abdomen • with the abdominal plate covering them • female frequently aerates the eggs • after eggs hatch, larvae become planktonic until juvenile stage is reached
Predators/Prey	• feeds on sea urchins, other echinoderms, and sea anemones
Noteworthy Facts ……	• almost always adorned in algae, sponges, hydroids, and other invertebrates; some of these provide more than mere camouflage by being toxic or distasteful to would-be predators

36. **Helmet Crab,** *Telmessus cheiragonus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Atelecyclidae
Genus *Telmessus*

Occurrence	• Norton Sound to Chukchi Sea (northern range limit) to Puget Sound, Alaska, Washington to Monterey Bay, California; Siberia to Japan in northwest Pacific • low intertidal to 350 feet
Form/Function	• greenish or brownish yellow • carapace up to 4 inch diameter • hairy • carapace lateral margin bears six “teeth”
Reproduction	• breeds in early spring • in laboratory observations, females were observed to molt prior to copulation; males performed precopulatory guarding of their mates • all molted females copulated • female broods eggs • upon hatching, larvae are planktonic • juveniles eventually develop from larvae
Predators/Prey .....….....	• notably preyed upon by sea otters and giant Pacific octopus • feeds upon bivalves, small polychaetes, and gastropods
Noteworthy Facts ……	• found in or near beds of eelgrass and on masses of rock heavily covered in algae • during spring their molted carapaces are often seen in great numbers along sediment shores

37. **Pygmy Rock Crab,** *Cancer oregonensis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Cancridae
Genus *Cancer*

Occurrence	• St. George Island (Pribilof Islands, Alaska) to Palos Verdes (Los Angeles County, California) • low intertidal on rocky shores, but more common subtidally to 1500 feet
Form/Function	• carapace to 1.25 inches wide in males, 1.9 inches wide in females • walking legs hairy • body dark red above, lighter below
Reproduction	• courtship, molting, and mating occur in late from April to June • male will grasp and carry a female for several days prior to her molt • mating occurs after female's molt • male remains with the post molted female until her shell has become sufficiently hardened to resume normal activities • sperm are stored by female until eggs are laid • females bearing eggs are seen November to February • depending upon size of carapace, females produced from 10,000 to 30,000 eggs per individual
Predators/Prey	• feeds on barnacles, polychaete worms, and smaller

	crustaceans
Noteworthy Facts ……	• this crab can open barnacles and gastropods with its powerful claws

38. Graceful Cancer Crab, *Cancer gracilis*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Cancridae
Genus *Cancer*

Occurrence	• Prince William Sound, Alaska to Bahia Playa Maria (Baja California) • occasionally common on mud flats and eel grass beds; low intertidal in bays; subtidal to 500 feet
Form/Function	• carapace to 3.4 inch diameter in males, 2.5 inches in females • walking legs slender and graceful • absence of tubercles on carapace surface
Reproduction	• in Monterey, California mating is common in November • females bearing eggs were noted in July and August • in Puget Sound, animals maintained in a laboratory bore eggs from December to April • a few of these females later produced a second brood • males stay with females after mating and may thus protect the females • larval stages planktonic
Predators/Prey .....….....	• in Monterey Bay preyed upon by the starry flounder • feeds on small bivalves and barnacles
Noteworthy Facts ……	• unharmed juveniles are sometimes found within the bells or stomachs of large jellyfish • although found seasonally in bays, this species

	does not tolerate brackish water conditions as its body wall is permeable to water and salts

39. Red Rock Crab, *Cancer productus*

Kingdom Animalia
Phylum **Arthropoda**
Subphylum **Crustacea**
Class Malacostraca
Order Decapoda
Family Cancridae
Genus *Cancer*

Occurrence	• Kodiak Island, Alaska to Isla San Martin, Baja California, Mexico • mid intertidal and subtidal to 250 feet; occurring on a wide range of substrate, it is most commonly found on gravel areas
Form/Function	• carapace to 6.3 inches in both sexes • carapace smooth with serrated margins • adults usually with upper surface dark red and lower surface yellowish white; young pure white or of various color patterns, including bands of brown and white, red and white stripes, and brown stripes
Reproduction	• mating occurs when females are recently molted and thus soft-shelled • egg-bearing females occur October to June in Puget Sound
Predators/Prey .....….....	• juveniles preyed upon by sculpins • feeds upon barnacles, clams, snails, mussels, small crabs, and dead fishes
Noteworthy Facts ……	• this crab can crush barnacles with its large claw

XVI. Sea Squirts/Tunicates: Kingdom Animalia, Phylum Chordata, Subphylum Urochordata

Before beginning our description of the sea squirts/tunicates, we need to first consider the phylum of the chordates (Chordata) in general. This phylum includes two less familiar invertebrate subphyla, the Urochordata (sea squirts/tunicates) and the Cephalochordata (lancelets). In addition, the phylum Chordata also consists of many organisms with which we have become most familiar, including the fishes, amphibians, birds, mammals, and reptiles.

The characteristics of the Chordata can be summarized as follows:

Chordata

- four anatomical features common among all members (often these features are only apparent during the embryonic development)

    1. Notochord
        - a longitudinal, flexible rod running the animal's length and located between the digestive tract and the nerve cord
        - provides skeletal support
        - only present in the adults of invertebrate chordates and primitive vertebrate chordates
        - in more advanced chordates, a jointed skeleton mostly replaces the notochord

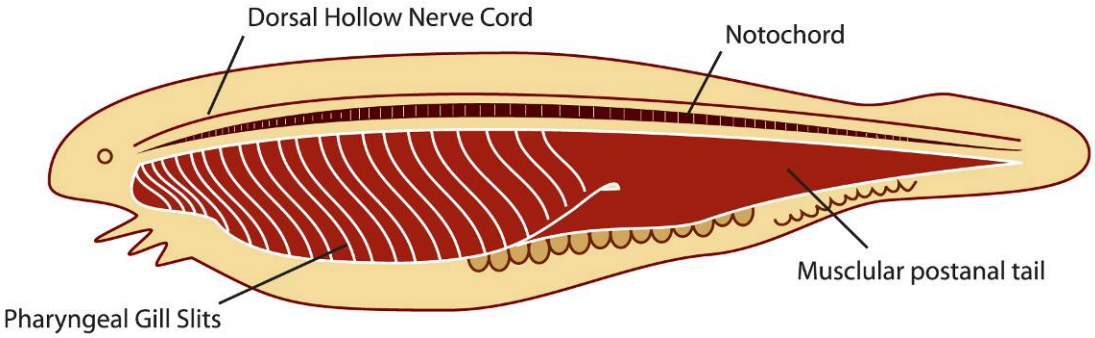


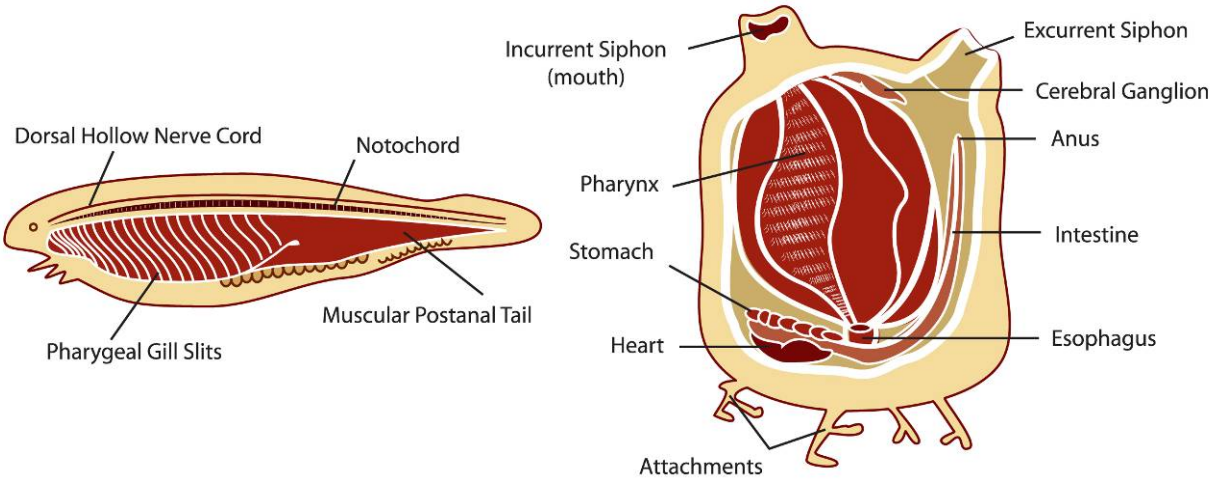
Fig XVI.1. The Four Chordate Characteristics (shown here in a primitive Chordate, the Amphioxus)

2. Dorsal, Hollow Nerve Cord
   - begins as a plate of embryonic nervous tissue that is rolled into a tube and located atop the notochord
   - in more advanced vertebrates (including fishes, amphibians, reptiles, birds, and mammals), the dorsal, hollow nerve cord develops into the central nervous system, consisting of both the brain and spinal cord.
3. Pharyngeal Slits
   - the pharynx is the throat and pharyngeal slits allow water to enter and exit the mouth without the animal having to swallow the water from the pharynx on through the remainder of the digestive tract (including the esophagus, stomach, intestine, and anus).
   - used for suspension feeding in many aquatic chordates
   - in some chordates, these slits and their supporting structures have undergone changes to facilitate gas exchange, support of jaws, hearing, and other functions.
4. Muscular, Postanal Tail
   - most chordates possess a tail that extends beyond the anus
   - muscles and skeletal elements in the tail come together to form propulsive structure for many aquatic chordates

Subphylum Urochordata, the Sea Squirts/Tunicates

- larval stage resembles a tadpole
- it is during this stage that the four chordate characteristics are most apparent
- as adults, most of the members of this phylum stay in one place (sessile) and adhere to the natural substrate or man-made surfaces
- some examples are planktonic (e.g., salps)
- some species live solitarily, others colonially

- a siphon brings water into the sea squirt
- the water then passes into through the pharyngeal slits to enter a large, open area called the atrium
- an exhalent siphon then takes water out of the animal; this structure can spout forth water when the animal is disturbed; hence the name sea squirt
- feeding is accomplished by the secretion of a net of mucous threads into the pharynx; these threads entrap organic matter that is pumped through the pharynx by long cilia
- mucus threads break off, enter the esophagus and then are passed on to the stomach and intestine for nutrient processing



Figs. XVI.2. Sea Squirt/Tunicate, Larva (left) and Adult (right, cutaway view)

- heart is a short, U-shaped tubular structure located near the digestive loop (i.e., the U-shaped turn in the digestive tract located near the base of the organism)
- no true blood vessels exist; rather, there are simply channels within the tissue through which the heart pumps the blood
- flow of blood through the heart changes direction at regular intervals
- nervous system is simple
- consists of a brain located between the two siphons; nerve cells arising from this brain control muscle contractions in "walls" of organism as well as siphons
- no special sense organs
- reproduction
    - asexual reproduction occurs as a result of budding
        - highly complex and variable among species
    - in sexual reproduction most tunicates are hermaphroditic (i.e., contain both male and female sex organs)

        - eggs or sperm are shed through the exhalent siphon and fertilization takes place in ocean
        - some species brood fertilized eggs in areas such as the atrium
        - larvae hatch out and become planktonic
        - larvae are free swimming for about 36 hours
            - thereafter the larvae settle down to the bottom and there develop into adults
- average life span of a sea squirt/tunicate is three years
- tunicates are either solitary individuals (e.g., the Sea Peach *Halocynthia* shown below) or colonial or compound tunicates
    - in the simplest colonies individuals are separate but joined by tube-like stolons
    - in the most specialized colonial species, all individuals of the colony are completely embedded in a common tunic

Urochordate maintained at the Alaska Sea Life Center

1. **Sea Peach**, Halocynthia aurantium

Kingdom Animalia
Phylum **Chordata**
Subphylum **Urochordata**
Class Ascidiacea
Order Stolidobranchia
Family Pyuridae
Genus *Halocynthia*

Occurrence	• from Arctic, throughout Bering Sea, south to Puget Sound; common north of Alaska Peninsula • commonly occurs at depths of 130 to 330 feet
Form/Function	• up to 7.5 inches in height • barrel shaped body that attaches directly to substrate • red orange outer covering may be smooth or wrinkled • two large siphons located atop the animal
Reproduction	• reproduces both sexually and asexually (see above generalized description for the Urochordata)
Predators/Prey .....….....	• preyed upon by crabs, some sea star species, and walrus • occasionally feeds on mussels and sea stars
Noteworthy Facts ……	• a suspension feeder • often occurs in groups • a related species has been cultured in Korea and Japan for human consumption

XVII. Fishes: Kingdom Animalia, Phylum Chordata

When one thinks of an aquarium, whether it be one in the home or a huge, public facility, the mind almost inevitably conjures up images of fish. Fish are a very diverse vertebrate group made up of the following three broad categories: jawless fishes (Class **Myxini**, hagfishes; Class **Cephalaspidomorphi**, lampreys), cartilaginous fishes (Class **Chondrichthyes**; sharks, skates, rays, and chimeras), and bony fishes (Class **Osteichthyes**; ray finned fishes, lobe finned fishes, and lungfishes). Practically all of the fishes maintained at the Alaska SeaLife Center are bony fishes.

We begin our survey of the Alaska SeaLife Center fish species with the big skate and the Alaska skate, the two **cartilaginous** species exhibited here. As a cartilaginous fish, this is a member of the class Chondrichthyes. The characteristics of this class are as follows:

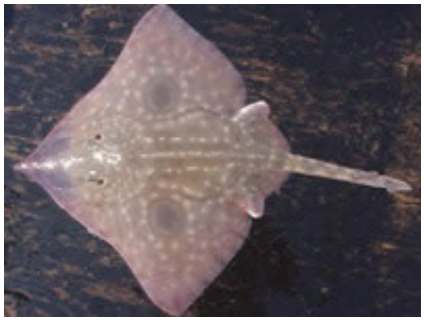
Class Chondrichthyes, the sharks, skates, rays, saw fishes, and guitar fishes

- **cartilaginous** skeleton (in fact, most species of chondrichthians have some mineralization of the otherwise flexible cartilaginous skeleton; in addition, chondrichthian teeth are bony)
- **swim bladder** or lung absent
- flow through intestine regulated by a special valve
- male has **pelvic fins**, called **claspers**, modified for sperm transfer
- teeth not fused to jaws
- teeth exhibit continual replacement

It should be noted that numerous shark species inhabit Alaskan waters. However, as these require a very large aquarium to accommodate their open ocean mode of life, they are impractical as specimens here at the Alaska Sea Life Center. The skate, a bottom swelling (benthic) cartilaginous fish species, does take to life at the Sea Life Center much better than most sharks from Alaskan waters.

Fishes in the Class Chondrichthyes Maintained at the Alaska SeaLife Center

1. Big Skate, Raja binoculata



top view

bottom view

Kingdom Animalia
Phylum **Chordata**
Class **Chondrichthyes**
Order Rajiformes
Family Rajidae
Genus *Raja*

Occurrence	• from Bering Sea and Aleutian Islands, at least as far as Unalaska Island, to eastern Gulf of Alaska to Cabo Falsa, southern Baja California • over soft bottoms from depths of 7 – 2,624 feet
Form/Function	• up to 8 (rarely over 6) feet long and 200 lbs • gray, brown, reddish brown, olive brown, or blackish with rosettes of white spots, darker mottling, and two prominent eye spots above • a flattened, diamond-shaped body with a stiff snout tapering to a blunt tip • dorsal surface light brown in color with dark brown spots • eyes positioned about 1/4th of the distance back from the snout to the terminal area of the ventral fins • **spiracles**, dorsal openings that allow breathing while animal is on substrate, located behind eyes • two small dorsal fins on the tail • pelvic fins large, tail long and narrow; weak notch

	in pelvic fin • mouth and five gill slits on ventral surface
Reproduction	• male uses claspers to insert sperm into female cloaca • an egg-layer (oviparous), the female produces egg capsules that are 9 to 12 inches long and 4 to 7 inches wide • capsules usually contain 3 to 4 eggs (occasionally contain as many as 7) • females releases pairs of egg capsules along sandy or muddy bottom • hatchlings emerge from eggs about 9 months after being released from the female • the empty egg case may be found washed up on the shore; it is called a **mermaid's purse**
Predators/Prey	• sharks and large bony fishes (e.g., halibut) prey upon big skates at various life stages • feeds on marine invertebrates (e.g., shrimps, worms, crabs, squid, and clams) as well as various fish species, including the great sculpin (*Myoxocephalus polyacanthocephalus*)
Noteworthy Facts ……	• often caught commercially and through sport fishing, though of little or no commercial value

2. **Alaska Skate,** *Bathyraja parmifera*

Kingdom Animalia
Phylum **Chordata**
Class **Chondrichthyes**
Order Rajiformes
Family Rajidae
Genus *Bathyraja*

Occurrence	• from Sea of Okhotsk, northern Sea of Japan, and Pacific Ocean off Hokkaido to Bering Sea to eastern Gulf of Alaska • demersal, 66 – 4,703 feet
Form/Function	• to 51.2 inches long • dorsal surface brownish colored with white spots; ventral surface white except for black blotches in tail region • rostrum soft and flexible • dorsal surface, covered in small prickles, is of a sandpaper texture • has a noncontinuous row of midback thorns
Reproduction	• male uses claspers to insert sperm into female cloaca • an egg-layer (oviparous), the female produces egg capsules that are 4 to 5 inches long approximately 3.5 inches wide • capsules usually contain 3 to 4 eggs • these capsules are oblong with stiff, pointy horns at the corners • are deposited in sandy or muddy flats • young may tend to follow larger objects, such as their mother
Predators/Prey	• predators unknown; juveniles likely preyed upon by benthic fishes • consumes benthic invertebrates, including polychaetes and crustaceans
Noteworthy Facts ……	• most common skate of eastern Bering Sea shelf

We now consider the characteristics of the Class Osteichthyes, the bony fishes.

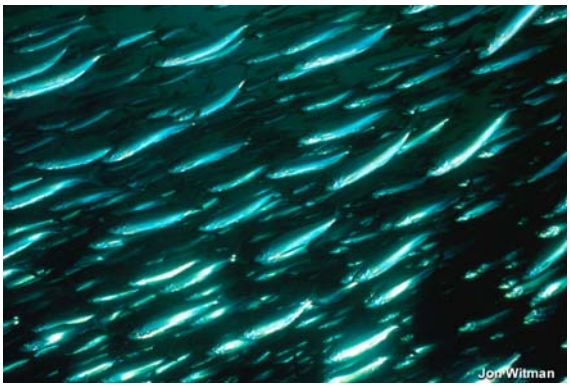
Class Osteichthyes characteristics

- fishes with bony skeletons
- scaly skin
- several gills on each side beneath a single gill cover
- with air sacs that function as lungs or as swim bladders

The remaining fish featured at the Alaska SeaLife Center are all of the class Osteichthyes.

Fishes of the Class Osteichthyes Featured at the Alaska SeaLife Center

3. Pacific Herring, *Clupea pallasii*



Herring School

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Clupeiformes
Family Clupeidae
Genus *Clupea*

Herring

Occurrence	• Korea and Japan to Arctic Ocean off Alaska to Northern Baja California; Arctic Canada to White Sea • inshore waters • surface to 820 feet deep
Form/Function	• up to 18 inches long • body laterally compressed, **fusiform** • dark green above, silvery white below • gill covers lack striations • a single **dorsal fin** positioned directly above pelvic fins
Reproduction	• spawn from late winter through spring and occasionally early summer • very sticky eggs deposited on structures, such as

	algae, kelp, rocks, and eel grass, in shallow water • eggs hatch in ten days • emerging larvae become part of the zooplankton; larvae develop into juveniles, which ultimately develop into adults
Predators/Prey .....….....	• preyed upon by many important commercial and sport fishes, such as salmon • feeds on a variety of small zooplankton, particularly copepods
Noteworthy Facts ……	• large amounts of eggs are often harvested for export to Japan • a continuous small market exists for fresh and specially treated herring as pickled or kippered • greater depths reported for this species are likely the result of individuals that entered a tow net before it had reached maximum depth

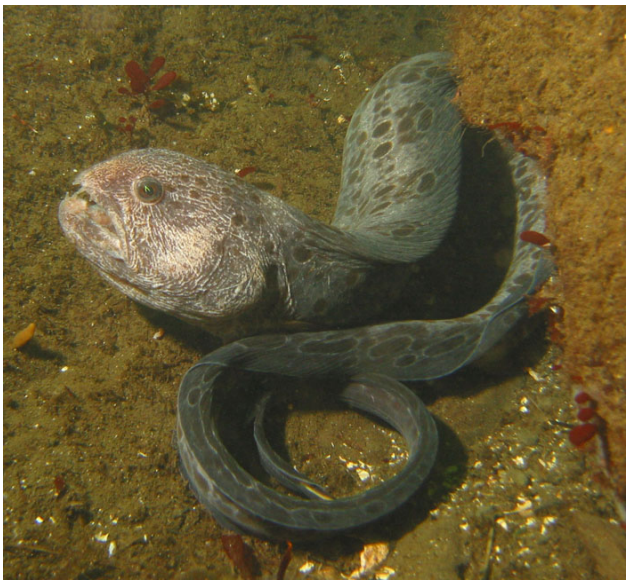
4. Three-Spined Stickleback, *Gasterosteus aculeatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Gasterosteiformes
Family Gasterosteidae
Genus *Gasterosteus*

Occurrence	• North Atlantic, Arctic Europe and Asia, and North Pacific; Korean Peninsula to Seas of Japan and Okhotsk to Bering, Chukchi, and Beaufort seas, and Gulf of Alaska to Monterey Bay, central California • occur in freshwater, brackish, or marine environments from 0 to 90 feet
Form/Function	• up to 4.5" long • two to four dorsal spines • color: freshwater examples mottled brown or greenish; anadromous forms silvery green to bluish-black
Reproduction	• this species is famous for the building of a nest by the males • the territorial male develops a red chest at breeding time (spring) • this red color is a stimulus that promotes aggression in other males and also attracts gravid (i.e., egg-laden) females to nest • after egg fertilization it is only the male that tends them
Predators/Prey	• eaten by larger fishes and fish-eating birds • feeds on small crustaceans and other invertebrates, larval and adult aquatic insects, and small fishes
Noteworthy Facts	• specimens living in calcium-deficient waters may not develop spines • like salmon, sticklebacks migrate between freshwater and the sea; they have been found up to 100 miles out at sea

	• commonly used as a laboratory research animal • may occur up to 500 miles offshore

5. **Wolf Eel,** *Anarrhichthys ocellatus*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Anarhichadidae
Genus *Anarrhichthys*

Occurrence	• Southeastern Bering Sea east to Cape Menshikof, west along Aleutian Islands to Krenitzin Islands, on to Gulf of Alaska and Pacific Ocean to southern California at Imperial Beach • rocky reefs and shorelines, occurring often in caves or crevices • intertidal to 740 feet (reported but not confirmed to 1,365 feet)
Form/Function	• very elongate body up to 6'6" long • head large and square, equipped with powerful jaws • mouth terminal and large, directed upward and forward • conical canine teeth in anterior part of jaws strong; molars in jaw sides very strong as well • dorsal fin continues to end of body • body tapers posteriorly to a point • tiny scales are buried in the skin • color ranges from grays, to browns, to dark green; juveniles may be orange
Reproduction	• at four years, aquarium-maintained wolf eels form

	pairs and these pairs remain together for life • usually mate in October to late winter • they produce eggs at 7 years • to induce female to mate, male butts female's abdomen with head and wraps his body around hers • male fertilizes eggs as they are released; up to 10,000 eggs laid at one time • both parents wrap themselves around the egg mass and protect them until hatching, which occurs in 13 – 16 weeks
Predators/Prey .....….....	• predators unknown or information unavailable • feeds on crustaceans, sea urchins, mussels, clams, snails, and some fishes
Noteworthy Facts ……	• conservationists are currently pushing for use of fish traps that do not disturb wolf eels and other residents of Alaska's rocky reefs • a formidable invertebrate predator

6. Grunt Sculpin, *Rhamphocottus richardsoni*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Rhamphocottus*

Occurrence	• Japan; western Gulf of Alaska near Unimak Pass, Sanak Islands, and Semidi Islands to Santa Monica Bay, southern California and Tanner Bank; likely also occurs in southern reaches of Bering Sea • intertidal rocks and reefs and below tide level; soft bottoms to depths of 846 feet • common in tide pools and shallow water, usually along rocky shores but also occurs on sandy beaches
Form/Function	• up to 3.25 inches long • short, stout, spiny body with a pointed snout • head large • pelvic fins and tail base may be orange
Reproduction	• females are egg layers (oviparous); often lay eggs in crevices or empty barnacle shells during winter; eggs are yellow to orange • male guards eggs • parents assist egg hatching by picking them up in their mouths and releasing larvae into the water column
Predators/Prey .....….....	• preyed upon by pigeon guillemots • feeds on zooplankton as larvae and crustaceans as adults
Noteworthy Facts ……	• use **pectoral fins** to crawl over rocks and seaweed • common name comes from half grunting, half hissing sound made when fish is removed from

	water

7. **Sailfin Sculpin,** *Nautichthys oculofasciatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Nautichthys*

Occurrence	• Kodiak archipelago, western Gulf of Alaska to San Miguel Island, southern California; common off Puget Sound • prefers rocky, intertidal areas with algae • to depths of 360 feet
Form/Function	• up to 8 inches long • unmistakable high **dorsal fin** • upturned caudal (tail) fin • a dark stripe angles through eye, ends on lower cheek
Reproduction	• females are egg layers (**oviparous**); often lay eggs among rocks • male guards eggs
Predators/Prey .....….....	• feeds on zooplankton as larvae and crustaceans as adults
Noteworthy Facts ……	• use pectoral fins to crawl over rocks and seaweed • swimming thrust provided mainly through movement of long, spinous dorsal fin • nocturnal • occasionally observed hanging upside down from the roof of a cave with the long dorsal fin extending in front of the head

8. Shortmast Sculpin, *Nautichthys robustus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Nautichthys*

Occurrence	• Aleutian Islands and Bristol Bay, southeastern Bering Sea, Alaska to northern Washington • sand and rock bottom and shallow exposed areas; near shore to 318 feet
Form/Function	• up to 2.5 inches long • mouth small, terminal, and directed somewhat upward • upper jaw extends to anterior portion of eye • steep and short snout • eye large • black bar across cheek, through eye, and on to the cirrus above the eye • pale brown with dark saddles on back
Reproduction	• unknown, however females of other sculpin species are egg layers (**oviparous**); often lay eggs among rocks and the male guards the eggs
Predators/Prey	• prey unknown but likely feed upon small invertebrates and small fishes
Noteworthy Facts ……	• a rather small sculpin

9. Tidepool Sculpin, *Oligocottus maculosus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Oligocottus*

Occurrence	• Pribilof Islands, southeastern Bering Sea; Shumagin Islands, western Gulf of Alaska to Palos Verdes Peninsula, southern California • in tidepools and other sheltered, rocky, intertidal areas
Form/Function	• up to 3.5 inches long • a single preopercular (i.e., before-the-gill) spine • few cirri on top of the head • no cirri between dorsal fin base and lateral line • in the male the first 3 – 4 rays in the caudal fin are large and swollen • green to red above, with irregular dark saddles on back; white or cream tinged with green or blue below
Reproduction	• unknown though all sculpin species are egg layers (**oviparous**) and some have internal fertilization; often lay eggs among rocks and these are often guarded by the male
Predators/Prey .....….....	• unknown, though likely feeds on small invertebrates and small fishes
Noteworthy Facts ……..…	• a small sculpin • after as much as a 335 ft. displacement, individuals of this species are still capable of finding their way back to home tide pools

10. **Roughspine Sculpin,** *Triglops macellus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Triglops*

Occurrence	• Kiska and Amchitka islands, Aleutian Islands to eastern Bering Sea north of St. Matthew and Nunivak islands, Alaska to Washington; also reported from central Oregon • Benthic; flat bottoms at 52 – 902 feet
Form/Function	• up to 8 inches long • slender and elongate • tiny scales on back • oblique folds of skin below lateral line • olive green to light brown above; white below with a silvery throat; approximately five saddles on the back
Reproduction	• unknown though all sculpin species are egg layers (**oviparous**) and some have internal fertilization; often lay eggs among rocks and these are often guarded by the male
Predators/Prey .....….....	• prey items unknown, though likely feeds on small invertebrates and small fishes
Noteworthy Facts ……	• a demersal species

11. **Big Mouth Sculpin,** *Hemitripterus bolini*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Hemitripterus*

Occurrence	• Eastern Sea of Okhotsk and northern Kuril islands to Commander-Aleutian Chain, Bering Sea to Cape Navarin, to north side of Alaska Peninsula to Eureka, northern California • offshore from 82 – 3,034 feet
Form/Function	• up 2 feet 3 inches long • large flattened head with blunt spines and knobby ridges • mouth very large; lower jaw projects outward • almost entire body covered in prickles • wide gap between dorsal fins • gray to brown above with vague saddles on back; paler below; fins with dark bars on stripes
Reproduction	• unknown though all sculpin species are egg layers (**oviparous**) and some have internal fertilization; often lay eggs among rocks and these are often guarded by the male
Predators/Prey .....….....	• unknown, though likely feeds on invertebrates and fishes
Noteworthy Facts ……	• distinguished by its enormous, oblique mouth

12. **Pacific Staghorn Sculpin,** *Leptocottus armatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Leptocottus*

Occurrence	• Port Moller, southeastern Bering Sea to Bahia San Quintin, north central Baja California • common inshore, especially within bays and estuaries; frequently found on sandy bottoms, it sometimes enters the lower portions of coastal streams; to 300 feet
Form/Function	• up to 18 inches long • no scales • upper preopercular spine long and antler-like • pelvic fin has four soft rays • tan to greenish brown or grayish above; yellowish to white below • dark spot present at rear of first dorsal fin
Reproduction	• unknown, though all sculpin species are egg layers (**oviparous**) and some have internal fertilization; often lay eggs among rocks and these are often guarded by the male
Predators/Prey	• preyed upon by cormorants, sea lions, and other predators
Noteworthy Facts ……	• one of the few sculpins that is caught by fishermen using baited hooks

13. **Padded Sculpin,** *Artedius fenestralis*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Artedius*

Occurrence	• Unalaska Island, Aleutian Islands to north side of Alaska Peninsula at Herendeen Bay and to Diablo Cove, central California • intertidal to 402 feet
Form/Function	• up to 5.5 inches long • scales on head and cheek • almost fully scaled between dorsal fin base and lateral line • generally pale orange or yellowish to greenish with dark saddles on back; paler below
Reproduction	• spawning occurs in spring • eggs are laid on rocks • male guards eggs
Predators/Prey	• unknown
Noteworthy Facts ……	• more common in the northern part of its range

14. **Smoothhead Sculpin,** *Artedius lateralis*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Artedius*

Occurrence	• Sanak Island, western Gulf of Alaska to Punta Baja • intertidal to 49 feet; has been reported to 228 feet
Form/Function	• up to 5.5 inches long • head profile steep and not rounded in front • no scales between top of pectoral fin base and lateral line • greenish to brown above, with approximately six brown saddles on back; cream to light green below; pale spots on underside of head and body
Reproduction	• spawning occurs in February • small, bright cherry red eggs are deposited in a mass and within a protected location among rocks • eggs hatch in 16 days
Predators/Prey	• prefers to eat small invertebrates
Noteworthy Facts	• formerly called the round-nosed sculpin

15. **Scalyhead Sculpin,** *Artedius harringtoni*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Artedius*

Occurrence	• Aleutian Islands at Unalaska Island to western Gulf of Alaska; Kodiak Island, western Gulf of Alaska to southern California at San Miguel Island • intertidal and subtidal to 70 feet
Form/Function	• up to 4 inches long • brown and orange to olive, often having pink and red • pale spots and mottling on sides and transition to ventral side and blending with a white or tan belly • saddles that are dark red or reddish brown • bars radiating from eye • posterior nostril tube noticeably longer than anterior • maxilla extend to pupil
Reproduction	• spawns in winter and spring • eggs are laid on rocks • male guards eggs
Predators/Prey	• prefers to eat small invertebrates
Noteworthy Facts ……	• maintained as an aquarium fish, this is regarded as a good community species

16. Spinyhead Sculpin, *Dasycottus setiger*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Dasycottus*

Occurrence	• Seas of Japan and Okhotsk, Pacific coast of northern Honshu, Japan to Commander-Aleutian chain and Bering Sea, Alaska to Navarin Canyon, to Washington • demersal from 49 - 2789 feet; on soft bottoms
Form/Function	• up to 18 inches long • color pinkish-gray with gray to dark brown blotches and bars occurring on head, body, and fins • large head with lower jaw protruding • maxilla extends all the way to the posterior eye margin • four spines projecting at various angles above eye • many cirri scattered about head and body
Reproduction	• unknown or information unavailable
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• usually occurs on the middle shelf to upper slope at 60 – 330 feet

17. Coastrange Sculpin, *Cottus aleuticus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Cottus*

Occurrence	• Kobuk River (drains to Kotzebue Sound, eastern Chuckchi Sea); Bristol Bay, Alaska Peninsula, and Aleutian Island drainages to Oso Flaco Creek, Santa Barbara County, central California • occurs in freshwater and in estuaries
Form/Function	• up to 5.75 inches long • a smooth body with prickles restricted to area behind pectoral fin • all four nostrils tubular • no scales • no cirri on head or body • mottled black or brown, becoming yellowish white on underside • vague, dark saddles below second dorsal fin • male much darker than female during spawning
Reproduction	• spawning occurs in lower areas of streams as well as estuaries; migrate downstream to these areas during the spring • each female lays up to 800 eggs on a rock undersurface • eggs guarded by male
Predators/Prey .....….....	• eats invertebrates as well as salmon eggs and fry
Noteworthy Facts ……	• the prickly sculpin, *Cottus asper*, is similar except that it is sometimes partially or entirely covered with prickles and may (rarely) grow to a foot in length

18. Longfin Sculpin, *Jordania zonope*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Jordania*

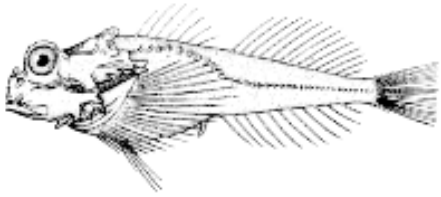
Occurrence	• Danger Island, Prince William Sound to Diablo Canyon, central California • Intertidal, including tidepools • Commonly to 126 feet, it has been reported to 306 feet
Form/Function	• up to 6 inches long • first dorsal fin long with 17 – 18 spines • anal fin elongate with 23 – 24 rays • scales cover most of body • scales below lateral line fused in oblique rows • olive green marked with red; dark bars on cheek below eye • 6 – 8 dark saddles on back; large, dark blotches on side • caudal fin bright orange; pelvic fin dusky
Reproduction	• breeding observed in October • several clusters of 20 – 30 eggs each are released
Predators/Prey	• prey items unknown but likely feeds on invertebrates and small fishes
Noteworthy Facts ……	• this species frequently hangs vertically on underwater rock faces

19. **Armorhead Sculpin,** *Gymnocanthus galeatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Gymnocanthus*

Occurrence	• Northern Japan Sea off Hokkaido to Commander-Aleutian chain and Bering Sea to Wales Island, British Columbia • soft bottom near shore to 1,900 feet (possibly to 2,050 feet); most frequent below 165 feet
Form/Function	• up to 14 inches long • only scales are modified, T-shapes ones located behind the pectoral fin and small, rough, plate-like scales atop the head that occasionally extend down the gill cover and on to the gill cheek • upper preopercular spine antler-like • pelvic fin containing three soft rays • brown to tan above; paler below; portions of head darker; four pale areas located below dorsal fins; fins with oblique bars
Reproduction	• unknown; all sculpins are egg layers (ovoviviparous) although some species have internal fertilization • males typically guard eggs until hatching
Predators/Prey	• unknown; likely feeds on invertebrates and small fishes
Noteworthy Facts ……	• resilience of this species is very low as some 14 years are required for population doubling to occur • in the original description of the species, the genus name was misspelled as *Gymnacanthus* (instead of the correct *Gymnocanthus*); thus, later correction to the correct genus spelling did not constitute this fish being moved to a different genus

20. Leister Sculpin, *Enophrys lucasi*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Enophrys*

Occurrence	• Bering Strait, Alaska and Commander-Aleutian chain to northern British Columbia near Port McNeill • Benthic; from shallow subtidal depths of 56 feet and less to 650 feet
Form/Function	• up to 8 inches long • 13 – 14 rays on average in second dorsal fin • 9 – 11 anal fin rays • long preopercular spine with barbs on its upper surface; this spine is shorter than in the antlered sculpin, *Enophrys diceraus*
Reproduction	• unknown; all sculpins are egg layers (ovoviviparous) although some species have internal fertilization; males typically guard eggs until hatching
Predators/Prey .....….....	• unknown; likely feeds on invertebrates and small fishes
Noteworthy Facts ……	• resilience of this species is very low as some 4.5 - 14 years are required for population doubling to occur

21. **Buffalo Sculpin,** *Enophrys bison*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Enophrys*

Occurrence	• Uyak Bay, Kodiak Island, western Gulf of Alaska to Monterey Bay, central California • Inshore; benthic intertidal to depths of 85 feet; rarely in tidepools; reported to 450 feet
Form/Function	• up to 8 inches long • dark-brown, green-black, or white with black mottling • ivory or white on ventral side • 3 or 4 dark bands • dorsal, caudal, and pectoral fins with heavy spotting and having black bars • pectoral, pelvic, and anal fins having an orange fringe • portion of eye lies above profile • scales only present on lateral line
Reproduction	• spawns intertidally • male guards eggs
Predators/Prey	• feeds on invertebrates and small fishes
Noteworthy Facts ……	• a common inshore species

22. **Tadpole Sculpin,** *Psychrolutes paradoxus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Psychrolutes*

Occurrence	• Okhotsk Sea and Sea of Japan to Norton Sound, Bering Sea and Commander-Aleutian chain to Puget Sound, Washington • found on soft and rocky bottoms, near shore to demersal, 20 - 722 feet
Form/Function	• up to 2.5 inches long • large, smooth head; gives fish a tadpole-like appearance • upper dorsal fin low and spinous • strong, dark bar on the pectoral fins
Reproduction	• females are egg layers (oviparous); often lay eggs among rocks • male guards eggs
Predators/Prey	• feeds on zooplankton as larvae and crustaceans as adults
Noteworthy Facts ……	• use pectoral fins to crawl over rocks and seaweed • This picture was taken with “off hatsushima” cabled observatory which is located on deep seafloor at a depth of 1175 meters in Sagami Bay, Japan.

23. **Plain Sculpin,** *Myoxocephalus jaok*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Myoxocephalus*

Occurrence	• Japan Sean off north Korea to and Okhotsk Sea to eastern Chukchi Sea at least as far north as Point Blecher, to eastern Gulf of Alaska at Limestone Inlet and Glacier Bay • Intertidal and to depths of 2,231 feet
Form/Function	• up to 24” • three long ridges on head • large, broad head • gray with dark blotches irregularly scattered over body; no prominent dark saddles across body
Reproduction	• females are egg layers (oviparous); often lay eggs among rocks • male guards eggs
Predators/Prey	• feeds on zooplankton as well as crustaceans (the crabs *Chionoecetes, Hyas lyratus, H. coarctatus,* crangonid shrimp), cephalopods, and fishes (walleye pollock, small sculpins, and other fishes) • they appear to have few predators; however, harbor, spotted, and ringed seals feed on sculpins, and it is likely that species within the genus *Myoxocephalus* are included
Noteworthy Facts ……	• use pectoral fins to crawl over rocks and seaweed

24. Great Sculpin, *Myoxocephalus polyacanthocephalus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Myoxocephalus*

Occurrence	• Okhotsk Sea and eastern Japan Sea to Commander-Aleutian chain to Bering Strait, to southern Puget Sound, Washington • sandy and muddy bottoms and in the vicinity of rocks • usually intertidal to depths of less than 650 feet, but still common at 650 to 1000 feet • can occur to a depth of 2,707 feet
Form/Function	• up to 30 inches long • large head, broad body, long snout • three short ridges on head • dark, saddle-like markings across the body • adults have reddish-orange eyes
Reproduction	• spawn in late winter to early spring but precise mode of reproduction unknown
Predators/Prey .....….....	• feeds on crustaceans (the crabs *Chionoecetes, Hyas lyratus, H. coarctatus,* crangonid shrimp), cephalopods, fishes (walleye pollock, small sculpins and other fishes) • they appear to have few predators; however, harbor, spotted, and ringed seals feed on sculpins, and it is likely that species within the genus *Myoxocephalus* are included
Noteworthy Facts ……	• use pectoral fins to crawl over rocks and seaweed

25. **Frog Sculpin,** *Myoxocephalus stelleri*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Myoxocephalus*

Occurrence	• Japan Sea coast of South Korea to Okhotsk Sea, east coast of Kamchatka, and Commander Islands; Unalaska Island, Aleutian Islands, to Port Conclusion, southeastern Alaska • Intertidal to 180 feet, often found in the lower reaches of streams • Can occur in tidepools and shallow grassy tidal areas to depths of 3 feet and less
Form/Function	• up to 16 inches long • brown on back; dusky blotches and mottling; three light gray bands • in young individuals the dorsal head side is mottled • fins barred and spotted • males have round white spots laterally • head large, wide, and depressed • very thick lips • skin naked
Reproduction	• unknown, though all sculpin species are egg layers (**oviparous**) and some have internal fertilization • often lay eggs among rocks and these are usually guarded by the male
Predators/Prey	• food items unknown, though likely feeds on small invertebrates and small fishes • they appear to have few predators; however, harbor, spotted, and ringed seals feed on sculpins, and it is likely that species within the genus *Myoxocephalus* are included
Noteworthy Facts ……	• the presence or absence of this species has been utilized as an environmental indicator in the Sea of Japan

26. **Red Irish Lord, Hemil***epidotus hemilepidotus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Hemilepidotus*

Occurrence	• Commander-Aleutian chain and southeastern Bering Sea to Mussel Point, Monterey Bay, central California • intertidal (including tidepools) to 289 feet; has been reported to 552 feet
Form/Function	• up to 20 inches long • large head, broad body, rounded snout, thick lips fringing mouth • eyes have a protruding appearance • body mostly red in color
Reproduction	• reproduces in March • egg layers (oviparous) • females lay masses of pink eggs in low intertidal or shallow subtidal rocky environments • male guards eggs until they hatch and become larval zooplankton
Predators/Prey	• preyed upon by river otters • feeds on zooplankton as larvae • eat larger crustaceans , barnacles, and mussels as adults
Noteworthy Facts ……	• use pectoral fins to crawl over rocks and seaweed • one of Alaska's largest sculpins • contrary to previous reports, this species has not been documented from the Pacific Ocean off southeastern Kamchatka or the western Bering Sea except off the Commander islands

27. **Yellow Irish Lord,** *Hemilepidotus jordani*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Hemilepidotus*

Occurrence	• Okhotsk Sea off Hokkaido to Commander-Aleutian chain, Bering Sea, and southern Chukchi Sea to Port Conclusion, southeastern Alaska • inhabits soft bottoms, often in shallow, near-shore waters; to depths of 3,008 feet, however and rarely deeper than 800 feet; juveniles occasionally found in rocky tide pools
Form/Function	• up to 20 inches long • large head, broad body, rounded snout, thick lips fringing mouth • yellowish tan to dark brown with vague, dark saddles • gill membranes yellow • dorsal fin continuous; third dorsal spine shorter than 4th, thereby forming a notch in the fin profile
Reproduction	• unknown or information unavailable
Predators/Prey	• feeds on small fishes
Noteworthy Facts ……	• of some commercial importance

28. **Shortspine Thornyhead,** *Sebastolobus alascanus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastolobus*

Occurrence	• Sea of Ohkotsk and Sea of Japan to Pacific Ocean and Bering Sea off Kamchatka to Navarin Canyon and Pacific to Boca de Santo Domingo, southern Baja California • occurs over deep soft bottoms and occasionally over reefs to depths ranging from 56 to 5000 feet
Form/Function	• up to 32 inches long • body bright red in color with some black on fins • 1 to 2 black dots on the spiny dorsal fin • head large, body elongate • strong spiny ridges on head • broadly notched dorsal fin with more than 13 spines • pectoral fins in two sections
Reproduction	• are oviparous • twin-lobed, gelatinous eggs that drift in upper water column • eggs hatch and larvae become zooplankton; larval stage lasts 14 15 months • settle to life at bottom in juvenile stage; thereafter develop into adults near/at bottom
Predators/Prey .....….....	• feeds on fishes and crustaceans
Noteworthy Facts ……	• a frequently encountered species, but commercially not important due to its small size • *alscanus* means “Alaskan” and refers to the first scientific capture location • colloquially referred to as *idiot* • may live to 100 years or more

29. Cabezon, *Scorpaenichthys marmoratus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Cottidae
Genus *Scorpaenichthys*

Occurrence	• Southeastern Alaska near Sitka to Punta Abreojos, central Baja California • intertidal and to 360 feet
Form/Function	• up to 30 inches long • upper opercular spine usually over 18 inches long • unscaled • branched cirrus above eye • skin flap present on snout • five soft rays present in pelvic fin • brown, reddish, or greenish above; whitish to greenish below
Reproduction	• adults spawn on rocky outcrops • aggregates for spawning • male guards eggs until they have hatched • larvae are planktonic • juveniles settle into tide pools and later move to reefs and kelp forests with continued development into adulthood
Predators/Prey	• feeds on crustaceans, mollusks (including abalones, squid, and octopus), fish eggs, and small fishes
Noteworthy Facts ……	• eggs are poisonous to birds, humans, and other mammals; will make humans violently ill • bluish green flesh turns white when cooked and is good eating • important to some west coast, nearshore commercial fisheries • larvae have been collected from the western Gulf

	of Alaska along the shelf east of Kodiak Island

30. **Copper Rockfish,** *Sebastes caurinus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Western Gulf of Alaska east to Kodiak Island to Islas San Benito, central Baja California • Intertidal, over low profile rock and shallow reefs to depths of 607 feet
Form/Function	• up to 22 inches long • deep fusiform body • body colors range from orange-brown, olive, dull yellow or copper above, white below and on head • snout of moderate sharpness
Reproduction	• ovoviviparous (young develop in females and are extruded as larvae); fertilization of eggs is thus internal • larval length 0.2” when extruded from mother • lack an extensive pelagic juvenile stage • young fish first settle out among large algae • subadults and adults are found in boulder fields and over high relief rocks
Predators/Prey	• feeds on fishes and crustaceans
Noteworthy Facts ……	• a popular, though not very abundant, sport fish • take care when handling to avoid mildly venomous dorsal and anal spines • some specimens have been aged to 50 years • occasionally found in the dens of giant octopus, *Enteroctopus dofleini*

31. **Yellowtail Rockfish,** *Sebastes flavidus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Eastern Aleutian Islands south to Unalaska Island to Isla San Martin, northern Baja California • mostly pelagic and in schools; near surface to 1,801 feet; also intertidal
Form/Function	• up to 26 inches long • deep fusiform body • mostly olive to greenish brown or dark gray above; paler below; light areas on upper back and reddish brown speckles present on scales; caudal fin dirty yellow; other fins with touches of yellow • head spines weak
Reproduction	• ovoviviparous • spawn January to July • lay 56,000 to 1,993,000 eggs • juveniles found in kelp beds • pelagic juvenile stage lasts 3.5 months
Predators/Prey .....….....	• feeds on pelagic crustaceans, fishes, and squids
Noteworthy Facts ……	• very difficult to distinguish from the olive rockfish, *Sebastes Serranoides*, which has an additional soft ray (9, not 8) in the anal fin and also more prominent pale areas below the dorsal fin and no pink on the pectoral fin rays • very important commercial fishery; sold as fillet

32. **Rougheye Rockfish,** *Sebastes aleutianus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• North Pacific off northern Hokkaido, Japan and Kuril Islands to Bering Sea at Navarin Canyon, and Commander Islands and Aleutian Islands to San Diego, southern California • bathydemersal, from 82 – 2953 feet
Form/Function	• up to 39 inches long • 2 – 10 spines occurring in a rasp-like ridge just below front of eye • red or reddish black; more pinkish below; vague, dusky blotches also present • large specimens have a white to pink mouth inside and black blotches
Reproduction	• are ovoviviparous • females extrude larvae who then assume a planktonic existence; extent of larval dispersal currently unknown • in the northwest Pacific, rougheye rockfish aggregate more in the fall to winter months (i.e., November – December); this may coincide with their mating season
Predators/Prey	• major consumer of pandalid and hippolytid shrimps, gamarrid amphipods, mysids, crabs, and fishes
Noteworthy Facts ……	• natural history of this species is as yet poorly understood • very slow growing but can live to 205 years; may be one of the oldest lived fishes on Earth • a valued commercial species, the rougheye

	rockfish is especially popular in Asian markets • Lover *et al.* (2005) observed that recent molecular (i.e., DNA) work has shown that *Sebastes aleutianus* is made up of two species; a description of the second species is currently in progress

33. **Silvergray Rockfish,** *Sebastes brevispinus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Southeastern Bering Sea to Bahia de Sebastian Vizcaino, Central Baja California • wide-ranging, surface – 1,437 feet
Form/Function	• up to 28 inches long • mouth large • chin projects strongly • gray above; silver gray on side; white below • anal, pelvic, and pectoral fins tinged with red or pink near base • lips blackish
Reproduction	• ovoviviparous • off of Oregon the young are probably not released until late spring or summer • off Washington young are released in June
Predators/Prey .....….....	• consumes marine invertebrates and fishes
Noteworthy Facts ……	• commercially important from southeastern Alaska to Oregon • life history poorly understood • can live to 82 years

34. **Canary Rockfish,** *Sebastes pinniger*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Western Gulf of Alaska south of Shelikof Strait to Punta Colnett, northern Baja California • rocky bottoms at about • young in shallow waters • adults inhabit waters ranging from 59 – 2,749 feet
Form/Function	• up to 30 inches long • usually orange on a gray background • fins are bright orange • rear portion of spinous dorsal fin dusky in specimens under 14 inches long • lateral line typically located in a plain, gray zone
Reproduction	• ovoviviparous • spawning adults produce planktonic larvae • larvae and pelagic juveniles live in upper water column for 3 – 4 months, after which they descend to benthic environments • reproduction rate is slow (population doubling can require 15 years)
Predators/Prey	• feeds on small fishes and krill
Noteworthy Facts ……	• adult specimens commonly caught by hook and line over deep reefs • commonly caught in trawls in northern regions • live to at least 84 years • because of low reproductive rate, harvesting of this, and most rockfish species, should be limited

35. **Dusky Rockfish,** *Sebastes ciliatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• from Hokkaido, Japan, off Kamchatka in the Western Bering Sea, along the Aleutian Island to Zemchug Canyon in the Eastern Bering Sea, and south to Johnstone Strait, British Columbia • 100 to 1750 feet; most commonly at 17 - 528 feet
Form/Function	• up to 22 inches long • deep fusiform body • two distinct forms • most commonly light colored individuals in deep water along outer continental shelf • dark colored individuals in shallow water
Reproduction	• ovoviviparous • light and dark dusky rockfish have been collected in Northern Gulf of Alaska, west of Kodiak, in May and June • fertilization and development of eggs is internal
Predators/Prey	• when inshore feed on **mysids**, amphipods, and copepods • in deeper water (83 – 363 feet) feeds mostly on crab larvae, but also consume salps, copepods, and amphipods
Noteworthy Facts ……	• have been aged to 67 years • maximum recorded age in Gulf of Alaska is 59 years • deep water forms important to trawl fishery • make up substantial portion of nearshore jig fishery in parts of Gulf of Alaska • sometimes misidentified as black rockfish

36. **Black Rockfish,** *Sebastes melanops*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Southern Bering Sea and Amchitka Island, Aleutian Islands to northern Baja California • rocky and soft bottomed area • from surface to depths of 1,200 feet
Form/Function	• up to17 inches long • deep fusiform body • body color black with gray mottling • convex between eyes with spines weak or absent • spiny dorsal fin continuous with soft dorsal fin • caudal fin somewhat truncated and deep
Reproduction	• ovoviviparous • males sexually mature at three years or 9.8 inches • females sexually mature at 5 years or 11.8 inches • mating occurs between September and November in California • females store sperm until eggs develop • fertilization occurs between September and November in California • larvae emerge January to May in California; are about 0.2” long
Predators/Prey	• feeds on small fishes, crustaceans, polychaete worms, cephalopods, and jellyfish; are opportunistic predators that feed primarily in the water column
Noteworthy Facts ……	• may occur solitarily or in large congregations • may weigh up to 10.5 pounds • live to approximately 50 years

	• mature females produce from 125,000 to 1,2000,000 eggs • mid 1990s stock assessments indicate that black rockfish populations are in a general state of decline

37. **China Rockfish,** *Sebastes nebulosus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Kodiak Island, western Gulf of Alaska to Redondo Beach and San Nicolas Island, southern California • rocky areas containing caves and crevices from 10 to 420 feet deep
Form/Function	• ovoviviparous • up to18 inches long • deep fusiform body • black and yellow mottling for body colors • yellow stripe extends from spiny dorsal (front) fin to and along lateral line, bluish-white spots below • head is deeply concave between eyes • caudal fin somewhat rounded
Reproduction	• fertilization of eggs is internal and eggs thus develop inside female (ovoviviparity) • little known of china rockfish early life stages • in southeast Alaska, juveniles live in shallow subtidal water during summer and fall
Predators/Prey	• feeds on brittlestars, crabs, and shrimps

Noteworthy Facts ……	• perhaps the most attractive of all rockfish species, this species is strikingly beautiful • very little is known of life history • live to at least 79 years • often found lurking about caves, propping itself up on the cave floor with its large pectoral fins • frequently inhabit the lairs of the giant pacific octopus, *Enteroctopus dofleini* • sometimes caught as a sport fish • dorsal and anal spines mildly venomous • often sold alive today in Asian markets; commands a high price • "China rockfish" is a relatively recent name and refers to the perceived preference of this fish species by Chinese of central California

38. **Quillback Rockfish,** *Sebastes maliger*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• Kodiak Island, Gulf of Alaska to Anacapa Passage, southern California • inhabits rocky reefs with caves and crevices • to depths of 899 feet
Form/Function	• up to24 inches long • deep fusiform body • high, deeply incised spinous dorsal fin • brown with orange spots and blotches on back and dorsal fin • rear of head to pectoral fin yellow with brown spots, orange spots below (i.e., ventrally) • head flat between eyes • pectoral and pelvic fins blackish
Reproduction	• ovoviviparous • in Puget Sound, young of the year occur from July through November on shallow rocks • older juveniles appear to move inshore and live among kelp-covered rocks • in California all females and males are sexually mature by age 7
Predators/Prey .....….....	• feeds on fishes and crustaceans
Noteworthy Facts ……	• common name derives from prominent spines in dorsal fin • a common, solitary rockfish of inshore waters

	• take care when handling to avoid mildly venomous dorsal and anal spines • maximum age is 95 years • commercially important, especially in southeast Alaska and British Columbia • quillback rockfish caught in southeast Alaska made croaking sounds when captured, perhaps by grinding of pharyngeal (throat) teeth • may hybridize with brown and copper rockfish • maximum age thus far documented for this species is 95 years

39. **Northern Rockfish,** *Sebastes polyspinis*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Scorpaenidae
Genus *Sebastes*

Occurrence	• North pacific off Kuril Islands to Bering Sea at Pervenets Canyon and Commander-Aleutian chain to Graham Island, northern British Columbia • 33 – 2,428 feet
Form/Function	• up to16 inches long • dark greenish gray on a red background with red-orange or brown specks • dark bands radiating from eye • head dark on top • fins reddish to a dusky red • fourteen spines in dorsal fin • head spines weakly present • only rockfish to occur in the eastern Gulf of Alaska that has 14, rather than 13, dorsal spines
Reproduction	• ovoviviparous
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• distinguished from the dusky rockfish by its pink-orange belly

40. Atka Mackerel, *Pleurogrammus monopterygius*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Pleurogrammus*

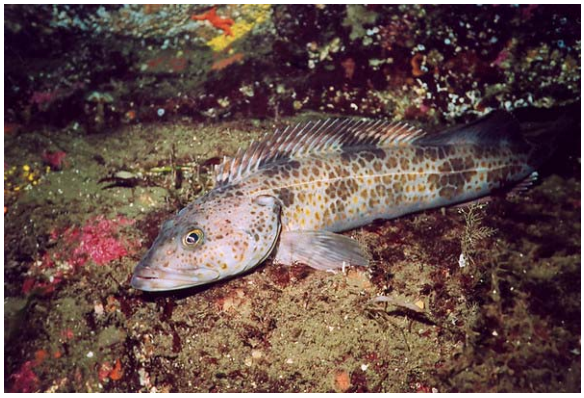
Occurrence	• Sea of Japan and Sea of Okhotsk to Commander-Aleutian chain and northern Bering Sea to Redondo Beach, southern California; rare in eastern north Pacific south of Alaska • low intertidal zone to 2,362 feet deep
Form/Function	• up to18 inches long • body elongate and fusiform • five lateral lines on each side of body • light and dark bars along body sides • caudal fin deeply forked
Reproduction	• slow reproductive development from January to May with subsequent rapid egg development in June • spawn from July to October • female lays an average of three egg batches • males guard egg batches and guard them until larvae hatch out • larvae become zooplankton upon emerging from eggs
Predators/Prey .....….....	• feeds on fishes and crustaceans
Noteworthy Facts ……	• found on rocky reef areas among kelp during the summer • very good eating • recent molecular data (Crow et al.) supports the existence of two distinct species, the other being the southern atka mackerel/arabesque greenling, *Pleurogrammus azonus*

41. **Sablefish,** *Anoplopoma fimbria*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Anoplopomatidae
Genus *Anoplopoma*

Occurrence	• Pacific Ocean off central Honshu, Japan to Aleutian Islands and Bowers Bank to Bering Sea south to St. Lawrence Island, Alaska and to Islas San Benito and Isla Cedros, central Baja California • shallow reefs to depths of 3379 feet
Form/Function	• up to 3 feet 4 inches long • body elongate and fusiform yet almost round in cross section • two medium sized, almost equal dorsal fins • blackish gray above, gray to white below • moderately sharp snout • slight over-bite • anal fin spineless
Reproduction	• females are egg layers (oviparous) • spawns during the winter • eggs drift near surface • newly hatched larvae become part of zooplankton
Predators/Prey	• feeds on worms, crustaceans, and fishes
Noteworthy Facts ……	• a very important fish commercially, it is nonetheless of minor interest to sport anglers • also called black cod • in Canada highly regarded as a fish for smoking • liver is source of oil rich in vitamins A and D

42. **Lingcod,** *Ophiodon elongatus*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Ophiodon*

Occurrence	• Shumagin Islands, southwestern coast of Alaska to Pacific Ocean off Punta San Carlos, northern Baja California • over reefs and soft bottoms, in shallow and deep waters to 1,558 feet
Form/Function	• up to 5 feet long • elongate and fusiform body shape yet almost round in cross section • small smooth scales covering body and head • body gray-brown to green with dark spots and mottling • sharp snout • large mouth with large over-bite • jaws with very large canine teeth • dorsal fin long and continuous • tail fin tapered
Reproduction	• females sexually mature at age three, males at age two • males set up territories in late winter/early spring; defend these against other males and predators • females migrate from deeper waters to the shallower water areas defended by the males • females lay on average 150,000 to 250,000 adhesive eggs among rocky crevice areas

	• males guard eggs for six weeks until larvae hatch out to become part of zooplankton
Predators/Prey	• feeds on various large fishes, crustaceans, and mollusks
Noteworthy Facts ……	• a very highly regarded sport fish, it is also valuable commercially • excellent eating • important commercial food fish

43. **Sturgeon Poacher,** *Podothecus accipenserinus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Agonidae
Genus *Podothecus*

Occurrence	• Southern Bering Sea and Aleutian Islands, from Attu Island to northern California at Point Reyes; western Bering Sea south of Cape Navarin to Commander Islands, and Pacific Ocean to Sea of Okhotsk off southwestern Kamchatka and northern Kuril Islands • soft bottoms ranging from depths of 7 to 1,640 feet
Form/Function	• up to 12 inches long • body elongate and tapered posterior to caudal (tail) fin • head flattened both above and below • mouth located on ventral side and directed downward • snout flattened and pointed broadly • scales replaced by rows of spine-bearing plates • color: dorsal surface a light, grayish brown; light yellow to or orange on ventral side
Reproduction	• unknown; species within the family Agonidae are not known to guard their eggs
Predators/Prey	• feeds on worms, crustaceans, and small fishes
Noteworthy Facts ……	• scientific names from Greek (*agonia* = lacking joints) and Latin (*acipenserinus* = like a sturgeon) • swims primarily through undulating movements of the pectoral fins • the specific name is correctly spelled *accipenserinus*, not the frequently encountered *acipenserinus* (Love *et al*., 2005)

44. **Kelp Greenling,** *Hexagrammos decagrammus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Hexagrammos*

Occurrence	• Attu Island, Aleutian Islands to Gulf of Alaska coasts to La Jolla, southern California • shallow reefs to depths of 2,740 feet
Form/Function	• up to 21 inches long • body elongate and fusiform yet almost round in cross section • male body color dark gray with bright blue spots • female body color gray-brown with golden or brown spots • snout moderately sharp • mouth yellowish inside • lips fleshy • single long dorsal fin
Reproduction	• spawns in the fall • a mass of blue eggs is attached to the substrate and then guarded by the male • eggs hatch and emergent larvae become zooplankton
Predators/Prey .....….....	• feeds on shrimp, small crabs, polychaete worms, small fishes, and clam siphons
Noteworthy Facts ……	• a colorful fish, popular among anglers

45. **Rock Greenling,** *Hexagrammos lagocephalus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Hexagrammos*

Occurrence	• Yellow, Japan, and Okhotsk seas to Commander-Aleutian chain and northern Bering Sea to Point Conception, central California • Recorded to depths of 262 feet
Form/Function	• up to 21 inches long • elongate and fusiform body shape, slightly compressed • one pair of cirri over eyes; short and fleshy or long and feathery • dark spot above base of each eye • reddish-brown with dark mottling and large, bright-red blotches on the sides • snout moderately sharp • inside of mouth bluish
Reproduction	• sexually mature when attaining a size of 11.4 to 13.8 inches • females are egg layers (oviparous) • adhesive eggs stick to substrate and are guarded by male • larvae hatch out to become part of zooplankton
Predators/Prey .....….....	• juveniles feed on euphausiids and possibly copepods
Noteworthy Facts ……	• ling cod and rock fishes compete with rock

	greenlings for food and space • molecular evidence of Crow concludes that there is a single, widely distributed species

46. Masked Greenling, *Hexagrammos octogrammus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Hexagrammos*

Occurrence	• Okhotsk and Japan seas to Commander-Aleutian chain and St. Lawrence Island, northern Bering Sea to Banks Island, northern British Columbia • 20 – 102 feet
Form/Function	• reaches lengths of at least 11 inches • mouth terminal and directed forward; lips thick • teeth of moderate size; occur in both upper and lower jaws • small scales cover body and dorsal portion of head; snout and lower part of head bare of scales • dorsal fin extends from terminus of gill operculum to almost the anterior region of the caudal fin; anterior half of dorsal fin spiny, posterior half soft
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• caught by anglers

47. **Whitespotted Greenling,** *Hexagrammos stelleri*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Hexagrammidae
Genus *Hexagrammos*

Occurrence	• Japan Sea to Commander-Aleutian chain and Chukchi and Bering seas to Puget Sound, Washington; a single, unconfirmed report from Simpson Cove, Beaufort Sea • occurs intertidally from between 0 to 574 feet; found near rocks, pilings, and eel grass beds
Form/Function	• up to 16 inches long; body elongate • mouth terminal and directed forward • eye longer than it is deep
Reproduction	• unknown or information unavailable
Predators/Prey	• predators unknown or information unavailable • feeds on worms, crustaceans, and small fishes
Noteworthy Facts ……	• it appears that little is known of this species

48. **Prowfish,** *Zaprora silenus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Zaproridae
Genus *Zaprora*

Occurrence	• Hokkaido, Japan, and Sea of Okhotsk to Bering Sea and Aleutian Islands to San Miguel Island, southern California • Adults near bottom, young fish generally collected near the surface
Form/Function	• up to 35 inches long • long, deep body • high, blunt snout • no pelvic fins • straight tail • no lateral line • large pores ringed with white on head
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• young have been found living with the large, orange jellyfish *Cyaena*

49. **Northern Ronquil,** *Ronquilis jordani*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Bathymasteridae
Genus *Ronquilis*

Occurrence	• Southeastern Bering Sea and Amchitka Island, Aleutian Islands to LaJolla, southern California • coastal bottom fishes of the north pacific • inhabits depths ranging from 10 - 908 feet
Form/Function	• up to 7 inches long • small scales on cheeks behind and below the eyes • pores on head relatively inconspicuous • males are orange on top with dark bars on their sides • females are olive • dorsal fin very long and tall • tail rounded
Reproduction	• females with fully developed, salmon colored eggs have been taken in March • ripening females have been taken in Puget Sound in February
Predators/Prey .....….....	• preyed upon by flatfishes • feeds on planktonic crustaceans and worms
Noteworthy Facts ……	• current status unthreatened

50. **Alaskan Ronquil,** *Bathymaster caeruleofasciatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Bathymasteridae
Genus *Bathymaster*

Occurrence	• Commander Islands, Russia and Aleutian Islands, Alaska to Queen Charlotte Islands, northern British Columbia • Subtidal; demersal, from depths of 16 to 738 feet
Form/Function	• up to 12 inches long • body elongate • eyes and terminal mouth large • a single, long dorsal fin continues from just behind the head to the caudal fin
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• preyed upon by halibut and flounders • feeds primarily on benthic mollusks and crustaceans
Noteworthy Facts ……	• retreats into a hole or crevice when threatened

51. **Decorated Warbonnet,** *Chirolophis decoratus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Chirolophis*

Occurrence	• Eastern Bering Sea and Aleutian Islands, Alaska to Humboldt Bay, northern California • subtidal to 300 feet deep
Form/Function	• up to 16.5 inches long • body elongate • mouth terminal, directed forward and upward • lips thick • teeth small and conical • dorsal fin originates at end of gill operculum and extends posteriorly to and merges with the caudal fin • anal fin beginning about one third of the way back from the anterior-most region and extending posteriorly to just before the caudal fin • large, complex cirrus originating in front of eyes and extending to the first four or more dorsal spines • caudal fin rounded • color is pale brown with white to cream markings, paler below; irregular light areas on upper part of body, vertical light bars below; prominent dark bars on dorsal, caudal, and anal fins
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• having generally low resilience, population doubling may require from 4.5 to 14 years

52. **Mosshead Warbonnet**, *Chirolophis nugator*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Chirolophis*

Occurrence	• Western Aleutian Islands, Alaska to San Miguel Island, southern California • Intertidal; demersal; to 264 feet deep
Form/Function	• up to 4.8 inches long • body elongate • mouth terminal, small, and directed forward • lips thick • teeth flattened and in closely set rows within the jaws • dorsal fin beginning just before terminus of gill operculum and extending just barely to and touching the caudal fin • anal fin beginning about one third of the way down from the anterior-most portion of the body and extending back to but terminating just before the caudal fin • caudal fin rounded • a dense cluster of evenly sized cirri located atop the head and extending to the first dorsal spine
Reproduction	• little known • females produces large (2 mm) eggs
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• sometimes hide in crevices and tubeworm holes with only the head protruding

53. **Snake Prickleback,** *Lumpenus sagitta*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Lumpenus*

Occurrence	• Sea of Japan and Sea of Okhotsk to Commander Islands, Russia, southern Bering Sea, and eastern Aleutian Islands, Alaska to Humboldt Bay, northern California • Intertidal, nearshore to depths of 1,394 feet
Form/Function	• up to 20 inches long • body very elongate • mouth terminal, small, and directed forward • lips thickened • teeth in jaws small, columnar, oval, and well separated • spiny dorsal fin beginning approximately over the midpoint of the gill operculum and extending posteriorly to just before the caudal fin • spiny anal fin begins about 2/5ths of the body's length behind the anterior-most region of the body and extends to just before the caudal fin such that a distinct gap is visible • pale green on dorsal surface, cream ventrally
Reproduction	• unknown or information unavailable
Predators/Prey	• young (2 inches long and less) feed entirely upon copepods • larger individuals have been caught with hooks baited with marine worms
Noteworthy Facts ……	• an active species, this fish can jump out of aquaria

54. **Black Prickleback,** *Xiphister atropurpureus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Xiphister*

Occurrence	• Kodiak Island, western Gulf of Alaska to Rio Santo Tomas, northern Baja California • intertidal to at least 60 feet
Form/Function	• up to 12 inches long • body very elongate • head small • mouth terminal, rather large, directed forward and upward • lips thickened • snout bluntly rounded and short • teeth on jaws conical • dorsal fin beginning approximately 1/5th of the body's length down from the anterior-most region of body and extending posteriorly and merging into the caudal fin • anal fin begins just before halfway point of the body's length and extending back to and merging with the caudal fin • pelvic fins absent • dark reddish brown to black in color with head sufficiently pale to display three dark, light-edged bands radiating from each eye
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• the intertidal juveniles have been found under rocks at low tide

55. Crescent Gunnel, *Pholis laeta*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Pholididae
Genus *Pholis*

Occurrence	• Southeastern Kamchatka, Commander Islands, and Aleutian Islands, east along north side of Alaska Peninsula to Port Heiden, southeastern Bering Sea and Gulf of Alaska to Crescent city, northern California • Intertidal, including in tide pools, under rocks to as deep as 240 feet
Form/Function	• up to 10 inches long • pelvic fins minute • dark, crescent shaped markings along fish's sides against a yellowish-green to blackish background • adult female belly creamy to slightly greenish • adult male belly orange red
Reproduction	• female produces an egg mass of 600 to 1,600 small, white eggs • eggs, which stick together, often affix themselves to rocks • larvae emerge from eggs after 4 to 8 weeks; become part of zooplankton
Predators/Prey .....….....	• preyed upon by hermit crabs, red breasted and common mergansers • feeds on algae, ribbon worms, polychaete worms, snails, slugs, small crustaceans, barnacles, and fly larvae

Noteworthy Facts ……	• very common but often overlooked

56. **Wattled Eelpout,** *Lycodes palearis*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Zoarcidae
Genus *Lycodes*

Occurrence	• Okhotsk Sea to Chukchi Sea, over the continental shelf in the Bering Sea and off the Aleutian Islands to Oregon • Benthic; at depths of 7 - 3035 feet
Form/Function	• up to 20 inches long • body very elongate • small pelvic fins • undivided pectoral fins • tail (caudal) fin not clearly distinguishable from dorsal and anal fins
Reproduction	• an egg layer (oviparous) • eggs large and ellipsoidal
Predators/Prey	• feeds on small bivalves and shrimp
Noteworthy Facts ……	• too small and inaccessible to be of interest as food for humans

57. **Graveldiver,** *Scytalina cerdale*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Scytalinidae
Genus *Scytalina*

Occurrence	• Western Aleutian Islands to Diablo Cove, central California • occurs in tidepools and in beaches burrowing in sand and gravel; to depths of 25 feet
Form/Function	• body very elongate; to 6 inches long • head slender • mouth terminal and directed forward • upper and lower jaws about equal in size • two large, strong blunt canine teeth at anterior ends of upper and lower jaws • body scaleless • dorsal and anal fins, beginning approximately midway along the back, each merge with rounded caudal • brownish purple or pink dorsally, paler below, all with vaguely banded, speckled, mottled, or vermiculated
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• only one species in this family • bury themselves in the gravel

58. **High Cockscomb,** *Anoplarchus purpurescens*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Anoplarchus*

Occurrence	• Attu Island, Aleutian Islands, and Pribilof Islands, Bering Sea to Santa Rosa Island, southern California • demersal; intertidal to 100 feet deep
Form/Function	• up to 8 inches long • body elongate, head small • dorsal fin beginning just behind the head and extending to just before the anterior region of the caudal fin • caudal fin rounded • mouth terminal and moderately large • lips fleshy • pelvic fins absent; an important character for identification • color highly variable; light to dark gray with olive overtones, brown to dark brown with red overtones, or purple to almost black
Reproduction	• females may produce up to 2700 eggs while spawning • in winter egg masses are placed under or between rocks and shells and are guarded by the female by bending her body around egg mass • eggs are fanned by the female making undulating movements with the posterior portion of her body • in British Columbia eggs have been observed to hatch in three weeks
Predators/Prey .....….....	• feeds on green algae, polychaete and other worms, amphipods, mollusks, and crustaceans
Noteworthy Facts ……	• can breathe air; may therefore remain out of water for 15 to 25 hours if it is kept moist

59. **Walleye Pollock,** *Theragra chalcogramma*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Gadiformes
Family Gadidae
Genus *Theragra*

Occurrence	• Seas of Okhotsk and Japan to southern Chukchi Sea, Bering Sea, and Gulf of Alaska to Carmel, central California • Generally demersal; in shallower; shallow inshore waters to 3,921 feet
Form/Function	• up to 3 feet 6 inches long • body elongate with a pointed snout • three separate dorsal fins • two anal fins, the first beginning just after the terminus of the first dorsal fin • body color brown to olive green on dorsal side with many brown spots; ventral side lighter; fins dusky to black
Reproduction	• fish sexually mature at three or four years of age • spawning begins in late February and occurs in shallower waters (300 to 650 feet) of the outer continental shelf • some spawning may occur under sea ice • spawning fish move high in water column, form dense schools, release fertilized eggs which become part of the zooplankton • eggs occur within about 100 feet of surface • after about 10 days, fertilized eggs hatch and resulting larvae become part of the zooplankton
Predators/Prey .....….....	• it takes a variety of prey that varies with the size of the fish and the area where it occurs • a major prey item of other fish species, fur seals, harbor seals, ribbon seals, and seabirds; in Bering

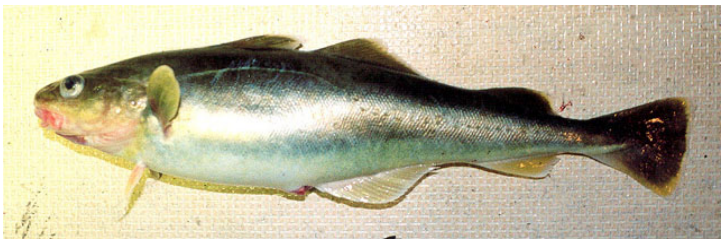
	Sea, juvenile pollock are a major food item of adult Pollock • major predators are other Pollock (that feed on the juveniles), many other fish species (including Pacific Cod, *Myoxocephalus* spp., flathead sole, Greenland halibut), murres, harbor seals, ribbon seals, and humans
Noteworthy Facts ……	• a schooling fish found on or near the sea bottom • one of the most abundant codfish of the Pacific • the liver contains much fat and vitamin A, used in preparing delicatessen-canned goods

60. **Pacific Tomcod,** *Microgadus proximus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Gadiformes
Family Gadidae
Genus *Microgadus*

Occurrence	• Southern Bering Sea and eastern Aleutian Islands to Point Sal, central California • demersal, to 905 feet deep; over soft bottoms and at piers and jetties around bays • occasionally found in the surf zone
Form/Function	• up to 12 inches long • mouth moderate, terminal, and directed slightly upward • snout blunt • teeth occur as bands in jaw • three distinctly separate dorsal fins • two distinctly separate anal fins • barbel present under chin • olive green color dorsally, creamy white below, and dusky on all fin tips
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• eats shrimp/krill, amphipods, isopods, gastropods, mussels, and fish
Noteworthy Facts ……	• subject to parasitism by copepods • flesh excellent eating but not commercially important due to low abundance

61. Saffron Cod, *Eleginus gracilis*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Gadiformes
Family Gadidae
Genus *Eleginus*

Occurrence	• North Pacific and adjacent Arctic; Yellow Sea to east Siberian Sea and east to Dease Strait; western Canada; Beaufort, Chukchi, and Bering Seas and Gulf of Alaska to Sitka, southeastern Alaska (rare in Gulf of Alaska) • Brackish water and river mouths to limit of the tidal influence, to edge of continental shelf and depth of 656 feet
Form/Function	• up to 22 inches long • mouth moderate, terminal, and directed slightly upward • snout blunt • teeth occur as bands in jaw • three distinctly separate dorsal fins • two distinctly separate anal fins • barbel present under chin • dark grey-green to brown color and mottled dorsally; pale ventrally
Reproduction	• spawns once a year, for five to seven times throughout its life (maturity reached at 2 to 3 years of age for both sexes) • in early winter move from coast or estuaries to sand-pebble areas for spawning; spawning occurs January – February • two year old females will produce a minimum of 4,900 eggs while a 9 year old female can produce up to 680,000 eggs • eggs believed to be adhesive • larvae hatch out in early spring (May – June)
Predators/Prey	• feeds on shrimp/krill as well as a variety of benthic organisms including polychaete worms
Noteworthy Facts ……	• subject to parasitism by copepods

	• may enter brackish and even fresh waters, occurring quite far up rivers and streams but always remaining within regions of tidal influence

62. **Pacific Cod,** *Gadus macrocephalus*

Pacific cod is lower fish

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Gadiformes
Family Gadidae
Genus *Gadus*

Occurrence	• Yellow Sea off Manchuria, China to Bering Sea, Aleutian Islands, and Gulf of Alaska to Santa Monica, southern California • benthic or sandy/muddy substrate, to 2,871 feet
Form/Function	• up to 3 feet 6 inches long • body elongate with a pointed snout • three separate dorsal fins • two anal fins, the first beginning just after the terminus of the first dorsal fin • body color brown to gray on dorsal side with many brown spots or pale areas on backside; ventral side lighter; fins dusky, with caudal, dorsal, and anal fins being white-tipped
Reproduction	• fish spawn from January to April in water 130 to 380 feet deep • Pacific cod are ovoviviparous (i.e., eggs are fertilized externally) • females produce from 225,000 to 5 million eggs per year each • eggs are **demersal** (on or near the bottom) and somewhat • adhesive; larvae become part of the zooplankton • hatching occurs in 8 to 28 days and is temperature and salinity dependent • it is inferred that optimal spawning habitat is a coarse sand and cobble type substrate as eggs and

	winter adult populations are associated with this form of bottom
Predators/Prey	• feeds on polychaete worms, amphipods, shrimps (the pink shrimp *Pandalus borealis* often dominant in diet and crangonid shrimp), crabs (*Chionoecetes spp. Hyas)*, hermit crabs, the clam *Yoldia* and other clam species, snails, octopus and fishes (walleye pollock, herring,smelt (Osmeridae), capelin, eelpouts, sand lance, flatfishes • preyed upon by sablefish, Greenland halibut, Pacific halibut, arrowtooth flounder, harbor seals, other seal species, sea lions, and humans
Noteworthy Facts ……	• a schooling fish found on or near the sea bottom • one of the most abundant codfish of the Pacific • the liver contains much fat and vitamin A, used in preparing delicatessen-canned good

63. **Southern Rock Sole,** *Lepidopsetta bilineata*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Lepidopsetta*

Occurrence	• Atka Island, Aleutian islands and southern Bering Sea to Cortes bank, southern California • Benthic, usually found on sandy to rocky bottoms**;** occurs from 43 to 1,112 feet
Form/Function	• up to 24 inches long • body **dorsoventrally** compressed (literally meaning compressed from back to front, which in fishes is top to bottom) • eyed side dark brown in color with gray mottling • blind side whitish • snout short and bluntly sharp • teeth in both jaws • both eyes on right side of the head (eye side)
Reproduction	• males sexually mature at 3 years in Puget Sound, Washington • females of Puget Sound, Washington, reach sexual maturity in years 3 to 4 • females produce from 400,000 to 1,200,000 eggs • eggs are demersal (on or near the bottom) and somewhat adhesive • larvae become part of the zooplankton • at about one inch long, juvenile rock sole assume their life on the bottom
Predators/Prey	• preyed upon larger crabs, marine mammals, and larger fishes • diet varies depending on area; feeds on polychaete worms, bivalves, shrimp, amphipods, *Chionoecetes opilio,* brittle stars, and fishes
Noteworthy Facts ……	• a fine eating fish popular with anglers • the northern rock sole, *Lepidopsetta polyxystra*, is

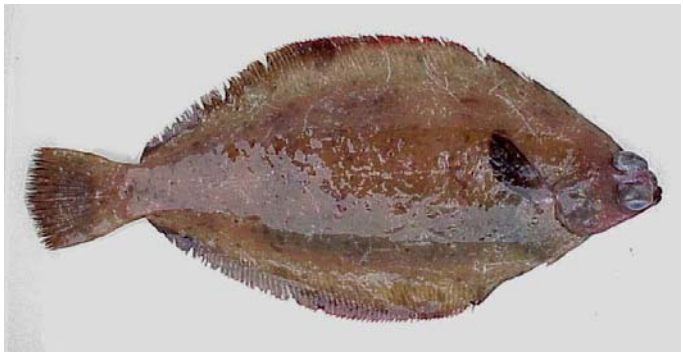
	a very similar species whose range somewhat overlaps the southern rock sole; as its name suggests, the northern rock sole is the more northern of the two species

64. Northern Rock Sole, *Lepidopsetta polyxystra*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Lepidopsetta*

Occurrence	• Northern coast of Hokkaido, Kuril Islands, and Okhotsk Sea to Gulf of Anadyr and vicinity of St. Lawrence Island, Bering Sea, and Commander-Aleutian chain to Puget Sound, Washington • usually found on sandy to rocky bottoms from 10 to 1,696 feet deep
Form/Function	• very similar to *L. bilineata* (see above) in form, with the following differences: higher gill raker count; higher number of pores above the eye
Reproduction	• unknown; perhaps similar to that of *L. bilineata* (see above description)
Predators/Prey .....….....	• unknown; perhaps similar to *L. bilineata* (see above description)
Noteworthy Facts ……	• described in 2000 by J.C. Orr and A.C. Matarese; life history details remain to be determined • often caught in beach seines

65. **Dover Sole,** *Microstomus pacificus*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Microstomus*

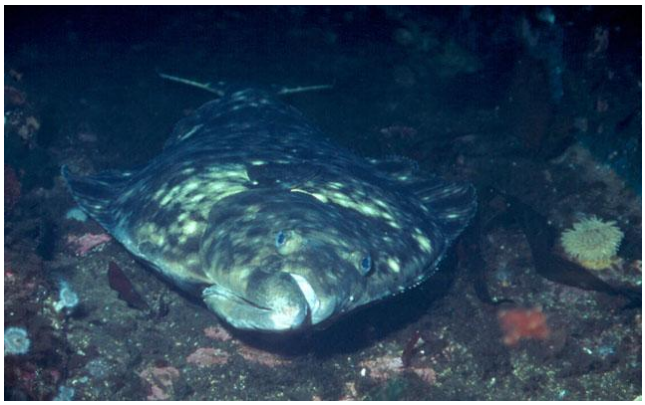
Occurrence	• Northwestern Bering Sea, southeastern Bering Sea and Aleutian Islands from Stalemate Bank to just south of Punta San Juanico, southern Baja California • Benthic; inhabits sandy to muddy bottoms from 7 to 4,500 feet deep
Form/Function	• up to 30 inches long • body dorsoventrally compressed • eyes on right side, project upward • mouth small; jaws terminate before eye • eyed side brown in color, blind side lighter
Reproduction	• spawn at various time of the year; up to nine spawns per year • females of Puget Sound, Washington, reach sexual maturity in ears 3 to 4 • females produce from 400,000 to 1,200,000 eggs • eggs are buoyant and require from 10 to 38 days to hatch • larvae make up portion of zooplankton • juveniles settle out upon substrate at about 2 inches long
Predators/Prey .....….....	• preyed upon larger crabs, marine mammals, and larger fishes • consumes polychaete worms, clams, shrimps, brittle stars, and sometimes fish
Noteworthy Facts ……	• a fine eating fish that supports a commercial fishery • not commonly caught by anglers

66. English Sole, *Parophrys vetulus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Parophrys*

Occurrence	• Bering Sea from Nunivak Island to Alaska Peninsula and Aleutian Islands to as far west as Agattu Island and Gulf of Alaska to central Baja California at San Cristobal Bay • intertidal (juveniles) to 1800 feet
Form/Function	• up to 24 inches long • eyed side reddish-brown or olive-brown • non-eyed side white to soft yellow • body, head, and snout elongate; snout also pointed • some of the upper eye is visible on blind side • ridge between eyes tall and narrow • caudal fin tapered
Reproduction	• oviparous • spawn over sand and sea mud • females mature in 3 – 5 years, males mature in 2 – 3 years • 17 inch long females may produce up to 2,000,000 eggs
Predators/Prey .....….....	• Feeds on worms, amphipods, clams, brittle stars, and small fishes
Noteworthy Facts ……	• a fine eating fish that supports a commercial fishery • second only to dover sole in pounds caught • has been described as the choicest flatfish, with a delicate flavor

67. **Pacific Halibut,** *Hippoglossus stenolepis*

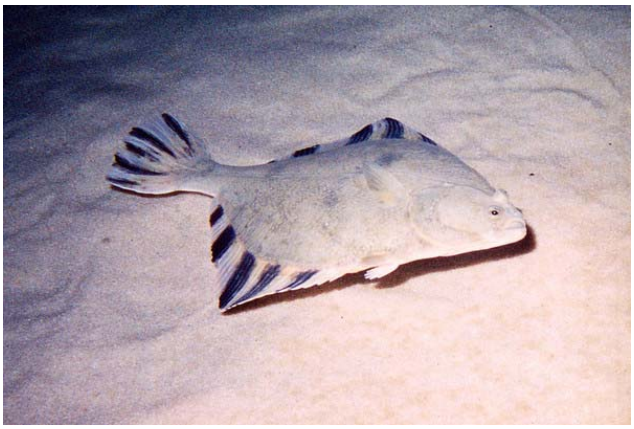


Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Hippoglossus*

Occurrence	• Hokkaido, Japan and Sea of Okhotsk to southeastern Chuckchi Sea, Bering Sea, and Aleutian Islands to Punta Camalu, Baja California • Benthic; over soft bottoms from 29 to 3,756 feet deep
Form/Function	• up to 8 feet 9 inches long • body dorsoventrally compressed • diamond-shaped eyes, both on right side of head • eyed side dark brown in color with fine mottling • blind side light brown • snout moderately sharp • teeth in both jaws • lateral line arched over pectoral fin
Reproduction	• spawning season runs November through March • males and females congregate along edge of continental shelf during spawning season • males sexually mature at 7 years, females at 8 to 12 years • adult female lays 2 to 3 million eggs • eggs hatch in approximately 15 days • eggs and larvae form part of zooplankton • larvae may drift for 4 to 6 months; considerable developmental changes occur during this time, most notably the migration of the left eye to the right side of the head
Predators/Prey .....….....	• as adults, preyed upon by humans • consumes a wide range of prey items, including

	invertebrates such as polychaete worms, clams, shrimps, brittle stars, and fishes such as cod, turbot, and pollock
Noteworthy Facts ……	• this fish supports a very important commercial fishery • as the flesh is of excellent eating quality, it is also a much sought after sport fish

68. Starry Flounder, *Platichthys stellatus*

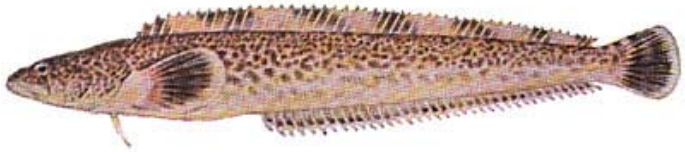


Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Platichthys*

Occurrence	• Sea of Japan off Korean Peninsula and Japan to Sea of Okhotsk, to Arctic Ocean in East Siberia Sea, Chukchi Sea, Beaufort Sea, and Canada to Bathurst Inlet, Northwest Territories, and Bering Sea and Commander-Aleutian chain to Los Angeles Harbor, southern California • bays and estuaries over soft bottoms, off coast to 900 feet deep
Form/Function	• up to 3 feet long • body dorsoventrally compressed • diamond-shaped eyes, both either on left or right side of head • eyed side dark brown to almost black with indistinct blotches • blind side white to creamy white • dorsal, anal, and caudal fins have characteristic black and white or black and orange bars • mouth small • scales star shaped, are very rough to the touch
Reproduction	• spawning season runs November through March • males and females congregate along edge of continental shelf during spawning season • males sexually mature at 7 years, females at 8 to 12 years • adult female lays 2 to 3 million eggs • eggs hatch in approximately 15 days • eggs and larvae form part of zooplankton; larvae

	may drift for 4 to 6 months; considerable developmental changes occur during this time, most notably the migration of the left eye to the right side of the head
Predators/Prey	• consume a wide range of prey items, including such as polychaete worms, clams, shrimps, brittle stars, sand dollars, and small fishes
Noteworthy Facts ……	• can tolerate very low salinity and is even found in major rivers far from the open ocean

69. Arctic Shanny, *Stichaeus punctatus*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Stichaeidae
Genus *Stichaeus*

Occurrence	• Canadian Arctic east to Greenland and Gulf of Maine (does not occur in eastern North Atlantic), west to Beaufort and Chukchi seas, Alaska and south to Seas of Okhotsk and Japan and to Skidegate Inlet, British Columbia, including Commander-Aleutian chain • Shallow subtidal over rocky and sandy areas; to 328 feet
Form/Function	• to at least 7 inches long • has single row of 5 – 9 round, black spots • pale margins present on dorsal fin • irregular dark bars on cheeks and chin • Alaskan specimens of a bright scarlet color (those from Maine are brown) • single dorsal fin begins over gill cover edge and extends back to the caudal fin at an almost uniform height (an exception to this is the first 2 – 3 dorsal ray spines, which are shorter) • caudal fin having a gently rounded outline • anal fin approximately 2/3rds as long as dorsal fin • pectorals broadly rounded and somewhat longer than the body's depth • ventral fins about half as long as pectorals
Reproduction	• unknown or information unavailable
Predators/Prey .....….....	• unknown or information unavailable
Noteworthy Facts ……	• easily distinguished from the rock eel by the well developed ventral fins and much larger pectoral fins

70. **Pacific Sanddab,** *Citharichthys sordidus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Bothidae
Genus *Citharichthys*

Occurrence	• Holiday Beach, Kodiak Island, western Gulf of Alaska to Cabo San Lucas, southern Baja California • Benthic; more common in shallow waters but occurs to depths of 1, 800 feet
Form/Function	• to 16 inches long • body extremely compressed dorsoventrally • eyes on left side of body (“left handed”) • eyed side brown with darker brown mottling and sometimes dull, orange spots • snout moderately sharp • eyes concave • pelvic fins asymmetrical • dorsal fin originates over eyes • anal and dorsal fins extend almost to caudal fin
Reproduction	• spawning occurs in February in Puget Sound • eggs, 0.1 mm in diameter, appear clear with a single oil globule • certain data suggest that the female may spawn twice during the spawning season
Predators/Prey .....….....	• consumes a wide range of prey items, including small invertebrates and fishes
Noteworthy Facts ……	• small, steady commercial demand for this species; in California considered a delicacy • records of occurrence in southeastern Bering Sea and Aleutian Islands are either in error or unverifiable (Love et al., 2005)

71. **Flathead Sole,** *Hippoglossoides elassodon*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Hippoglossoides*

Occurrence	• Okhotsk Sea off southwestern Kamchatka and northern Kuril Islands to Gulf of Anadyr, Bering Sea and Commander-Aleutian chain to Monterey, central California; not extending into the northern part of the Bering Sea where the *Hippoglossoides robustus* takes over • benthic, found from intertidal to 3,445 feet
Form/Function	• to 20 inches long • body extremely compressed dorsoventrally and very asymmetrical • eyes on right side of body (“right handed”) • eyed side brown with darker brown mottling and sometimes dull, orange spots • mouth large, terminal, with a wide gape, and nearly symmetrical • teeth well developed in both jaw sides • eyes large and separated by a raised space • dorsal fin originates over anterior part of upper eye • pectoral fins large with rounded tips
Reproduction	• males mature at 2 years of age, females at three years of age • spawning occurs from March to late April • eggs large (2.75 – 3.75 mm in diameter) appear clear with a single oil globule • young females can have 72,000 eggs while older (5 years old) females can have 600,000 eggs • eggs hatch, depending upon temperature, in 9 to 20 days • larvae absorb yolk sac in 6 to 17 days
Predators/Prey .....….....	• in the southeastern Bering Sea it feeds on shrimps (the pink shrimp *Pandalus borealis*, crangonid shrimp), the crab *Chionoecetes opilio,* benthic

	amphipods, mollusks (especially the clam *Yoldia),* the brittle star *Ophiura sarsi,* juvenile walleye pollock, fish remains • in shallow inshore waters it feeds on planktonic Crustacea (hyperiid amphipods, euphausiids) and the arrow worm (*Sagitta)* • in the Gulf of Alaska both euphausiids and *Ophiura sarsi* comprise most of the diet
Noteworthy Facts ……	• scientific name means small and *halibut-like*

72. **Butter Sole,** *Isopsetta isolepsis*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Isopsetta*

Occurrence	• Southeastern Bering Sea and Aleutian Islands to Ventura, southern California • benthic; more common in shallow waters (can occur in waters less than 7 feet deep) but down to depths of 1,404 feet
Form/Function	• female to 18 inches long; male to 15.3 inches long • body extremely compressed dorsoventrally • eyes on right side of body (“right handed”) • eyed side gray and irregularly blotched; fresh specimens sometimes have clear yellow or green spots • head asymmetrical • mouth terminal, small, with narrow gape, asymmetrical • snout roundly pointed • pectoral fins small and bluntly pointed • dorsal fin originates above eye
Reproduction	• spawning occurs in February or March to late April • eggs are nonadhesive, transparent, spherical, with a diameter of 1.031 mm
Predators/Prey	• as adults, preyed upon by humans • consumes polychaete worms, young herring, shrimps, sand dollars, and young herring
Noteworthy Facts ……	• due to the need to remove its rough scales via filleting and its thinness, this species is not of

	great commercial importance despite an excellent flavor; most commercially caught examples are processed into mink feed

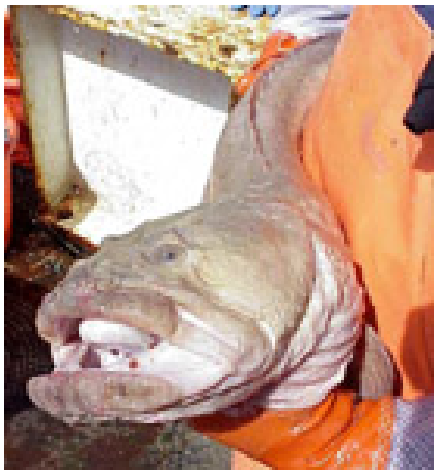
73. **Alaskan Plaice,** *Pleuronectes quadrituberculatus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Pleuronectiformes
Family Pleuronectidae
Genus *Pleuronectes*

Occurrence	• Sea of Japan to Chukchi Sea and possibly Beaufort Sea, to eastern Gulf of Alaska to southeastern Alaska near Ketchikan; one record from Bellingham Bay, Washington • demersal; 16 to 1,640 feet deep
Form/Function	• to 24 inches long • eyes on right side of body (“right handed”)
Reproduction	• are sexually mature at age 7 • spawn April through June on hard, sandy substrates of the shelf region at about 325 feet deep • eggs and larvae are pelagic and transparent • eggs have been hatched artificially; these required 15.5 – 18 days • upon hatching the larvae are more developed than in other flounder species • relatively large (5.85 mm) larvae mostly occur in the surface layer • larvae become demersal at 17 mm
Predators/Prey …….....	• major benthic species consumed are polychaete worms, mollusks and crustaceans (amphipods and hermit crabs); when mollusks comprised a considerable proportion of the diet, either the Greenland cockle (*Serripes groenlandicus*) or some combination of three other species of bivalves (*Yoldia hyperborea, Y. johanni* and *Liocyma fluctuosa*) occurred in stomachs • amphipods are main crustaceans taken

	• in shallow areas of the Kamchatka, Russia coast the clam *Siliqua media* was the dominant prey
Noteworthy Facts ……	• of commercial importance but not extensively exploited at this time; 62,000 tons caught in 1988

74. **Giant Wrymouth,** *Cryptacanthodes giganteus*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Perciformes
Family Cryptacanthodidae
Genus *Cryptacanthodes*

Occurrence	• Southeastern Bering Sea and eastern Aleutian Islands from Unalaska Island, Alaska to Humboldt Bay, northern California • demersal; from depths of 20 to 400 feet
Form/Function	• length to 3 feet 10 inches • body very elongate • mouth terminal, large, directed upward and forward • lower jaw thick and protruding • dorsal fin begins at area just above gill operculum terminus and extends all the way to and is continuous with the tail • anal fin begins approximately half way down body and extends to and is continuous with caudal fin • notable absence of pelvic fins • coloration pale brown with darker longitudinal bands
Reproduction	• unknown or information unavailable
Predators/Prey	• unknown or information unavailable
Noteworthy Facts ……	• found on soft bottoms, probably spends part of its life buried

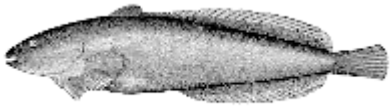
75. **Bay Pipefish,** *Syngnathus leptorhynchus*

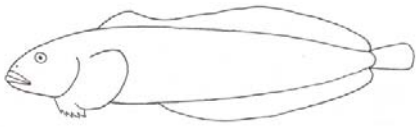
Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Syngnathiformes
Family Syngnathidae
Genus *Syngnathus*

Occurrence	• Prince William Sound to eastern Gulf of Alaska to Bahia Santa Maria, southern Baja California • intertidal; brackish to marine; common in eelgrass of bays and estuaries, sometimes found in shallow offshore waters • to 10 feet
Form/Function	• to 13 inches long • mouth terminal, minute, directed somewhat upward • females larger than males
Reproduction	• mating occurs in May and June • female deposits up to 225 eggs in male's pouch • males carry eggs in May and young in August; incubation of eggs and development of larvae takes 2 to 3 weeks • eggs and larvae found in male's pouch from February through November; this has been cited as possible evidence that males accept eggs from more than one female • early juveniles are released from male's pouch; these are slow swimmers
Predators/Prey	• feeds on very small crustaceans (mysid shrimp, small amphipods)
Noteworthy Facts ……	• like their "curled-up" cousins the seahorses, pipefish generally swim upright and take refuge among blades of eel grass

	• some individuals probably spend there life in kelp beds

76. Spotted Snailfish, *Liparis callyodon*





Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Scorpaeniformes
Family Laparidae
Genus *Liparis*

Occurrence	• Kuril Islands, southeastern Kamchatka, and Commander Islands to Gulf of Anadyr, Bering Sea; St. Lawrence Island and Norton Sound, eastern Bering Sea to Aleutian Islands to Oregon • intertidal, occurring in tide pools, to 66 feet
Form/Function	• to 6 inches long • body elongate and nearly cylindrical • head depressed • mouth terminal, small, and directed forward, overhung by upper lip and snout • snout bluntly rounded • teeth in bands on jaws • dorsal fin lobed anteriorly • pelvic fins modified to form an adhering disc • olive brown color on fins and body, paler below and modified parts of paired fins almost white; small dark spots occurring sparsely on back and sides • vertical fin edges dark
Reproduction	• unknown
Predators/Prey .....….....	• unknown, but likely feeds on invertebrates such as small crustaceans
Noteworthy Facts ……	• highly prized as table fare • very popular as a uniquely attractive game fish

77. **Arctic Grayling,** *Thymallus arcticus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Salmoniformes
Family Salmonidae (grayling are the silver-bodied fish)
Genus *Thymallus*

Occurrence	• North America: widespread in arctic drainages from Hudson Bay, Canada to Alaska and in Arctic and Pacific drainages to central Alberta and British Columbia in Canada; upper Missouri River drainage in U.S.A., formerly in Great lakes basin in Michigan U.S.A. Asia: Siberia, Russia • inhabits clear, cold medium to large sized lakes and rivers
Form/Function	• up to 24 inches long; up to 5 pounds (usually smaller) • body elongate and fusiform, moderate compression • prominent, greatly enlarged dorsal fin • adipose fin present
Reproduction	• females produce 4,000 – 10,000 amber colored, heavy, adhesive eggs (2.5 mm diameter) • spawning occurs in small streams • eggs are shed over the bottom substrate without construction of a redd • males fertilize eggs by spreading sperm (called **milt**) over eggs • young hatch out in 16 – 18 days at 9 ^{o}C
Predators/Prey	• consumes a wide range of prey items, including surface insects, fishes, fish eggs, lemmings, and planktonic crustaceans

Noteworthy Facts ……	• highly prized as table fare • very popular as a uniquely attractive game fish

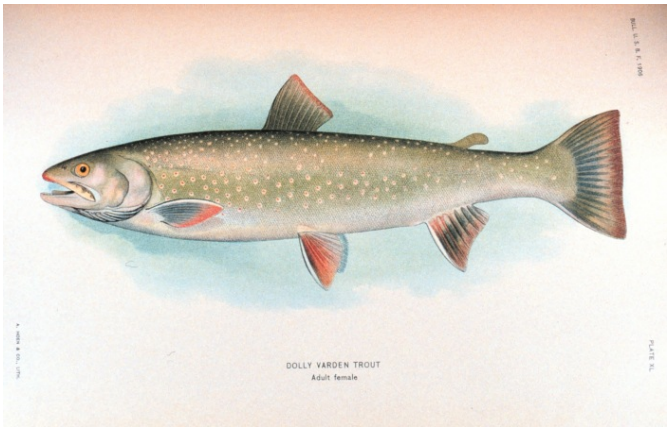
78. **Arctic Char,** *Salvelinus alpinus*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Salmoniformes
Family Salmonidae
Genus *Salvelinus*

Occurrence	• Circumpolar, including Iceland, the British Isles, Europe, northern Russia, south to Kamchatka. In north America from the Kenai Peninsula and Kodiak Island, Alaska, around the Bering and Arctic coasts to Newfoundland, the Gulf of St. Lawrence, and Greenland; relic populations exist in Quebec, New Brunswick, Maine, and New Hampshire • occur in the Arctic and Subarctic in either landlocked or **anadromous** populations; anadromous forms may spend considerable time at sea but do not appear to migrate far from river mouths
Form/Function	• up to 3 feet 2 inches long; up to 26 pounds (usually much smaller) • body elongate and fusiform, moderate compression • color highly variable and dependent upon size and habitat; anadromous examples have a dark blue back and silvery undersides; landlocked forms have a dark blue to olive-green or brown back with white, dusky, or (in breeding fish) red sides; dorsal surface and sides usually has violet-pink or red spots • adipose fin present
Reproduction	• anadromous examples mature at 7 – 12 years of age; landlocked examples mature at 2 – 3 years of

	age • spawning occurs in fall • migration of anadromous populations begins in July and extends into September • spawning occurs in lakes and in pools below river rapids • female usually spawns with more than one male • males fertilize eggs by spreading sperm (called **milt**) over eggs • after one to five spawnings, the female buries the eggs in the redd by digging another nest nearby • after two months the eggs hatch; the hatchlings, called **alevins**, remain in the gravel, subsisting on the egg yolk sac • eggs are large (3 – 4 mm diameter); a large female may contain 7200 eggs • eggs incubate over winter and young emerge the following spring to develop for 5 to 7 years, after which they migrate to the sea (if not landlocked) to develop further • after developing in the ocean, the adult salmon now make the journey from the ocean back upstream to the waters of their birth; the spawning cycle repeats itself • in anadromous examples, adults that have spawned return to the sea in late spring of the following year
Predators/Prey	• as adults, preyed upon by bears, sharks, and halibut • consumes a wide range of prey items, including such as worms, arthropods, clams, shrimps, and smaller fishes
Noteworthy Facts ……	• highly prized as table fare • very popular as a hard fighting game fish

79. **Dolly Varden,** *Salvelinus malma*



Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Salmoniformes
Family Salmonidae
Genus *Salvelinus*

Occurrence	• Western North America and northeast Asia (from the Yula River, Korea to the Anadyr River). On the pacific coast of North America from the Sacremento System (McCloud River) and isolated streams in Nevada north to the Seward Peninsula; on the east slope of the continental divide from the upper Mackenzie system south to headwaters of the south Saskatchewan River; many nonmigratory populations in the Bristol Bay area of Alaska as well as waters of the Yukon and Tanana River systems • occur in the Arctic and Subarctic in either landlocked or **anadromous** populations; anadromous forms may spend considerable time at sea but do not appear to migrate far from river mouths
Form/Function	• up to 4 feet 2 inches long; up to 32 pounds (usually much smaller) • body elongate and fusiform, moderate compression • color highly variable and dependent upon size and habitat; anadromous examples have a dark blue back and silvery undersides; landlocked forms have a dark blue to olive-green or brown back with white, dusky, or (in breeding fish) red sides; dorsal surface and sides usually has violet-pink or red spots • adipose fin present

Reproduction	• reach sexual maturity in 3 – 4 years • spawning occurs in fall • migration of anadromous populations begins in July and extends into September • spawning occurs in lakes and in pools below river rapids • female usually spawns with more than one male • males fertilize eggs by spreading sperm (called **milt**) over eggs after one to five spawnings, the female buries the eggs in the • redd by digging another nest nearby • after two months the eggs hatch; the hatchlings, called **alevins**, remain in the gravel, subsisting on the egg yolk sac • eggs are large (approximately 5 mm diameter); a large female may contain 8000 eggs • eggs incubate over winter and young emerge the following spring to develop for 5 to 7 years, after which they migrate to the sea (if not landlocked) to develop further • after developing in the ocean, the adult salmon now make the journey from the ocean back upstream to the waters of their birth; the spawning cycle repeats itself • in anadromous examples, adults that have spawned return to the sea in late spring of the following year
Predators/Prey .....….....	• as adults, preyed upon by bears, sharks, and halibut • consumes a wide range of prey items, including worms, insects and other arthropods, clams, shrimps, and smaller fishes

Noteworthy Facts ……	• though closely related to the arctic char, in Alaska where dolly varden and arctic char populations overlap a great deal in lakes and rivers there is no evidence that they hybridize; hence they are considered separate species • highly prized as table fare • very popular as a hard fighting game fish • the common name derives from the character *Dolly Varden* in the Charles Dickens novel Barnaby Rudge; at the time the name was applied to the fish in the American west as a polka-dotted material named after the Dickens character was popular there • also sometimes called *bull trout*

80. Silver Salmon/Coho Salmon, *Onchorhynchus kisutch*

Note: *From among the five species of Pacific salmon that are indigenous to Alaska, we present here only the silver salmon, Onchorhynchus kisutch; most of what is said about this species= life history is also applicable to the other Pacific salmon species; these other species are the pink salmon, Onchorhynchus gorbuscha, the chum salmon, Onchorhynchus keta, the sockeye/red salmon, Onchorhynchus nerka, and the king salmon, Onchorhynchus tshawytscha; it should be mentioned that the king salmon is the largest of the Pacific salmon species, with some specimens reaching weights of almost 100 pounds; while the silver, sockeye/red, and king salmon have red flesh, that of the pink and the chum salmon is pink in color; juveniles of all five Pacific salmon species are maintained at the Alaska SeaLife Center.*

Kingdom Animalia
Phylum **Chordata**
Class **Osteichthyes**
Order Salmoniformes
Family Salmonidae
Genus *Onchorhynchus*

Occurrence	• from Bering Strait to Baja California, Mexico; coastal streams south to Monterey, California; introduced elsewhere, especially Great Lakes • pelagic
Form/Function	• up to 3 feet 3 inches long • body elongate and fusiform, moderate compression • blue-green above, silver-white below • irregular dark spots on back and occasionally on upper caudal fin lobe • gums at base of teeth white or gray • adipose fin present
Reproduction	• in Alaska, spawning season extends from summer through fall • males and females swim from ocean to up an

	inflowing river; this journey may cover from hundreds to thousands of mile; eggs are laid in gravel depressions, called **redds**, the river substrate • males fertilize eggs by spreading sperm (called **milt**) over eggs • male and female die after spawning is complete • after two months the eggs hatch; the hatchlings, called **alevins**, remain in the gravel, subsisting on the egg yolk sac • alevins develop into **fry** and leave gravel bed to feed on plankton and insects two years later, a new moon in the spring triggers hormonal • factors in the fry and they thus develop into **smolts** • smolts swim en masse downstream to the ocean; here they will feed for a year and a half • after developing in the ocean, the adult salmon now make the journey from the ocean back upstream to the waters of their birth; the spawning cycle repeats itself
Predators/Prey	• as adults, preyed upon by bears, sharks, halibut, and humans • consumes a wide range of prey items, including such as worms, clams, shrimps, and smaller fishes

Noteworthy Facts ……	• like all Pacific salmon, the silver is anadromous, meaning that it is born in freshwater, after some development in the fresh water moves to saltwater to develop into an adult, and then returns to the freshwater to spawn • a red-fleshed salmon, it is highly prized as table fare • supports an important commercial fishery • very popular as a hard fighting game fish

XVIII. Mammals: Kingdom Animalia, Phylum Chordata, Class Mammalia

The mammals are perhaps the most familiar of all animal organisms. This is not surprising given that human beings are themselves members of this class. We present in this chapter the general characteristics of the Class Mammalia and consider some four different marine mammal species, two of which are regularly featured on exhibit here at the Alaska Sea Life Center and two of which are occasional visitors here as injured or sick animals undergoing rehabilitation. We also present several species of whales, which, though not residents of the Alaska SeaLife Center *per se*, are seen from time to time from the observation platform at the rear of the facility. This platform overlooks a portion of Prince William Sound, which is part of Resurrection Bay, and is, in effect, the ASLC's "backyard."

Class Mammalia

- Common Features
- mammary glands (produce milk to nurse young)
- warm blooded with an active metabolism
- well developed circulatory and respiratory systems support the high metabolism
- hair and a fat layer help to maintain heat of metabolism in the body
- most mammals are born alive and not hatched from eggs (exceptions are the echidna and the platypus)
- mammals tend to have larger brains than other animals of equivalent size
- many are capable of learning
- mammals usually have teeth adapted to a variety of roles, including shearing, crushing, and grinding
- three major mammalian groups
    1. Monotremes: young are hatched from laid eggs; the spiny ant eater (echidna) and the platypus are the only living examples
    2. Marsupials: young are born early and complete development in a specialized pouch of the mother; the kangaroo and the opossum are examples
    3. Placentals: young complete their development inside the mother in a structure called the uterus; dogs, cats, whales, rats, tigers, elephants, moose, skunks, and sheep are examples

Here at the Alaska Sea Life Center, we are concerned only with placentals. The four organisms that we consider are the sea otter, the harbor seal, the Steller sea lion, and the Walrus.

Order Pinnipedia, the Seals, Sea Lions, and Walrus

- occur along ice fronts and coast lines of polar and temperate parts of the oceans as well as some tropical areas
- measured from the tip of the nose to the end of the tail, pinnipeds measure from 2 feet to 14 feet long, with weights ranging from 80 to 8000 pounds
- tail is short and vestigial; grows very little after birth
- body is streamlined, torpedo-shaped
- the four limbs have been modified into flippers
    - base of the limbs deeply enclosed within the body
    - hands and feet are flattened into swimming structures (Pinnipedia means *feather footed*)
- face is shortened to accommodate movement through water wit least amount of drag
- external ears small or absent
- eyes well adapted to aquatic life as they are very effective in dark water
- neck is thick and muscular but flexible
- less interlocking vertebral processes enables pinnipeds to arch their backs backwards far more than most other mammals
- general body design is fluid, well adapted to graceful movements in the water
- layer of blubber beneath the skin provides energy, insulation, and buoyancy
- a hairy coat protects the skin
    - hair traps air to keep skin dry
    - molting of pinniped fur usually occurs after breeding season
- graceful in water, Pinnipeds are, by comparison, less graceful on land
- efficient usage of oxygen enables pinniped to dive for extended periods without damage to brain
- diving reflex enables the heart rate to drop from a rate of 55 to 120 beats per minute to that of 4 to 15 beats per minute
    - some pinniped species can dive to almost 3000 feet; the longest recorded dive period for a pinniped is 96 minutes
- Reproduction
    - pinnipeds give birth on the shore or on ice; they must thus maintain a link with the land
    - many species, but not all, congregate to reproduce in areas ranging from ice floes to sandy beaches to caves
    - reproduction appears to either prefer or require being isolated from humans and other predators
- are carnivorous, consuming prey items ranging from krill and other crustaceans to mollusks and fishes
    - smaller items are usually swallowed whole while larger food is shaken into more manageable sizes

Pinnipeds maintained at the Alaska Sea Life Center

1. Steller Sea Lion, *Eumetopias jubatus*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Pinnipedia
Family Otariidae
Genus *Eumetopias*

Occurrence	• northern Pacific Ocean from the Channel Islands of California north to the Gulf of Alaska and Hokkaido, Japan through the Bering Sea; breeding colonies mostly on Kuril Islands, Kamchatka, islands in the Sea of Okhotsk, the Aleutian Islands, and the Pribilof Islands
Form/Function	• male: 9 to 11 feet long, 1200 to 2200 pounds • female: 7 to 8 feet long, 580 to 700 pounds • pups about 3 feet long, 35 to 48 pounds • front flippers used for flapping ("flying") through water and for movement on land • hind flippers used like rudders to steer animal while swimming; rear flippers can be rotated to accommodate walking on land on all fours • whiskers (vibrissae) are tactile organs used for navigating and foraging
Reproduction	• some of the largest rookeries are in the Gulf of

	Alaska and southeast Alaska • males reach sexual maturity at 3 to 7 years of age; females at 3 to 8 years • gestation lasts 11.5 months • birthing occurs from May to July, usually a few days after the female has arrived at the rookery • males arrive at the rookery much earlier in order to establish dominance and territories; a male will mate with any female in its territory • one pup born of a female per season • pup nurses for 1 – 3 years • pup is nursed constantly for first nine days; thereafter the mother leaves the pup periodically to forage for food • foraging trips get longer as pup matures • nursing on about 2 gallon of milk a day, the pup puts on about 9 pounds of weight per day • pup stays with mother for 1 to 3 years
Predators/Prey .....….....	• preyed upon by orcas (killer whales) • feeds on fishes (herring, capelin, pollock, salmon, Pacific cod), squid, octopus, shrimp, crabs, and sometimes other pinnipeds
Noteworthy Facts ……	• females live an average of 30 years, males an average of 18 years • swimming speeds of 6 to 13 feet per second • largest members of the Otariid family • deepest recorded dive approximately 900 feet • are on the threatened (east) or endangered (west) species list; their numbers are still declining

2. **Harbor Seal,** *Phoca vitulina*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Pinnipedia
Family Phocidae
Genus Phoca

Occurrence	• circumpolar distribution in northern hemisphere; in Pacific from Baja California, Mexico to Nome, Alaska, including Aleutian, Pribilof, and Commander Island chains; in Atlantic, western populations concentrated from Greenland to Hudson Bay (Massachusetts) but occur as far south as Florida
Form/Function	• 4 to 6 feet long, 130 to 230 pounds • pups 2.5 to 3 feet long, 18 to 25 pounds • front flippers assist in steering while swimming and are used for movement on land; nails on front flippers assist movement on slippery surfaces (e.g., ice floes and algae covered rocks) as well as providing protection • hind flippers also used to propel animal through water; have nails but function of these is unknown • whiskers (vibrissae) are tactile organs used for navigating and foraging • lack external ear flap; does not impair their capacity to hear

Reproduction	• males reach sexual maturity at 3 to 7 years of age; females at 3 to 6 years • copulation occurs in the water • 10 month **gestation** period • one pup born of a female per season • pup nurses for 1 – 3 years • pup begins losing birth coat (lunago) in the womb • pup is nursed constantly for first nine days; thereafter the mother leaves the pup periodically to forage for food • adult coat markings apparent after lunago is shed • pup blubber thickens rapidly during nursing period • pups can swim upon being born • most pups born between February and September • although mating occurs shortly after female gives birth, the fertilized egg does not get implanted into the uterus for some 1.5 to 3 months
Predators/Prey .....….....	• preyed upon by orcas (killer whales), sharks, Steller sea lions, bears, coyotes, and eagles • feeds on octopus, crustaceans, and a variety of fishes (capelin, herring, pollock, Pacific cod, salmon, flatfish, eels, sculpins, and many other species)
Noteworthy Facts ……	• blubber functions as insulation

3. **Walrus,** *Odobenus rosmarus*

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Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Pinnipedia
Family Odobenidae
Genus *Odobenus*

Occurrence	• ice **floes** and Arctic islands of the Bering Sea into the Beaufort Sea
Form/Function	• male: 9 to 12 feet long, 1800 to 3800 pounds • female: 7.5 to 10 feet long, 900 to 2500 pounds • body sparsely covered in short, coarse hair • color changes with body temperature from almost white to dark pink • all individuals have the moustache, made up of about 450 thick bristles, the roots of which are innervated and nourished with blood • these bristles are very sensitive tactile features that allow the walrus to assess critical aspects (e.g., food presence) of its environment • foreflippers almost as wide as long; hind flippers more triangular • body form is swollen, with a rounded head and muzzle • neck is short and thick • upper **canines**, the tusks, grow up to 40 inches long in males, 32 inches in females • these continue to grow throughout the walrus'

	lifetime • used for rivalries among other walruses, defense from other species, cutting through ice, hooking on to ice while sleeping in water, and helping to pull the body out of the water

Reproduction	• walrus congregate in traditional areas for mating; such areas can be several hundred square kilometers in size • females and young will form groups of 20 to 50 individuals • males follow these groups and, when the group is resting on ice, compete for nearby water locations where mating can take place • only about 10% of the males are strong enough to out-compete the others and mate with the females • a successful male attracts a female in the water with underwater clicks and bell-like sounds; mating occurs in the water • a young female tends to remain in her mother's group • a young male tends to stray from his mother's group after 2 to 3 years • mating occurs in winter, mostly during January and February • fertile egg becomes implanted in the uterus some 4 to 5 months after mating; the gestation period then lasts from 10 to 11 months after this • females can bear only a single calf per breeding season • evidence also supports community care and adoption of orphaned infants • **lactation** continues for two years • females sexually mature at 6 to 7 years, males sexually mature at 8 to 10 years, but this is usually still too young to compete with older, stronger males for mating privileges
Predators/Prey	• feeds mainly on a wide variety of benthic organisms (e.g., mussels and sea stars), with representatives from 10 phyla and at least 45 genera • occasionally preyed upon by polar bears, orcas (killer whales), and man
Noteworthy Facts ……	• mostly uses moving pack ice over shallow waters • most populations appear to be **migratory**, moving

	north in the spring and south in the winter; this movement is in specific association with the advance and retreat of sea ice edge • normal swimming speed about 4 mph, maximum swimming speed about 22 mph • a **gregarious** species, walrus herds can number several thousand

Order Carnivora

Family Mustelidae, Weasels, Badgers, Skunks, and Otters

- this family, made up of 65 species, indigenous to all areas of the world except the West Indies, Madagascar, most of the Philippines, New Guinea, Australia, New Zealand, Antarctica, and most oceanic islands
- smallest family member is the least weasel, reaching up to about 10 inches in length
- largest members, the otters, can reach a length of about 6 feet (Amazonian giant river otter)
    - males can be up to twice the size of females
- short ears are either rounded or pointed
- limbs are short and each bears five digits
- claws are curved and nonretractile
- skull is sturdy, facial region short
- many are agile climbers or adept swimmers
- some have glandular secretions for protection; for example, skunks
- gestation period usually 30 to 65 days
- Reproduction
    - pregnancy period often extended due to delayed implantation of fertilized egg in the uterus; pregnancy can thus take as long as 12.5 months
    - usually one litter per year
    - young typically blind at birth
    - most young can care for themselves after 2 months
    - sexual maturity generally reached by age 2 years

4. Sea Otter, *Enhydra lutris*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Carnivora
Family Mustelidae
Genus *Enhydra*

Occurrence	• Aleutian Islands, Alaska to California; most often seen off of Gulf of Alaska and into southeast Alaska
Form/Function	• up to 5 feet long • males 50 to 100 pounds, females 33 to 68 pounds • body color varies from reddish brown to dark brown, almost black, except for gray or creamy head, throat, and chest • ears short, thick, and pointy • hind feet webbed and flattened into broad flippers • forefeet small with retractile claws • unlike other members of the family, lack anal scent glands • lack a fat layer beneath the skin ▪ for insulation from the cold, traps a layer of air in its fur • this fur must remain clean for its insulator properties to be preserved • densest animal fur known; 100,000 hairs/sq. cm
Reproduction	• Often form large but sex-segregated aggregations • breeding season appears to last most of the year • males move into female areas and establish territories; such territories are patrolled, but fighting is rare • male attempts to mate with any female entering his territory • births peak in May and June in the Aleutian

	Islands • usually one pup born (rarely two) to female in a breeding season; Alaskan sea otters are capable of giving birth each year • pregnancy lasts from 6.5 to 9 months • a female may adopt a litter if she loses her own • the pup is nursed and carried on the mother's chest as she swims on her back for the first month • the pup begins to dive during its second month of life; though it may take some solid food, it continues to nurse until almost reaching adult size • pup is dependent on the mother for 6 to 8 months
Predators/Prey .....….....	• preyed upon by orcas (killer whales), brown bears, Steller sea lions, coyotes, and bald eagles • feeds on and marine invertebrates (such as clams, abalones, crabs, and sea urchins) and slow-moving moving fishes; prey generally captured with forepaws, not jaws
Noteworthy Facts ……	• use rocks to break open clams and urchins while feeding • in 1911, the sea otter was protected by a treaty between the United States, Russia, and Japan, and Great Britain; only 1,000 to 2,000 individuals are believed to have survived at this time • in southwest Alaska, their numbers during the past ten years have decreased precipitously such that they have been listed as threatened as of fall, 2006; in southeast Alaska their numbers have been increasing

Whales, Order Cetacea

While the Alaska SeaLife Center does not maintain any whales within the facility itself, one can see these giant mammals on occasion from the outdoor observation platform located at the rear of the building, the ASLC's sightseeing boat used on Resurrection Bay. The sight of a humpback whale or orca, as it surfaces and spews forth a plume of vapor in exhalation, is magnificent indeed. While visiting the Alaska SeaLife Center, be sure to take some time to look for this and other sights from this observation platform that looks out into the Prince William Sound.

Whales/Order Cetacea

- wholly aquatic mammals that occur worldwide
- though usually inhabiting oceans and adjoining seas, some whales will venture into certain lakes and river systems
- two suborders
    1. Odontoceti, the Toothed Whales
        - have teeth of one form
        - have a single blow hole
        - includes some seven families
        - feed on fish, cephalopods, and crustaceans, although killer whales may consume birds and marine mammals as well
    2. Mysticeti, the Baleen Whales
        - lack teeth and have **baleen** instead
        - have a double blowhole
        - includes three families
- head and body length, taken from the snout tip to the notch between the tail **flukes** (i.e., either of the two horizontal divisions of a whale's tail) ranges from 5 to 102 feet
- weight ranges from 70 pounds to 350,000 pounds
- tail flukes are horizontal and perpendicular to long body axis (note that fish have their tails in a vertical plane)
- body more or less torpedo-shaped
- limbs
    - front limbs are modified into flippers (pectoral fins)
    - hind limbs not present
- dorsal fin usually present\
- fins/flippers are for balance and directional control
- in adults the only hairs to be found are a few bristles around the mouth or, in the case of humpback whales, on top of the rostrum
- lack sweat glands
- blubber, an oily fat layer, occurs immediately beneath the skin
- lacks external ears
- nostrils situated at highest point atop head and open externally
- milk cannot get into a baby whale's lungs because the passage from the

blowhole to the lungs is direct
- the visible spout of an exhaling whale results not from liquid water but rather from lung water vapor and perhaps a mucous oil that fills air sinuses
- propulsion provided through up and down movements of the tail
- anatomical/physiological diving adaptations
    - 80 – 90 % of oxygen used during extended dives comes from proteins that are capable of binding and releasing oxygen in blood and muscles
    - vessels direct blood away from muscles and other nonvital organs and direct it to the brain
    - heartbeat is reduced
- brain respiratory center can withstand build up of carbon dioxide
- like elephants, the brains of whales are larger than those of humans (depending upon species, weight ranges from 0.5 to 20 pounds)
- whale high level of socialization suggest high intelligence
- produce underwater sounds and some species (perhaps all to at least some extent) use these for communication
- baleen whales use specially-adapted filtering structures (called baleen) in their mouth to feed upon zooplankton primarily made up of crustaceans; this is accomplished by swimming with the mouth open through huge aggregations of zooplankton and fishes
- most whales are, at least to some extent, gregarious
- Reproduction
    - usually one calf is born; it may require a long period of parental care to mature
    - offspring at birth has a length that ranges from one third to one fourth of that of the mother
    - initially the mother remains at the surface on her side so that the calf can suckle while still breathing
    - with development, the calf suckles underwater
    - teats located within slits that occur along both sides of the reproductive opening
- in 1982, the International Whaling Commission voted to cease all whaling by the end of the 1984/1985 season
- countries, such as Japan, which initially objected to the commission's decision, later came to near compliance in the wake of U.S. trade restrictions; however, Japan continues to harvest some whales under the guise of "scientific sampling" and the United States and Russia still allow a certain amount of subsistence whale harvesting

Whales/Cetacea Observable from the Alaska SeaLife Center Observation Platform

5. Orca/Killer Whale, *Orcinus orca*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Cetacea
Family Delphinidae
Genus *Orcinus*

Occurrence	• distributed throughout all oceans and adjoining seas of the world
Form/Function	• males up to 32 feet long, females to 30 feet • males to 20,000 pounds, females to 12,100 pounds • in older males body stocky; pectoral fins get quite large (6 feet 8 inches) and dorsal fin to 6 feet tall; these fins are smaller in females, with the dorsal fin being more hooked (falcate) • tail flukes span up to 11.5 feet • upper body black (with the exception of a light gray area usually behind the dorsal fin), lower body white; white patch above each eye
Reproduction	• sexual maturity attained at about 16 feet in females and about 18 feet in males • breeding can take place at any time of the year, though in the northern hemisphere it peaks from May to July

	• newborns weigh about 400 pounds and are 8 – 9 feet long • based upon observations of captive examples, **gestation** period is 517 days and **weaning** requires 14 – 18 months • births peak in May and June in the Aleutian Islands • usually one calf born
Predators/Prey .....….....	• predominantly consume fishes and cephalopods, but can also take marine mammals such as seals, sea otters, and small walruses • different diet patterns have been displayed among different populations, with some being predominantly fish-eaters and others being primarily mammal-eaters • sometimes a pack of orcas has been observed to take on a single, large baleen whale and tear chunks from the living animal until it at last ceases swimming and expires; the orcas then finish off this large meal
Noteworthy Facts ……	• largest of the dolphins • make clicking sounds to locate objects underwater (called echolocation); also make underwater sounds, including screams, whistles, and pulsed calls, for probable communication with others • may occur in pods numbering up to 250 individuals; groups more typically consist of 2 to 40 individuals • can break ice up to 3 feet 4 inches thick and thereby dislodge animals (such as seals) into the water so that these may be preyed upon • **pods** are usually well organized and are headed by a male

6. Beluga Whale/White Whale, *Delphinapterus leucas*

Beluga Whales

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Cetacea
Family Monodontidae
Genus *Delphinapterus*

Occurrence	• occurs primarily in the Arctic Ocean and adjoining seas, Sea of Okhotsk, Bering Sea, Gulf of Alaska, Hudson Bay, and Gulf of St. Lawrence
Form/Function	• males up to 15 feet long, females to 13 feet • males to 3,300 pounds, females to about 2,900 pounds • pectoral fin length to 18 inches • adult color a creamy white • young are dark gray, black, or bluish for first year and subsequently become yellowish, mottled brown to pale gray; attain adult coloration at five years
Reproduction	• although different sources of reproductive information conflicts to some extent, research on belugas in the Canadian Arctic indicates that calving season occurs from April to September and peaks in late June and July • female produces a calf every 2 – 3 years • gestation period 14 – 15 months • newborn about six feet long • births peak in May and June in the Aleutian Islands • usually one calf born and weighs about 175 pounds • calf nurses for 20 – 24 months
Predators/Prey .....….....	• consumes fishes, cephalopods, and small

	crustaceans
Noteworthy Facts ……	• when migrating may occur in schools consisting of 10,000 individuals • surfaces to breathe every 30 – 40 seconds • emits a variety of sounds, some of which are used in echolocation • can only break through thin ice and therefore cannot remain in waters that freeze over with thick ice • occasionally a small pod of belugas will become "frozen in" to a small area where their frequent surfacings to breathe make them susceptible to being preyed upon by polar bears

7. **Gray Whale,** *Eschrichtius robustus*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Cetacea
Family Eschrichtiidae
Genus *Eschrichtius*

Occurrence	• Sea of Okhotsk to southern Korea and Japan and from Chukchi and Beaufort seas to the Gulf of California; it also appears that populations once lived in the North Atlantic
Form/Function	• males up to 46 feet long, females to 49 feet • weight to 81,000 pounds (40 tons) • pectoral fin to 6 feet 8 inches • fluke expanse to 10 feet • lacks a dorsal fin • color black to slate gray; has many white spots and skin blotches, some of these being discolored skin and others being white barnacles • has baleen instead of teeth
Reproduction	• females are generally on a two year reproductive cycle • mating usually occurs while migrating south during a three week period occurring in late November and early December • some matings are postponed until individuals are in wintering lagoons or migrating northward • gestation period is up to 13 months • calves born late December to early February • lactation lasts 7 months • newborn calf is about 16 feet long and weighs 1100 pounds • full sexual maturity reached by 17 years in females and 19 years in males

Predators/Prey .....….....	• gray whales feed in the summer in northern waters adjacent to Russia and Alaska • primarily feed upon bottom dwelling organisms (primarily crustaceans, mollusks, polychaete worms, and small fish) by plowing head from side to side through mud or sand; as water that has been taken into the mouth is expelled, the organisms are trapped in the baleen and this is what is consumed by the whale • feed while migrating northward, on summer range, and probably some also while on southbound migration; fasting may last up to six months
Noteworthy Facts ……	• tends to remain in shallow water and stays closer to shore than other whales • eastern Pacific population magites annually a distance of more than 10,000 miles • from May to early October, this population occurs in shallow waters of the northern and western Bering Sea, the Chuckchi Sea, the Beaufort Sea, and in scattered bays from Washington to the Aleutian Islands • in January and February, most individuals are found off of the Baja California coast • a generally less gregarious whale species that migrates solitarily or in groups of two to three, aggregations of up to 150

8. **Humpback Whale,** *Megaptera novaengliae*

Kingdom Animalia
Phylum **Chordata**
Class **Mammalia**
Order Cetacea
Family Balaenopteridae
Genus *Megaptera*

Occurrence	• occurs worldwide in all oceans and adjoining seas
Form/Function	• males up to 39 feet long, females to 40 feet • average weight to 66,000 pounds (33 tons) • pectoral fin to one third the length of the head and body (largest of any whale) • fluke expanse to one third head and body length • dorsal fin 6 to 24 inches high • color is black above and white below, although there is considerable variation from this • 10 – 36 grooves extend from the snout along the underside to the navel area

Reproduction	• sex and age segregation occurs during migrations and progresses as follows: • Spring: first females and newly-weaned calves, independent juveniles next, mature males and females that are not reproductively active next, late pregnancy females last • Fall: females in early pregnancy first, independent juveniles next, mature males and females not sexually active next, early stage of lactation females • the above migration patterns ensure that pregnant females maximize their time in feeding waters and that young calves maximize their time in warm waters • mating and calving season occurs October to March in the northern hemisphere and April to September in the southern hemisphere • males and females form temporary pair bonds, in which a male may drive other males away from a female; however, during the breeding season both sexes tend to associate with a number of members of the opposite sex • females usually produce every two years; occasionally reproduce in successive years • gestation period 11 – 11.5 months • newborn calf is about 14 – 17.5 feet long and weighs about 3000 pounds • sexual maturity at 4 – 5 years
Predators/Prey .....….....	• feeding occurs primarily from June – November on traditional feeding grounds in high latitude waters; in the Pacific, these waters include the Gulf of Alaska and the Bering Sea • Consume krill, other zooplankton, and fishes by gulping in huge quantities of water and expelling the water through the baleen and out of the mouth; the baleen retains the animal organisms, which are subsequently swallowed
Noteworthy Facts ……	• some individuals have lived to 77 years of age • a graceful swimmer that puts on dramatic displays in leaping and somersaulting completely out of the water • thousands of individuals currently residing in the North Pacific

XIX. Birds: Kingdom Animalia, Phylum Chordata, Class Aves

Birds make up an important component of the Alaskan marine ecosystem. They often represent top predators in various marine food chains. We begin our examination of Alaskan seabirds with a consideration first of what constitutes a bird generally.

Class Aves

The birds are chordates within the class **Aves**. This class contains the following characteristics:

- practically all of the anatomy of a bird is designed to improve flying ability
- bones are honeycombed, thus lightening them considerably
- number of ovaries reduced to one in females; in males, testes are small and, to minimize weight, enlarge only during reproduction
- modern birds lack teeth
- the bird beak, made of **keratin** (same material as in fingernails) is very light yet very strong and adaptable to many important uses (e.g., eating, **preening** feathers, and warding off would-be predators)
- warm-blooded
- feathers, which also are made of keratinaceous material, help to maintain heat of metabolism in the body; their hollow, light structure is an adaptation to flight
- well-developed four-chambered heart helps to support high bird metabolism
- Respiration
    - tubes leading from lungs help to ventilate off excess heat while simultaneously reducing body weight
    - lungs are extremely efficient in transferring oxygen into the body and transferring carbon dioxide out of it
- eyes are very well developed (perhaps the best-developed of all vertebrates)
- brain is larger and more complex than that of equally sized amphibians and reptiles; this enlargement has enabled the development of complex and sophisticated behavior, such as that displayed during courtship rituals
- Reproduction
    - fertilization is internal because each egg is laid with a hard shell around it
    - developing egg must be kept warm by brooding mother and/or father (depends upon species); there are exceptions to this, including storm petrels in Alaska, these birds abandoning their eggs at times during incubation

- Flight
    - wings are obvious adaptations for flight
    - are structured aerodynamically so as to provide lift

    - large muscles on the breast bone (**sternum**: it's the bone in humans that joins most of the ribs at the very front center of the chest area) are powerful and enable strong, flight-inducing power-strokes of the wings to be made
    - feathers, which are extremely modified scales, are remarkable for their ability to function as flight structures
    - benefits of flight
        - increases hunting and scavenging abilities
        - provides a means of escape from would-be predators
        - enables great migratory distances to be traversed
- Although past estimates have suggested that there are approximately 9,000 bird species, more recent genetics work has indicated that the number may be as high as 13,000
- 60% of all birds are members of the order Passeriformes (perching birds), which includes jays, swallows, sparrows, warblers, and a good many others as well

Order Charadriiformes: Family Alcidae

Family Alcidae, the auks (British term) or alcids (American term)

- includes 22 extant species of seabirds that are indigenous to northern latitudes of world
- 20 of these species occur in North America
- these include the following (A = occur in Alaska):
    - auklets (A)
    - dovekie (A)
    - guillemots (A)
    - murres (A)
    - murrelets (A)
    - puffins (A)
    - razor bill
    - the great auk (extinct since 1884)

Form/Function

- always occur in association with saltwater (except for a few marbled murrelets that occasionally become lost and starving murres that wander inland)
- most prefer open ocean
- smallest auks are 6 inches long, largest (Great Auk) 30 inches long
- appearance is duck-like, but neck is shorter
- beat wings rapidly in flight; can be described as a whir (heavy wing loading)
- head large, tail short, body chunky
- body colors mostly black and white
- have penguin-like appearance
- plumage dense and waterproof
- excellent swimmers and divers, they use their wings to effectively "fly" under water (this is what causes the heavy wing loading: to fly under water, wings need to be small, which makes flight in air difficult)
    - steer in water with their feet

- pursue fishes and marine invertebrates
- legs short; attached toward posterior end of body
- sexes appear identical outwardly (males slightly larger in general, but the difference is not readily apparent)

Reproduction Related

- while some species are migratory, most species simply disperse after breeding season
- very **gregarious** on breeding colonies
- make various sounds
- large flocks return annually to breed where they were raised (usually on islands); may return to exact same location
- may return to exact same ledge
- most courtship occurs on land, although some species may display on the water
- nest in colonies around fringes of Arctic Ocean as well as shores of North Atlantic and North pacific
- lay 1 to 2 eggs/season (varies with species; the inshore-feeders, such as guillemots, usually lay two eggs, whereas the more offshore-breeding species usually lay one egg)

Ecology

- auks are ecological counterparts of southern hemisphere penguins (however, all extant auks can fly; the extinct Great Auk could not fly as it had become so efficient in flying underwater that it could no longer fly in the air)
- Note: despite their similar mode of lifestyle, auks are **NOT** closely related to penguins
- swim and dive for food
- some auks are temporarily flightless when they molt their flight feathers; this is quite unlike the synchronous or near-synchronous molt characteristic of most other bird species)

Relatives

- auks are most closely related to other members of the order Charadriiformes, including gulls, terns, and shorebirds

Note: All auks are protected by law and may not be kept as pets. However, in the event that one finds a debilitated auk, contact authorities immediately to obtain further instructions on how to proceed (the Alaska SeaLife Center can be contacted at 1-888-774-SEAL). If the bird cannot immediately be taken to the authorities and you have good reason believe that it is in need of food and water (rescue agencies often prefer that the animal not be fed), it can be maintained alive by feeding strips of fish (1/4 to 2 inch thick and 2 to 4 inches long), squid, shellfish, meat, and/or shrimp. The strips should be dipped in salt water prior to feeding. A pool should be provided that enables the disabled bird to swim and dive. Once these requirements have been met, contact authorities again so that the bird may be best attended to.

Auks maintained at the Alaska Sea Life Center

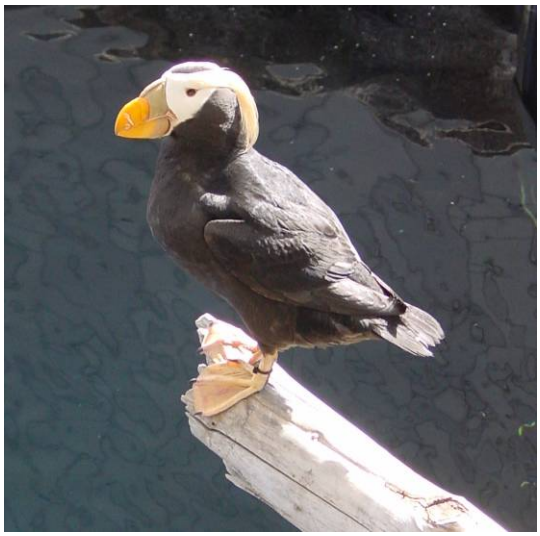
1. Horned Puffin, *Fratercula corniculata*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Alcidae
Genus *Fratercula*

Occurrence	• coasts and islands from northwestern Alaska, south through the Aleutian Islands and east to southeastern Alaska; also occurs in Asia in areas of Kamchatka and eastern Siberia; winters on open sea throughout its reproductive range south to Japan, British Columbia, Washington, Oregon, and to a lesser extent, California
Form/Function	• approximately 12 – 14 inches long • somewhat larger than common (Atlantic) puffin • sexes alike, with black above and white below • triangular, yellow adult bill is red tipped; immature lacks red tip and the yellow is often dark • cheeks white in summer, gray in winter • fleshy “horn” located above each eye • feet orange
Reproduction	• eggs may also be laid in cliff crevices and rock slide holes • a small amount of grass, moss, and feathers may be found in nest • eggs laid June to July; appear white with faint spots and scrawls • both sexes incubate eggs • young usually first fly in September • often shares nesting grounds with its generally more southern relative, the tufted puffin

Predators/Prey .....….....	• consumes mostly small fishes, including sand lances, sticklebacks, smelt, and assorted small swimming mollusks such as pteropods
Noteworthy Facts ……	• adult returns to nest during the day with a bill full of fish for the incubating mating and/or the young; however, the mate is not fed on the nest

2. **Tufted Puffin,** *Lunda cirrhata/Fratercula cirrhata*



Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Alcidae
Genus *Lunda*

Occurrence	• nests northwestern Alaska, south to Aleutian Islands, and east to British Columbia, Washington, Oregon, and southern California; in Asia nests from eastern Siberia south to Kamchatka and Japan; winters on open waters (especially oceanic North Pacific) except in the areas farthest north, which are covered in ice
Form/Function	• approximately 15 inches long • body all dark with a white face in breeding plumage • in summer, has long, backward-curving, golden plumes • lacks these plumes in winter; can then be distinguished from the horned puffin by its black belly and larger size • triangular orange bill • face white in summer, gray or black in winter • feet orange
Reproduction	• nests in a burrow usually dug into bluff edges at tops of islands • eggs may also be laid in cliff crevices and rock slide holes • a small amount of grass, moss, and feathers may be found in nest • eggs laid June to July; appear white with faint spots and scrawls of lavender or brown • both sexes incubate eggs

	• young first fly August - September • sometimes shares nesting grounds with crested auklet, least auklet, parakeet auklet, Glaucous winged gulls, murres, and/or cormorants
Predators/Prey .....….....	• consumes mostly small fishes, including sardines, herring, and perch; also feeds on various invertebrates
Noteworthy Facts ……	• in 1970, a captive pair bred in the New York Zoological Gardens

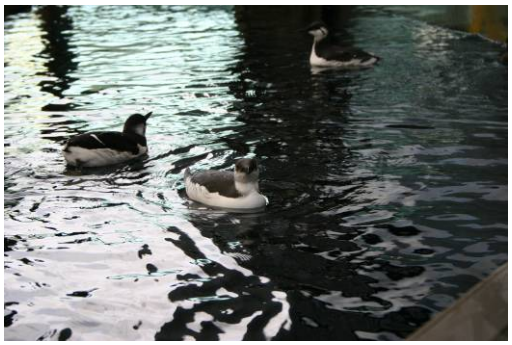
3. **Pigeon Guillemot,** *Cepphus columba*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Alcidae
Genus *Cepphus*

Occurrence	• nests from Chukotski Peninsula at Arctic Circle in Russia to islands in Bering Sea (except Pribilofs) south to Kamchatka Peninsula, and in North America from St. Lawerence Island, St. Matthew Island, Hall and Bogoslof Island, eastern Aleutian Islands, Shumagin island, Kodiak, and southern Alaska south to Santa Barbara Island, California; winters south of Bering Sea pack south to Kamchatka and Kurile Islands and to southern California
Form/Function	• approximately 12 inches long • summer breeding colors: body black, feet and inside of mouth red, extensive white patches on wings • pointed black bill • eyes brown or black • fall and winter plumage mostly white • distinguished from the black guillemot by a wedge-shaped black bar that extends into the prominent white wing patch (occasionally not visible)
Reproduction	• nests solitarily or in small colonies up to 50 pairs • nests in crevices or caves or talus slopes at foot of rocky island cliffs near salt water • a small amount of grass, moss, and feathers may be found in nest

	• eggs laid on bare rocks or open ledges; also laid in abandoned puffin burrows, rabbit holes, and beneath railroad ties; in Puget Sound, Washington area may dig its own nesting burrows in banks approximately 200 feet above sea • 1 to 2 eggs laid May to July • incubation period is 30 to 32 days • young fly at 29 to 39 days after hatching
Predators/Prey .....….....	• consumes mostly small fishes, mollusks, crustaceans and small worms
Noteworthy Facts ……	• a good underwater “flier”, it dives to feed on small fishes

4. **Common Murre,** *Uria aalge*



Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Alcidae
Genus *Uria*

Occurrence	• occurs in both the North Atlantic and North Pacific; in North America it is found during the summer along the eastern coast extending from Greenland south to Newfoundland; off the western coast, it breeds in summer from Alaska to northern Japan and central California; winters as much as 100 miles off the coast in Atlantic down to Maine and in the Pacific south down to California
Form/Function	• to approximately 16 inches long • has a long, dark, and slender bill and this characteristic enables one to distinguish between this and all other auks • sexes indistinguishable based upon outward appearance • breeding plumage: head and neck a rich, dark brownish-black color, underneath portions are white • trailing wing edge white • mouth yellow inside • the bridled murre, once believed to be a separate species, possesses a white eye ring as well as a thin white line extending from the eye back to the head's side; only occurs in North Atlantic examples • throat and cheeks of this species in winter are white instead of brown
Reproduction	• one of the most common and numerous of northern hemisphere sea birds, it often nests in huge colonies • does not form a nest but may cement together a few pebbles with excrement; this keeps the egg from rolling away; eggs are maintained on ledges or similar such structures of cliffs that usually face

	the sea, sometimes on flat ground on islands • eggs range in color from being entirely white to shades of blue, green, or brown with spotted with brown, lilac, or black: egg pear shaped • eggs incubated alternately by both sexes for 28 – 34 days depending upon nesting site microhabitat • chick, which is initially prevented by adults from jumping off of cliff, does do just this 18 – 25 days after hatching; may flutter down anywhere from 800 to 1500 feet or drop less than a foot, depending upon height of nesting area • several adults or a single adult will accompany the chick after it has landed in the water; it will be attended to at sea by adults (usually the male) until it is able to fly, which will occur approximately 39 – 46 days after hatching
Predators/Prey	• consumes mostly small fishes (up to 7 inches long); also squid, planktonic crustaceans, and sometimes polychaete worms
Noteworthy Facts ……	• one of the deepest diving auks, can go to depths of at least 240 feet, although Pacific records indicate depths to 600 feet • can attain flight speeds of up to 45 miles per hour • some naturally occurring albino specimens were observed in the 1950s

Order Charadriiformes: Family Haematopodidae

Family Haematopodidae

- name means blood foot
- large (15 to 21 inches long) shorebirds
- six species, occurring in Europe, Eurasia, Australia, South America, and North America
- nearly all are seashore birds of temperate and tropical coasts; some occur inland
- body mostly black and white or simply pure black
- feet and legs pink
    - feet have three toes
    - toes slightly webbed
    - no hind toe
- wings long and pointed
- tail short
- sturdy, bright red bill is more than twice as long as the head; this bill is the most distinguishing feature; has appearance of a large red clothespin at a distance
    - bill is compressed laterally
    - has been compared to the double-edged knife used by oystermen
    - bill used to pry shellfishes from rocky shores
    - inserts bill into bivalve shell and cuts the molluskσ abductor muscle, thus disenabling the ability of the shell to close
- feeds on mussels, clams, chitons, barnacles, limpets, and oysters crabs, marine worms, and other invertebrates
- wade up to their bellies in search of prey
- usually walk on ground but can run rapidly
- flight rapid, wing beats shallow
- very noisy, restless birds
- some species migratory
- are protected by law
    - contact authorities once an injured bird has been stabilized

5. Black Oyster Catcher, *Haematopus bachmani*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Haematopodidae
Genus *Haematopus*

Occurrence	• coastal from western Aleutian Islands, Alaska, south to Baja California, Mexico; casually encountered in winter off Pribilof Islands
Form/Function	• approximately 17 inches long • body large and all black or all dark brown in color • bill bright red and large • legs and feet pink
Reproduction	• nest is a hollowed area in the gravel of a beach located above the tide line or in a depression on a rocky islet or reef • eggs are laid May to June and number from 1 to 4, more commonly 2 to 3; eggs are buffy or greenish and spotted with light brown • eggs incubated by both sexes; eggs hatch after 26 to 27 days • chicks can run well at 3 days old, catch insects at 5 days old, and fly and, when 30 days old, remove mollusks from rocks by using the bill
Predators/Prey .....….....	• consumes mostly intertidal invertebrates, especially clams, snails, and chitons
Noteworthy Facts ..……..……	• moves with slow, jerky movements • very sharp *whick, whick* call when startled • species name given by John James Audubon for his friend the Rev. John Bachman of Charleston, S.C.

Order Charadriiformes: Family Laridae

Family Laridae, the Gulls

General

- composed of gulls and terns, a total of 82 species worldwide
- 43 gulls, 39 terns
  - 25 species in North America
- medium to large, gray to white seabirds; however, a few (e.g., Heerman's Gull, Black Tern, Black Noddy, and Brown Noddy) are dark
- young usually brown with a dark band on the tail
- most species live on or over saltwater seas and bays; however some occur inland over lakes and rivers
- are not strong fliers
  - mostly take advantage of updrafts for gliding
- follow mostly coastal migratory routes
- can drink fresh or salt water; excrete salt through glands located near eyes
- often show little or no fear of humans
- are gregarious at all times

Feeding

- gulls often forage over water
- can swim well on water's surface but do not swim under water
- feet are webbed
- sometimes dive shallowly from air for fishes, but prefer to dip head beneath surface while swimming about on surface searching for food
- are **omnivorous** and will eat practically anything; often function as scavengers and consume dead crabs, occasionally sea stars (for example the Western Gull *Larus occidentalis* feeds in California waters on the sea star *Pisaster giganteus*), fishes, and various other dead sea animals
- often eat eggs of other seabirds

Reproduction related

- Breed together in small to large colonies
- usually have one brood per year

Types of Gulls and Their Close Relatives

- kittiwakes are small, graceful gulls
- terns are generally smaller than gulls

Nesting/Raising Young

- often nest in tightly packed, dense colonies
- will vigorously defend their territories against other animals, including other birds
- chicks hatch with eyes open; are covered in down
- parents both feed the young and protect them from sun and rain
- chicks are fed fish and swallow these whole

Legal Protection

- are protected by law; contact authorities when a debilitated bird is found; if you believe that it is absolutely essential, the animal may be maintained on fishes while waiting to get the bird to authorities (ASLC emergency rescue: 1-888-774-SEAL)

6. **Red-Legged Kittiwake,** *Rissa brevirostris*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Charadriiformes
Family Laridae
Genus *Rissa*

Occurrence	• nests on ledges of sea cliffs of the Komandor. Aleutian, and Pribilof Islands in Bering Sea; overwinters on nearby seas; sometimes occurs accidentally south to Oregon
Form/Function	• approximately 18 inches long • wingspread to about 33 inches • summer adult is all white with gray mantle • bright red legs and feet • three toes only (most larids have four) • bill light yellow tinged with green
Reproduction	• nests in extremely large colonies on narrow cliff ledges overlooking the sea; in Pribilof Islands lays eggs in early to mid July • both sexes build deeply cupped nests made up of seaweed, mosses, and grasses • nests are cemented together with mud, which is carried to the nest location in the birds' bills • may nest in caves in more northern areas • 1 – 2 eggs, laid May through July, usually 2 in number; are blue-gray, blue-white, or shades of pink or brown spotted or splotched with gray or dark brown • incubation lasts 23 to 32 days; both sexes incubate • young are flying by 38 to 48 days after hatching
Predators/Prey .....….....	• consumes mostly small fishes (especially nocturnal lantern fishes) and small marine invertebrates

Noteworthy Facts ……	• are well known for amassing in huge flocks to consume scraps thrown from ships drinks salt water exclusively • flies more rapidly than other gulls

Order Anseriformes

Families Anhimidae (Screamers) and Anatidae (Ducks, Geese, and Swans)

- Worldwide all members of this Order resemble one another
- Two families
    - 1. Anhimidae: Screamers; long-legged wading birds, 3 species total
    - 2. Anatidae: Ducks, Geese, and Swans;148 total species; 64 North American species
- found worldwide except in polar regions
- most are migratory
- are small (12 inches long; consider teals) to large (62 inches long; consider swans)
- are aquatic, swimming birds with three webbed front toes
- fourth toe is smaller and free
- legs and tails short, neck long
- bill broad and somewhat flattened; tip is rounded
- Nesting/Reproduction
    - nest building usually by female alone or by male and female
    - clutches of 8 or more eggs laid in 1 to 2 weeks
    - incubation begins when last egg is laid; thus, all young may hatch at the same time
    - female usually does all incubation
    - after mating males often shed breeding feathers and thus appear more like females

7. **Long Tailed Duck,** *Clangula hyemalis*

Female in winter plumage

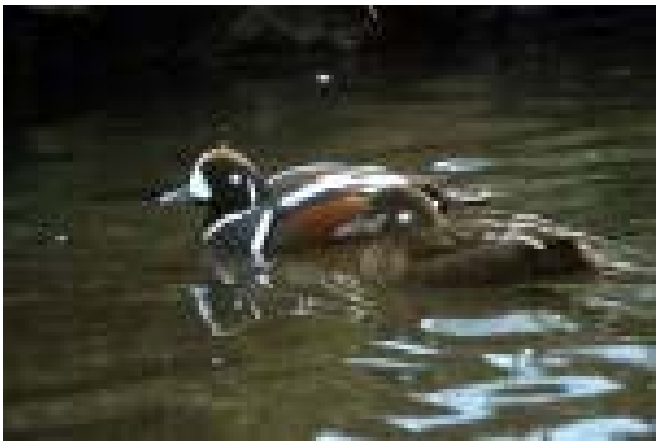
Male in breeding plumage

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Anseriformes
Family Anatidae
Genus *Clangula*

Occurrence	• nests along Arctic coasts of both hemispheres south to Labrador, south Hudson Bay, the Aleutian Islands in Alaska, Kamchatka, and south central Norway; winters in North America from south Greenland and Bering Strait south along Pacific coast from Aleutian Islands to Washington and southern California, in interior to Great lakes, Nebraska, Texas, Kentucky, and Tennessee, and along Atlantic coast to North Carolina, rarely to Florida and Gulf coast
Form/Function	• 15 to 23 inches long; wingspread 26 to 31 inches • male has two distinct plumages, one summer and the other winter; female also with a different summer and winter plumage • male has long, slender pointed tail regardless of his plumage
Reproduction	• nests widely scattered nesting on Arctic tundra; more regularly occur along shores of small, freshwater bodies; nest well concealed among grasses; sometimes nests are near salt water • 5 to 11 eggs laid from May to July • eggs yellow-buff or cream in color • female incubates eggs for 24 days • young fly 35 days after hatching

Predators/Prey .....….....	• are omnivorous, consuming a wide variety of invertebrates (including mussels, amphipods, shrimps, crabs, and other crustaceans) as well as roots, leaves, buds, and seeds of aquatic plants
Noteworthy Facts ……	• in 1946, a fisherman on Lake Michigan once caught, in his nets, some 27,000 long tailed ducks (!) • this duck can dive to 200 feet deep

8. **Harlequin Duck,** *Histronicus histronicus*



Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Anseriformes
Family Anatidae
Genus *Histronicus*

Occurrence	• occurs throughout northern latitudes; in North America ranges from Labrador and Alaska south to the Rocky Mountains to northern California and Wyoming, but further south in the winter to southern California, Maryland, and New Jersey; common along Aleutian Islands, Alaska
Form/Function	• a duck of medium size, from 15 - 21 inches long, wingspan from 24 - 28 inches • male blue-gray with chestnut sides • has a large white patch in front of the eyes, a smaller round spot and vertical white line behind eyes, patches of white occurring irregularly over body and wings • tail relatively long • female of a uniform brown with the exception that the underneath the body being paler and the head having three white spots
Reproduction	• nests in a shallow ground depression amongst bushes lined with grasses and down; may also nest in a hollow tree or a space among rocks • produces 5 – 10 (usually 6 – 8) eggs May through July • female incubates eggs for 28 - 29 days • young first fly at approximately 40 days after hatching
Predators/Prey .....….....	• in coastal waters, dive in rough surf to consume fishes, small echinoderms, small mollusks, sea

	worms, bryozoans, etc. • in freshwater habitats (e.g., streams) consume primarily insect larvae
Noteworthy Facts ……	• has been observed in Miami, Florida in the 1971 - 1972 season

9. **Spectacled Eider,** *Somateria fischeri*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Anseriformes
Family Anatidae
Genus *Somateria*

Occurrence	• occurs in Asia and North America; common along the Siberian northeast coast, it is rare in North America, where it breeds along very limited areas of the Alaskan Arctic coast
Form/Function	• has an overall ungainly appearance • wingspan from 35 – 36.5 inches • male white on top, black underneath • from 20 - 23 inches long • head pale green with a white patch around eye surrounded by a thin, black rim (hence the name *spectacled* eider) • female brown with a barred plumage pattern and with the suggestion of "spectacles" around the eyes • feathers on upper bill extend below nostrils
Reproduction	• nests occur 3 – 4 feet from water's edge • nest made of grass and lined with down; it is very well hidden near the edges of brackish or freshwater ponds • produces 4 – 9 eggs in June/July • incubation period believed to last 24 days • young fly in 50 – 53 days
Predators/Prey	• in summer consume small crustaceans, grasses, and seeds • in winter consume softer bodied crustaceans, small mollusks, echinoderms, and insect larvae
Noteworthy Facts ……	• may be seen in California as it can occur casually

	there

10. Steller's Eider, *Polysticta stelleri*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Anseriformes
Family Anatidae
Genus *Polysticta*

Occurrence	• from coasts of the Kamchatka Peninsula, northeast Russia and from Arctic coasts and islands of Alaska
Form/Function	• an unusually marked but attractive sea duck • from 17 - 19 inches long • wingspan from 28 – 30 inches • male breeding plumage: white head with a glossy black ring surrounding the eye and a green crest on top of the head; has a black collar with a black line that extends down the back; sides white with a round black spot on each breast side • female uniformly dark brown; also has a very small, rounded crest on back of head
Reproduction	• nests in deep cavities formed within tundra mosses; these are lined with down; occur on a pond edge or close to tidewater flats • 6 – 10 eggs laid from June to July • male remains with female until she has laid her eggs and begun incubating them • it is not known how long the incubation period lasts
Predators/Prey	• consumes primarily (87%) animal matter • eats soft crustaceans and other aquatic arthropods, mollusks, aquatic insects, annelid worms, and small fishes • also eats eels grass, crow berries, and algae
Noteworthy Facts ……	• the smallest eider

11. **Pacific Common Eider,** *Somateria mollissima*

Male

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Anseriformes
Family Anatidae
Genus *Somateria*

Female

Occurrence	• occurs during the summer in northern North America from Alaska to Newfoundland and south to Maine; winters along the Pacific coast to Washington and along the Atlantic coast to Virginia, North Carolina, and very rarely to Florida
Form/Function	• the largest eider • from 23 – 27 inches long • wingspan from 35 - 42 inches • male sides are black and back is white • wings having a good deal of white • pale green patches on back of head • female light brown with heavy barring in dark brown • head has a more sloping profile than those of other eiders
Reproduction	• where unmolested, nest in colonies on the ground, generally close to marine waters, and often on rocky headlands and islands; nests occasionally on ledges but usually covered by bushes or grasses; nest may occur in tundra or coastal marshes

	• 3 - 5 eggs laid from May to July; pale brown to olive-green color • eggs incubated for 26 – 30 days • young fly at 56 days old
Predators/Prey .....….....	• feed in shallow coastal waters by diving • feeds entirely upon animal foods, including small fishes (sculpins) and many marine invertebrates, including echinoderms, crustaceans, mollusks, and marine worms
Noteworthy Facts ……	• in captivity has produced hybrids through by crossing with pintail duck, king eider, mallard, and velvet scoter

Order Falconiformes

Vultures, Condors, Kites, Eagles, Hawks, Falcons, and Ospreys

- This order contains birds of prey that are active by day (diurnal) and resemble one another in form
- 271 species worldwide, including vultures, condors, kites, eagles, hawks, falcons, and the osprey
- Five families
    - Four of these in North America, including the vultures, hawks, falcons, and osprey
- Contains the two largest living birds that fly
    - Andean and California condors
- Characteristics of Falconiformes
- Hooked bill
    - Centrally-positioned nostril
- A grasping foot with the outer toe being longer than the inner
    - Middle toe is longest and is connected to the outer by a small web
    - Each toe possesses a long, curved claw
- Note: owls are no longer grouped within the Falconiformes as they are considered to be more distantly related and hence are placed in their own order, the Strigiformes

Family Accipitridae: Hawks

- Birds of prey family containing 208 species worldwide (except the northern Arctic, Antarctic, and numerous oceanic islands)
- Nearest relatives are osprey, falcons, American vultures, and condors
- From 8 – 48 inches long
- Weights from 3 – 8 ounces (sharp shinned hawk) to 15 – 20 pounds (harpy eagle of southern Mexico to South America)
- North American has 26 total species
    - 4 eagle
    - 5 kites
    - 17 hawks
- Strongly hooked bill
    - nostrils small and oval –shaped or occurring as slits
    - these open in the **cere**, a leathery skin covering that occurs on the upper mandible
- wings generally broad and rounded
    - by contrast, kite wings are long, narrow, and pointed
- neck short and powerful
- head round
- feet powerful and generally yellow; have sharp, curved **talons** (claws)

- Plumage is generally mottled, often wish shades of grays and browns on the back, pale to white below
    - Breast and belly often streaked or barred
- Sexes similar externally, but females larger than males (especially true of the more aggressive hunting species)
    - For example, the female harpy eagle is twice as large as the male
- Eyes are yellow, orange, red, or brown; more pale in younger birds
    - may provide the most acute vision of all living animals
    - large and move very little in sockets
    - possessing both monocular and binocular vision, their excellent predatory abilities absolutely depend upon the latter
- Reproduction Related
    - Courtship displays can be very dramatic
    - Certain eagle species may fight to death in aerial battles over mates or territories
    - Believed to mate for life or until one of the pair members dies
- Hunt by day
- Eagles are actually large hawks
    - eagle designation is based upon size; 50 species occur worldwide that are called either eagles or hawk-eagles
- largest individuals with wingspreads ranging from 6.5 – 8 feet
- usually weigh 8 – 16 pounds
- Stellar's sea eagle is largest in North America, reaching a weight of 11 – 20 pounds and a wingspan of 6.5 – 8 feet
- Stories of eagles carrying off children are pure mythology
- North American hawks
    - Wingspans range from 2 feet (sharp shinned hawk) to 4.5 feet (ferruginous hawk)
    - Ferruginousm Swainson's, red tailed, and other members of the genus *Buteo* circle high in the air, scanning the ground for potential prey items (mice, squirrels, rabbits, etc.)
    - Capture prey by swooping down and apprehending with the adept talons
- Cooper's and goshawks feed largely upon birds
    - Have shorter wings and tail that enables them to maneuver more nimbly and thus capture other birds in flight
    - Kill prey items by holding it down with talons, using the beak to tear off a portion of fur or feathers, and then tearing off pieces with the beak
- Kites habitat warmer regions of the world
    - Primarily consume insects, snails, reptiles, and amphibians
    - Graceful fliers
- Kites (continued)
    - Have the appearance of a large swallow in flight as they dive, glide, and soar
    - Wings appear gull-like
    - Lack fierce nature of hawks and eagles

- All members of the hawk family are protected by law
    - Cannot be maintained in captivity without special permits

12. **Bald Eagle,** *Haliaeetus leucocephalus*

Kingdom Animalia
Phylum **Chordata**
Class **Aves**
Order Falconiformes
FamilyAccipitridae
Genus *Haliaeetus*

Occurrence	• Often occurs within close proximity of water • Nests from northern Alaska to southeastern Quebec, and Newfoundland south to Baja California, Mexico, Arizona, New Mexico, southern Texas, Gulf coast and Florida; also in northeastern Siberia; accidental in Bermuda and Sweden; winters throughout its breeding range
Form/Function	• 34 - 43 inches long • Wingspan from 6 – 7.5 feet • Sexes similar • Adults: head and tail are snow-white; body brownish black; bill large; eyes, feet, and bill bright yellow; • Immatures: tail, body, and head dark brown; less black present than in adult; seen overhead the wings display more white than in adults; certain individuals may have the plumage haphazardly blotched with cream or white; bill brownish; eyes pale-yellow gray; feet lemon-yellow; tail and head white when bird is 4 – 5 years old • The broad wings are maintained in a flat posture while gliding or soaring (not seen turned up, as is

	the case with vultures) • Distinguished from immature golden eagle by large head, heavier bill, and the legs being unfeathered
Reproduction	• Nest 7 – 8 feet across and up to 12 feet deep; made of a foundation of sticks lined with various forms of soft vegetation; constructed in trees 10 – 150 feet above the ground; occasionally nests on a rocky precipice (as is occasionally the case in Alaska), on islands, or on ground • Eggs: Florida, November – January; more northward, March – April or May • Eggs: 1 – 3 (usually 2); dull white • Incubation in captivity 31 – 46 days; in wild 35 days • Often times there is great antagonism between eaglets such that the strongest kills the other or the weaker individual starves to death • Young take first flight at 72 – 75 days post-hatching
Feeding …….....	• feeds primarily on fish that it either catches itself or takes from ospreys • Will also apprehend and consume injured or shot waterfowl • Consumes a variety of mammals, including muskrats, squirrels, and rabbits • A noted consumer of "road kills"
Noteworthy Facts ……	• Make the largest nests known to be constructed by a pair of birds • Usually seen close to water • Benjamin Franklin, who preferred that the wild turkey be our national symbol, especially objected to the bald eagle being selected for this role, partially on the grounds that, "He is a Bird of bad moral Character. He does not get his Living honestly. You may have seen him perched on some dead Tree near the River, where, too lazy to fish for himself, he watches the Labour of the Fishing Hawk; and when that diligent Bird has at length taken a Fish, and is bearing it to his Nest for the Support of his Mate and young Ones, the Bald Eagle pursues him and takes it from him…" • United States national symbol • Profile is undeniably noble

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XXI. Glossary

abdomen	in crustaceans and insects, the most posterior of the three body divisions (i.e., head, abdomen, and thorax); in mammals, the body cavity containing the digestive, excretory, and reproductive systems
abiotic	non-living
aboral pole	in echinoids (i.e., sea urchins), the top, anus-bearing portion of the test (i.e., shell)
aboral surface	the topside of a sea star (Subclass Asteroidea) or central disc of a brittle star (Subclass Ophiuroidea)
adipose fin	present in some fishes (e.g., salmonids), a small, soft, fleshy fin located on the back between the dorsal and caudal fins
agar	a mucilaginous wall component of red algae; a sulfated polysaccharide commercially harvested for use in food and other products
akinete	a thick–walled resting spore in Cyanobacteria
alevin	a young fish; a newly hatched salmon with the yolk sac still attached
alga/algae	a heterogeneous assemblage of mainly aquatic, photosynthetic, non-vascular Plantae and Chromista that may be either unicellular or multicellular
alginic acid	a mucilaginous wall component of brown algae; a polymer of manuronic and guluronic acid and their salts; commercially harvested
allophycocyanin	a blue photosynthetic phycobilin pigment found in red algae, cryptophytes, and cyanobacteria
ambulacral groove	a furrow occurring in sea star (subclass Asteroidea) undersides that extends from the central disc to at or near the arm tip; tube feet emerge from the ambulacral groove
amoeba	a unicellular Amoebozoa characterized especially by its ability to form pseudopodia (false feet) and move about by cytoplasmic streaming that causes it to continually change shape
amoeboid	amoeba-like
anadromous	ascending rivers from the sea for reproduction; salmon are anadromous fishes
androgynous	hermaphroditic plants that produce their male and female gametes in separate reproductive structures (e.g., some flowering plants and some brown algae in the Fucales)
angiosperm	a vascular plant that produces flowers and generates seeds
animal	living organisms characterized by their ability to spontaneously move and have motor response(s) to stimulation; includes the Metazoa, Protozoa, and some members of the Amoebozoa
anisogamy/anisogamous	having male and female gametes that are of different sizes

annelid	Metazoa phylum consisting of elongated , segmented invertebrates (including earthworms, various segmented marine worm species, and leeches)
annual	in seaweeds and plants, a species that lives up to 1 year
annual rings	concentric rings that form annually in tree trunks and in algal stipes that can be used to determine age
antennae	in crustaceans and insects, the sensory head appendages
anther	the male part of the Anthophyte flower that produces pollen
antheridium/antheridia	the male gametangium in oogamous brown algae
antherzooid	the motile male gamete in oogamous brown algae
Anthozoa/anthozoans	a Cnidarian of the class consisting of sea anemones and corals
anus	the posterior opening of the alimentary canal
apical	at the top or apex of an organism or structure
aplanospore	a non-motile spore
Archaea	along with the Bacteria, one of two prokaryotic domains of life. Archaea occur in extreme environments like hot springs and hot vents and many produce methane. They are thought to be intermediate between Bacteria and Eukaryota.
archaeospore	a primitive monospore where the entire content of a cell is released into the water, found in *Smithora*.
Arctic	the region extending from 65 degrees N to the north pole
Aristotle's lantern	a feeding apparatus in regular echinoids (i.e., sea urchins); comprised of five calcareous plates (pyramids) located inside the test ("shell"); each pyramid is shaped like a down-pointing arrowhead; the pyramids are connected to one another by muscle fibe
Arthropod	the Phylum Arthropoda consisting of invertebrate animals (e.g., insects, spiders, crustaceans) having jointed body and limbs; the body is typically made up of a chitinous exoskeleton which is molted at intervals
articulated	jointed to allow mobility, said of the erect coralline red algae
aseasonal annual	an ephemeral, a short-lived species that can grow and reproduce multiple times during the year when conditions are good
asexual	a type of life history or propagation that does not involve the fusion of gametes or meiosis
asexual reproduction	reproduction characterized by a single parent producing genetically identical offspring via one of the following processes: (1) cell division, (2) fragmentation, (3) budding, (4) mitotic spore formation, or (5) division of the entire parental organism into two or more parts
atrium	large, open area inside of a tunicate; upper heart chamber of a vertebrate

autotroph	an organism that produces its organic molecules without eating other organisms or substances derived from other organisms. Photoautotrophs obtain organic molecules by using light energy to convert water and carbon dioxide into glucose. Chemoautotrophs obtain organic molecules by oxidizing inorganic molecules such as ammonia, hydrogen sulfide, or nitrites
autotrophy	an organism that obtains all of its organic molecules without utilizing compounds produced by other living organisms; some autotrophs, called photoautotrophs, use energy from the sun to convert water and carbon dioxide into organic molecules
Aves	the Class of the birds
Bacteria	along with the Archaea, one of two prokaryotic domains of life. They lack membrane-bound organelles such as a nucleus.
baleen	elastic, fringed material that forms a filtering device in the mouths of whales that filter feed upon zooplankton; such whales are called baleen whales
baleen whale	see baleen
benthic	of or associated with the bottom of water bodies, such as lakes and oceans
benthic zone	the surface of an aquatic environment's bottom
bilateral symmetry	a body form in which the organism may be divided along its central, longitudinal plane such that it divides into two equal but opposite halves
binomial naming system	The two-part naming system of biological classification established by the 17th century Swedish botanist Carolus Linnaeus. In this system the entire name is italicized, with the generic name appearing first and capitalized and the specific epithet appearing second and in small case. An example would be the scientific name of the giant Pacific octopus, *Enteroctopus dofleini*
biomass	the dry or wet weight of organic (i.e., carbon-containing) material making up organisms from a particular habitat
biotic	possessing properties of life
biphasic	A sexual life history that has 2 phases
birefringence	the refraction and separation of white light into the spectrum as occurs when light penetrates the thick walls of some red algae, e.g. *Mazzaella splendens*
blade	the leaf-like structures of a seaweed
brood	verb: to sit on or incubate eggs; noun: young of an animal or a family of young
bryozoans	colonial animals of the Phylum Bryozoa that superficially have the appearance of mosses

budding	asexual form of reproduction in which parental outgrowths either pinch off to live independently or remain attached to form colonies (such colonies may be extensive)
bulla/bullae	a characteristic rumpling of the blades of some kelp
bursa/bursae	occurring within the central disk of brittle stars (subclass Ophiuroidea), bursae are body pouches (sacs) containing cilia which generate water currents necessary for respiration
byssal threads	durable, fibrous cords secreted by certain bivalves (e.g., mussels and other such bivalves living in high wave energy areas) to secure the animal to the substrate
canine	a cone-shaped, pointed tooth; tooth between the lateral incisor and the first premolar
carapace	chitinous shield that covers an animal's back
carbohydrate	an individual sugar or sugars linked together
Carolus Linnaeus	17th Swedish botanist who established the binomial system of naming organisms according to genus and specific name; this system is still used today
carpogonium/carpogonia	the sessile female gamete or egg in red algae that typically has a long hair-like extension (the trichogyne) that protrudes out into the water to act as a receptive surface for sperm.
carposporangium/carposporangia	Mitotic sporangia in the carposporophytes of red algae that are monosporangia, each producing a single diploid spore (the carpospore)
carpospore	A diploid spore produced by the carposporophyte
carposporophyte	In the life history of red algae, the embryonic diploid phase that grows parasitically from the zygote in the female gametophyte; typically produces diploid carpospores.
carrageenan	a mucilaginous wall component of red algae; a sulfated polysaccharide polymer with a higher ash content than agar; commercially harvested for use in food and other products.
cartilaginous	composed entirely or primarily of cartilage; a cartilaginous skeleton is characteristic of sharks, skates, rays, and chimeras
caudal	of the tail region
caudal fin	tail fin
cell	the most fundamental unit of life; made up of cytoplasm and cell organelles (or their equivalent) separated from the environment by a cell membrane
cellular	of or pertaining to cells
cellulose	a long chain carbohydrate (a polysaccharide) comprised of numerous glucose molecules linked together into threads that are embedded in cell walls providing some structural support
central disc	that part of a sea star (subclass Asteroidea) or brittle star (subclass Ophiuroidea) where the arms merge; the central disc top is its aboral side and the bottom is its oral side, which bears the mouth

central nervous system	in vertebrates, the brain and spinal cord; in invertebrates, equivalent tissues/organs
Cephalaspidomorphi	the Class of fishes known as the lampreys
cerrata	finger or feather-like extensions along the back of a sea slug which contain a tubular branch of the digestive system
Cetacea	order of marine mammals including whales, dolphins, and porpoises
cheliped	in crustaceans, the first pair of leg appendages when it is larger that the other leg appendages; a crustacean claw
chemoreceptor	chemical receptors, as in olfaction (sense of smell) and gustation (sense of taste) and any other forms of chemical detection
chiton	any member of the order Polyplacophora; chitons are elongated, bilaterally symmetrical marine mollusks with a dorsal shell comprised of calcareous plates; often called sea cradles
chlorophyll a	the primary photosynthetic pigment that participates directly in the light reaction; consists of a porphyrin ring (with resonating bonds) and a hydrocarbon tail
chlorophyll b	an accessory photosynthetic pigment found in the higher plants and green algae, that transfers light energy to chlorophyll a
chlorophyll c	an accessory photosynthetic pigment found in the photosynthetic Ochrophyta groups, including the brown algae, that transfers light energy to chlorophyll a
chloroplast	the eukaryotic cell organelle that contains the photosynthetic pigments and undergoes photosynthesis
chloroplast endoplasmic reticulum/CER	the outer 2 membranes around the chloroplast in algal groups that have undergone a secondary endosymbiosis, found in the brown algae in this book
Chondrichthyes	the class of fishes including the sharks, skates, rays, and chimeras; chondrichthian skeletons are primarily composed of cartilage (cartilaginous)
Chordate	the Phylum Chordata that at some stage of development possesses a notochord, a dorsally (i.e., back) located central nervous system, and gill slits; members include the invertebrate tunicates and lancelets as well as all vertebrates (i.e., fishes, amphibi
chromatophore	pigment-containing cell in the integument of an animal that causes changes in skin color when that cell is expanded or contracted
chromosome	the combination of protein and DNA that makes up a thread-like structure containing the genes of eukaryotic cells (i.e., cells containing a nucleus)
cilia	cell processes that both project outwards and are capable of lashing movements that make possible mobility (e.g., cilia of sperm enable them to "swim")

circulatory system	the structures (e.g., heart and blood vessels) and functions that move extracellular fluids about an animal organism's body such that nutrients, oxygen and messages are brought to cells while wastes and carbon dioxide are removed from cells
cirri	a flexible animal appendage; in crinoids (the echinoderm group called sea lilies), jointed appendages displayed in whorls around the stalk
claspers	male copulatory organs located on the pelvic fins in fishes of the Class Chondrichthyes
Class	taxonomic level below Phylum and above Order
clone	a cell or multicellular organism that is genetically identical to its parent
Cnidaria	the phylum of the jellyfishes, hydroids, sea anemones sea pens, and corals
cnidocytes	specialized Cnidarian cells comprised of a capsule containing a fine, coiled thread which can be triggered outward for defensive or prey-capturing purposes
cnidosac	structures in which cnidocytes are stored
cockleburs	the spiny, bur-like seeds of the Anthophyte genus *Xanthium*, structures mimicking these occur in the red algal genus *Odonthalia*
colony	a distinguished, localized population of a particular species
commensal	organism engaging in commensalism (see below)
commensalism	a relationship among two organisms in which one obtains food or other benefits from the other without also harming it
community	all of the organisms that inhabit a particular area; populations residing sufficiently close to one another such that interactions are possible
complanate	flattened, used to describe many blades in the seaweeds
compressed	slightly flattened
conceptacle	an embedded flask-shaped structure that bears reproductive structures; occurs in the coralline red algae and in the Fucales.
congeneric	within a single genus, such as the species in a single genus
continental shelf	shallow, submerged plain of variable width that forms a continent's border and characteristically ends in a steep slope to the ocean abyss
continental slope	the steeply sloped area that lies between continental shelf and the abyss
copepods	small crustaceans that represent important components of freshwater and marine plankton communities
coralline	coral-like; used when referring to the calcareous red algae in the group Corallinales
cortex	a tissue that consists of isodiametric cells
corticated	covered by small round cells. Often used to refer to some filamentous red and brown algae

cristae	the convoluted inner membrane of mitochondria that functions in respiration
Cyanobacteria	photosynthesizing bacteria that contain chlorophyll a and a number of accessory pigments that generate oxygen; these organisms were formally called blue-green algae
cylindrical	round and hollow in cross section, said of the stipe of *Nereocystis*
cystocarp	the carposporophyte and its surrounding gametophytic tissue, used with some red algae
Decapoda	the Order of the crabs, lobsters, and shrimps
deciduous	structures that seasonally fall off due to an anatomical abscission zone, as occurs in many algae and flowering plants
deep sea hydrothermal vent	dark, hot, oxygen-poor environment associated with volcanic activity; autotrophic prokaryotes are the primary producers here
demersal	associated with living near or on the sea floor
deoxyribonucleic acid/DNA	a biomolecule that encodes the information required to form and maintain a living organism
desmarestene	a pheromone produced by *Desmarestia* eggs to attract sperm
detritus	organic material formed through decomposition of organisms
diatom	any member of the Bacillariophyceae, a class of minute, planktonic and benthic unicellular or colonial algae with external walls that contain silica.
dichotomous	branching in a Y-like pattern where 2 branches of equal size are formed from a single axis, as occurs in *Codium*.
Dicots/Eudicots	one of 7 kinds of flowering plants; two seedling leaves are produced by species in the Eudicots.
diffuse	occurring in a scattered, spread-out fashion. used to refer to meristems when any cell in an organism can divide
digestive system	structures (e.g., stomach and intestine) and functions that process and absorb ingested nutrients
dinoflagellate	single-celled photosynthetic algae often enclosed in cellulose plates that have two flagella, one girdling and one trailing; freshwater and marine species
dioecious	an organism that produces male and female reproductive structures on separate individuals
diploid	having a double set of chromosomes; 2N
direct development	Unusual biphasic life histories where one usually free-living phase grows directly from another without the intervention of spores or gametes; occasionally occurs in the red alga *Mastocarpus* and the brown alga *Scytosiphon*.
distichous	arranged in 2 rows on opposite sides of an axis or branch, giving the alga a bilaterally flattened appearance, as occurs in the red alga *Ptilota*
DNA	see deoxyribonucleic acid

Domain	the highest and therefore the broadest taxonomic level of the classification of living things
dorsal	back portion of an animal or plant body
dorsal fins	present as a single fin or fins on the back of a fish
dorsal hollow nerve cord	a characteristic of all chordates, this is a nerve cord lying along the midline and on the back of (i.e., dorsal to) the notochord; in vertebrates, the dorsal hollow nerve cord gives rise to the spinal cord, which is enclosed in vertebrae
dorsiventrally	from top to bottom
dry weight	weight obtained after all water has been removed from a tissue or tissues
echinoderms	The Phylum Echinodermata that demonstrates secondarily radial symmetry; includes many pentamerous marine animals (meaning with five equal parts); includes sea stars, brittle stars, sea cucumbers, sea lilies, sand dollars, sea urchins, and heart urchins
ecosystem	the living organisms of a specified area and all of their interactions with the non-living (abiotic) components of that area; a community and its associated environment
egg	a non-motile female gamete; in animals, a reproductive body made up of an ovum and a nutritive protective envelope that, after union with a sperm, gives rise to a new organism
eicosapentaenoic acid	a long chain omega-3 polyunsaturated fatty acid found in some red algae and in fish; has anti-inflammatory properties
embryo	young stage of plants or animals that is nourished and retained within parent tissue until birth or germination.
embryonic	in early stage of development of a fertilized egg, as in an embryo
encrusting, crustose	a condition where an organism grows tightly or loosely like a thick coat of paint on a surface, as in the red alga *Hildenbrandia*.
endocrine system	a regulatory function of the body that utilizes extracellular, fluid-borne chemical messages to control cell activities
endophytic	growing inside a plant or alga
endosperm	the 3N nutritive part of a seed that nourishes the developing embryo
endosymbiosis, primary	The original endosymbiosis of a procaryote to form chloroplasts and mitochondria surrounded by 2 membranes, as occurs in the Plantae.
endosymbiosis, secondary	The endosymbiosis of a eucaryote to form a chloroplast surrounded by 3-4 membranes, as occurs in the Ochrophyta
Endosymbiotic Theory	The early 1900's theory that the cell organelles such as chloroplasts and mitochondria evolved from primitive cells engulfing prokaryotes that became symbiotic permanent residents within the cell. As seen in the Eukaryota
energy	the capacity to do work (work = force X distance)

entire	whole -- often said of brown and red algal blades that have not split
environment	the portion of an area that is inhabited by life; an organism's surroundings; the combination of external conditions that influence the growth and development of organisms.
ephemeral	aseasonal annual; short-lived algae, plants, or their parts that can grow and reproduce multiple times during a year when the weather conditions are good
epilithic	growing on the top of rocks
epiphyte	any organism growing on the surface of a plant or alga
epiphytic	growing on the surface of a plant or alga
epizooic	growing on the surface of animals
erect	upright -- often said of the thalli of seaweeds
estuarine	growing in areas that have very low salinity such as bays and high tidepools
estuary	the region in which a flowing freshwater body merges with the salt water of the ocean
Eukaryota	One of the three Domains of Life; contains all organisms that have membrane-bound cell organelles (like the nucleus); consists of more than 6 Kingdoms
eukaryotic	cells and organisms that have membrane-bound cell organelles (like the nucleus)
Euphausiacea/Euphausiids	also called krill, an important, pelagic, shrimp-like Malacostracan that often make up a critical component of the marine food chain in the water column; notably preyed upon by baleen whales
exoskeleton	in arthropods, the chitinous, often hard exterior of the animal that both provides protection for internal organs and a place for muscle attachment
extracellular	outside the cell
facultative	an optional trait or function -- one that may or may not take place. e.g., facultative gametophytes do not necessarily form gametes
Family	level of taxonomic classification below Order and above Genus
fascia	a flattened planar area of an otherwise rumpled blade -- often occurs in place of a midrib in the kelps
fertilization, single or double	the union of a male and female gamete to form a zygote. Most organisms undergo single fertilization or syngamy. In Anthophyta, the pollen double fertilizes the ovule, fertilizing both the egg nucleus and two endosperm nuclei
filamentous	thread-like in appearance; can be unbranched or branched and thick or thin; growth by cell division in one plane
filter feeder	organism that obtains its food by filtering particulate organic matter or smaller organisms from the surrounding water; often enhanced by strong currents and water turbulence
fimbriae	fringed border of a body part

fin cells	tiny papery extensions of the epidermal cells along both margins of the upper leaves of some seagrasses making them feel rough to the touch. Detected in the field by running your fingers down the leaf edges near their tips.
fission	a mechanism of reproduction in which the parent organism splits into two individuals that are of about the same size
flagellum/flagella	a long hair-like appendage extending from a single-celled organism (like some algae) that enables the cell to move
floe	floating ice that forms as a large sheet at the surface of a large water body
floridean starch	The form of starch found in red algae; an alpha 1-4, 1-6 linked glucose polymer similar to the amylopectin starch of higher plants
flower	a showy angiosperm structure specialized for reproduction, that contains sepals, petals, stamens & carpels
flukes	either of the two flattened divisions of a whale's tail
foliose	leaf like
fragmentation	dividing or being torn into fragments; a form of asexual reproduction for some species
frond	a constant association of blades or leaves to form a compound structure. In red and brown algae
fruit	the mature ovary in angiosperms that is formed after fertilization as the seeds develop. Functions to protect the seeds and aid in seed dispersal
fry	fishes that have recently hatched
fucoiden	a polysaccharide in the cell wall and mucilage of brown algae; composed of sulfated fucose units
fucoserraten	a pheromone produced by the eggs of the Fucales (particularly *Fucus*) to attract the sperm
fucoxanthin	an brown-colored xanthophyll in brown algae; accessory photosynthetic pigment that traps light energy and transfers it to chlorophyll a
fusiform	tapered towards each end
gametangium/gametangia	structures that produce gametes
gamete	the male or female reproductive cell
gametophyte	the gamete-producing phase of a plant or algal life history; usually haploid
gas bladder	see swim bladder
gastrovascular cavity	also called the coelenteron, an incomplete gut cavity characteristic of cnidarians and some other invertebrates; used for both digestion and circulation
gene pool	the collective units of inheritance (i.e., genes) contained within a breeding population
geniculum/genicula	the flexible joints of articulated calcareous red algae that are non-calcified and allow flexibility.

genus/genera	taxonomic level below Family and above species; the first word of a species binomial name is the generic name, and it is capitalized. Onchorhynchus nerka is the complete species name of the sockeye salmon while Onchorhynchus is itself the generic name.
gestation	the carrying of young in the uterus
gill	characteristic of many aquatic organisms, a respiratory appendage in which gases (especially oxygen and carbon dioxide) are exchanged across tissues by passing from the aqueous environment to body fluids or vice versa
gland	cell or tissues that secretes substances either for further use within the body (e.g., hormone secretion) or for elimination from the body (e.g., sweat secretion)
gonad	female and male sex organs; gamete producing organs characteristic of most animals
grana	column-like stacks of thylakoids that occur in the Anthophyta and other land plants
green tide	A population explosions of green algae in the Ulvales (sea lettuce) -- often a nuisance in nutrient-rich estuaries
gregarious	having a tendency to associate with one's own kind; social
habitat	typical environment in which a particular organism resides
haploid	having one set of chromosomes; 1N
haptera	thickened branching finger-like corticated rhizoids that occur in the holdfast and aid in the attachment of some kelps
hermaphrodite	a hermaphroditic organism
hermaphroditic	the characteristic of having both eggs and sperm produced by the same individual and fertilization is the product of selfing. In algae, the gametes must also be produced on or in the same structure (e.g., the conceptacles of the Fucales)
heterocyst	a specialized thick-walled translucent cell that is the major site of nitrogen fixation in some Cyanobacteria
heterokont	of unequal length -- said of the flagella of the Ochrophyta
heteromorphic	having life history phases that look different
holdfast	organ at the base of a seaweed (alga) that functions to attach it to the substrate
hormogonium/hormogonia	free segments of the filaments of some Cyanobacteria that develop when cells die. When released from the sheaths, they can grow into another filament, providing a form of vegetative propagation for this group
hormonal system	see endocrine system
hormone	a chemical message that is secreted from one cell and alters the metabolism of another, distant cell
hydrostatic skeleton	skeletal system made up of fluid maintained at pressure in a closed body compartment; characteristic of flatworms, nematodes, cnidarians, and annelids
integument	skin or membrane
intercalary	occurring in the middle of a filament or thallus

intergeniculum/intergenicula	the inflexible calcified segments of articulated coralline red algae (as opposed to the flexible non-calcified genicula)
intertidal	the area on the ocean shore that occurs between the highest and lowest tide lines
intracellular	within the cell
invertebrate	animal lacking a vertebral column
iridescent	displaying colors like those of the rainbow usually due to the irregular refraction of light
isogamous	having male and female gametes that are of identical size
isokont	of equal length -- said of the flagella of the green algae
isomorphic	having life history phases that look the identical
kelp	members of the Laminariales, the brown algal order that contains some of the largest seaweeds
keratin	sulfur-containing fibrous proteins that form a horny material, such as that in fingernails and bird beaks
Kingdom	the taxonomic category below Domain and above Phylum
kleptoparasite	an organism that exploits food of another organism to the detriment of that other organism; for example, some large snails steal food from feeding sea stars
kleptoparasitism	The act of an organism functioning as a kleptoparasite (see definition of kleptoparasite above)
krill	see Euphausiacea/Euphausiids
lactate	to release milk from mammary glands
lactation	mammalian milk release during nursing
lacuna, lacunae	small cavity or chamber within a living organism that can have different functions. Lacunae in seagrass leaves are air chambers that aid in leaf flotation.
laminarin	photosynthetic energy reserve found in the brown algae, an insoluble β 1-3 linked glucose polymer
lamoxirene	a pheromone produced by the eggs of Laminariales to attract the sperm; a volatile unsaturated hydrocarbon
lanceolate	sword-shaped.
leucosin	an oil that is produced as a storage reserve in the Ochrophyta
lipid	a class of biochemical compounds, including tricylglycerols, phospholipids, and sterols, that are water insoluble
litter	offspring generated by a birth in a multiparous (i.e., producing more than one young at birth) animal
luminescence	light produced through biochemical/physiological processes; for example, certain species of deep sea fishes have biolumiscent organs for purposes of prey attraction, predator evasion, and/or intraspecific communication
macroalgae	multicellular algae that are typically visible to the naked eye
macrothallus, macrothalli	a large macroscopic thallus, often part of a biphasic life history that involves a microthallus

Malacostraca	Class of the crabs, lobsters, and shrimps
mammary glands	the milk secreting glands of mammals
mandible	the jaw-like structures located in front of the crustacean mouth; lower jaw of a vertebrate organism
mannitol	a 6-carbon sugar alcohol that is a transportable energy reserve in the brown algae; acts like an antifreeze in cold climates
mantle	deeply folded tissue mass in mollusks; it is draped over the mass of internal organs and also functions to secrete the shell
marine	of or related to the sea/ocean; living primarily in seawater that has a salt concentration of 20-33 ppt
marsupial	any of an order (Marsupialia) of lower mammals, including kangaroos, wombats, bandicoots, opossums, and relatives that usually have no placenta but instead have a pouch on the female abdomen in which are teats and in which the young develop
mastigonemes	the tripartite hairs that develop on the anterior flagellum of motile cells in the Ochrophyta
maxillae	in crustaceans and insects, one of the first or second pairs of appendages; in vertebrates the upper jaw
maxillipeds	crustacean or insect appendages making up the first pair or first three pairs behind the maxillae
medulla	the inner part of a complex thallus; usually containing cells that are non-photosynthetic, it is present in some red and brown algae.
medusa	the flattened, often pelagic, mouth-down version of the cnidarian (hydroid and scyphozoan) body; the polyp represents an alternate form of this body
meiosis	cell reduction division that involves the halving of the chromosome sets such that 2N thalli become 1N
meiosporangium/meiosporangia	a sporangium that undergoes meiosis and mitosis to produce haploid spores (meiospores)
meiospore	haploid spores produced through meiosis
membranous	thin and often transparent like a membrane; growth by cell division in 2 planes
meristem	the main site of cell division in a multicellular alga or plant
mermaid's purse	comprised of horny material, a protective structure in which develop the eggs of certain fishes of the Class Chondrichthyes
mesentery	a fold of membrane that supports a viscus (as the heart) and that is not a part of the digestive tracta; a support or partition in an invertebrate, similar to a vertebrate mesentery
metabolism	sum total of chemical reactions that sustain the life of a given organism
metamorphose	to dramatically change in body form while developing Give example

microthallus, microthalli	a microscopic or small thallus, often part of a biphasic life history that involves a macrothallus
midrib	a raised rib-like structure that runs down the center of the blades of some seaweeds
migration	the movement, often seasonal and cyclical, across a region; many times such movements are for feeding and/or breeding purposes
migratory	of or relating to migration
milt	fish male reproductive glands filled with secretion; the secretion itself
mitochondrion, mitochondria	the organelle in eukaryotic cells that serves as the site of cellular respiration
mitosis	The process of nuclear division in eukaryotic cells where the chromosome number remains the same
mitosporangium/mitosporangia	a sporangium that undergoes only mitosis to produce spores (mitospores)
mitospore	a spore produced only by mitosis
mollusk	the Phylum Mollusca made up of the bivalves (shipworms (Teredo),mussels, clams, cockles, oysters, and scallops), scaphopods (tooth shells), amphineurans (chitons), gastropods (limpets, nudibranchs and other sea slugs, snails) and cephalopods (octopus, sq
molt	in arthropods, the casting off of the old exoskeleton so that it may be replaced by the newly formed one; in vertebrates, the shedding of fur, hair, feathers, or horns
Monocot	A class of flowering plants that bears only 1 seed leaf
monoecious	having male and female reproductive structures on the same individual; used with the Plantae and Chromista
monopodial	having a distinct main axis that extends from top to bottom giving off smaller lateral branches, as occurs in the red algal genus *Odonthalia*
monosporangium/monosporangia	in red algae, a sporangium that produces 1 spore at a time (a monospore); some monosporagia can regenerate to produce additional monospores
monospore	a single spore produced from a monosporangium
monostromatic	1 cell thick, as occurs in the blade of the red alga *Smithora*
monotreme	any of an order (Monotremata) of lower, egg laying mammals, including the echidna and the duckbill platypus of Australia
morphology	form; the structure or structures comprising an organism
mucilage ducts	In some brown algae of the order Laminariales (kelps), specialized ducts that occur in the stipe and blade that function in the transport generally of fucoiden
mucronate	an apex or tip that bears a small central spine – as found on the tips of the leaves of some seagrasses
multiaxial	complex thalli that structurally consist of multiple axes, as occurs in the red alga *Mazzaella*.

Multicellular	comprised of more than one cell
muscle	tissues that contract to impart movement to body parts; different muscle forms include cardiac, skeletal, and smooth/visceral (in the wall of intestine of many animals)
mutualism	form of symbiosis in which both symbionts benefit
mysids	moderately sized crustaceans (to 14 mm) that often form swarms above and on the sea bottom; great swarms occur on the bottom in Prudhoe Bay; they are often very common in the intertidal wave region of sandy shores
Myxini	hagfish Class
nematocysts	the part of a cnidocyte that confers stinging ability (a cnidocyte is itself the cell that contains the nematocyst)
nerve	composed of nerve cell and nerve fiber, this is a structure that in conjunction with many nerve fibers forms a nerve that conveys messages to the central nervous system from other parts of animal body
nervous system	portion of an animal that is made up of both nerve cells and nerve fibers and functions to coordinate diverse functions (for examples, muscle contractions, release of hormones from endocrine tissues, and secretion from glands) from other, non-nervous system tissues
nitrogen fixation	process whereby some prokaryotic organisms utilize atmospheric nitrogen to form nitrogenous compounds (nitrate and ammonium) that can be used directly by plants.
Node	the swollen bumps on a seagrass rhizome that gave rise to leaves, shoots or roots
nori	the Japanese name for *Porphyra*, the red seaweed that is used to wrap around sushi
notochord	a long, flexible rod that runs along the dorsal (i.e., back) body axis in the area of the future vertebral column
nuchal	relating to the posterior portion of the head or to the neck
nucleic acid	the basic biochemical units comprising genetic material (i.e., DNA and RNA)
nucleomorph	In the Cryptophyta, a residue nucleus presumably from the endosymbiont that occurs outside the chloroplast envelope and inside the CER – providing additional evidence of the occurrence of a secondary endosymbiosis in this algal group
nucleus	the membrane-bound portion of a eukaryotic cell that contains the genetic material (DNA)
nudibranch	any of various marine gastropods (Suborder Nudibranchia) lacking a shell and true gills; these organisms are often brightly colored and often secrete irritating or toxic material that deters predators
nutrient	Substances that support, often by undergoing chemical changes, life functions; for animals, examples include proteins, carbohydrates, and lipids
obovate	the planar (2 dimensional) shape of an egg upside down

omnivore	organism that feeds on dead and living plants and animals
oogamous	forming eggs
oogamy	reproduction that involves eggs
oogonium/oogonia	in algae, a female reproductive organ that forms an egg or eggs internally
operculum	in gastropods a protective flap covering the opening when the animal withdraws into the shell; in fishes a protective flap covering the gills
oral disc	portion of a sea anemone that bears both the tentacles and the mouth (which is slit shaped and surrounded by the tentacles)
oral pole	in echinoids (i.e., sea urchins) the bottom, mouth-bearing portion of the test ("shell")
oral surface	the underside, mouth-bearing portion of a sea star (subclass Asteroidea) or brittle star (subclass Ophiuroidea) central disc
Order	taxonomic level below Class and above Family
organ	a body structure that is made up of different tissues and represents a center for a particular body function
organic	of, relating to, or obtained from a living organism
ossicle	a small bone or bony type of structure
Osteichthyes	the Class of bony fishes
ostium	mouthlike opening in a body part (e.g., a fallopian tube or a blood vessel)
oval	elliptical in shape
ovate	the planar (2 dimensional) shape of an egg
ovicell	egg brooding structure that occurs in Bryozoa
oviduct	a tubular structure passing from the ovary to the vagina of; birds and mammals are examples of animals possessing an oviduct
oviparous	producing eggs that both develop and hatch outside of the maternal body
ovoid	the solid (3 dimensional) shape of an egg
ovoviviparous	producing eggs that develop within the maternal body and hatch just before leaving or shortly after being extruded from the parent
ovule	the part of the Anthophyte flower that contains the female gametophyte or the embryo sac that produces the egg and endosperm nuclei
ovum	a female gamete in animals that has not been fertilized (union of ovum with sperm confers fertilization)
papilla	small projecting body part similar in form to a nipple
papillate	having very bumpy knob-like structures on the surface
papula/papulae	small, solid, conical skin elevation; in sea stars (Subclass Asteroidea), these function as areas of gas exchange (respiration)
Paramecium	the genus (Paramecium), a ciliated protozoan

paraphysis/paraphyses	sterile hairs that form around gametangia or sporangia in algae
parapodia	paired, fleshy, lateral appendages extending from most segments of a polychaete annelid worm
parenchyma/parenchymatous	a tissue consisting of isodiametric (equal-dimensional) cells; formed by growth that has cell division in 3 planes
paxillae	in certain sea star (subclass Asteroidea) species, small, movable spines on the ossicle; sea star ossicles are bony-like structures occurring on the surface of the animal's integument; these spines are an adaptation for burrowing; paxillae that are close
pectoral fin	either member of the pair of fish fins that correspond to the quadruped forelimbs
pedal disc	Bottom-most portion of a sea anemone column; the body portion used to secure the sea anemone
pedicellaria/pedicellariae	forceps-like extensions on the surface of certain echinoderms; function to pinch or cut organisms that might otherwise settle on the echinoderm surface; pedicellariae thus keep the body surface free of encrusting organisms; in Stylasterias the sea star c
pelagic	of the open water
pelagic zone	area of the open ocean located beyond the continental shelf and containing open water areas which may extend to great depths
peltate	consisting of a flat circular cap with a central stipe or stem; found in some seaweeds and vascular plants.
pelvic fin	either of a pair of fish fins that are homologous to the hind limbs of a quadruped (four-legged animal) Again, expand on this to actually give the location of these fins
pentamerous	divided into five equal parts
perennial	an organism that lives for more than 1 year, often at least 2 years
perfoliate	umbrella-like structure with the stipe or stem penetrating through the cap
pericarp	the sterile outer covering around some stalked carposporophytes in the red algae
periostracum	in Mollusks, the material (often of a fibrous nature) on the outside of the shell
petalloids	respiratory structures on the aboral side of sand dollars, heart urchins, and cake urchins; the five petalloids collectively form a flower-like image
pharyngeal slits	openings in the pharynx (throat) region of primitive chordates which permits the entrance and exit of water without the organism having to swallow and thus pass the water on through the digestive tract
pharynx	throat
pheromone	a diffusible hormone released by the egg in some brown algae to attract motile sperm

photic zone	portion of the ocean's surface through which sufficient light can penetrate for photosynthesis to exceed respiration, allowing for the survival of photosynthetic organisms; in clear ocean water, the photic zone can extend to 20 meters or more.
photophores	structure that form luminous spots on marine organisms (e.g., certain species of crustaceans, cephalopods, and fishes); especially characteristic of deep sea species
photosynthesis	the conversion of light energy into chemical energy contained in glucose or other organic compounds; this process occurs in plants, algae, and some prokaryotes Also found in the symbiotic unicellular algae inhabiting some invertebrates such as sea anemones and corals.
phycobilin pigments	the red and blue photosynthetic pigments found in red algae, cryptophytes, and cyanobacteria
phycobilisomes	small spheres or discs holding the phycobilin pigments that develop on the thylakoids of red algae and cyanobacteria
phycocolloids	mucilaginous polysaccharides that occur in the cell walls of some red and brown algae; extracted commercially and used as gelling, suspending, and emulsifying agents in a variety of products
phycocyanin	a blue accessory photosynthetic pigment found in the red algae and cyanobacteria that transfers light energy to chlorophyll a
phycoerythrin	a red accessory photosynthetic pigment found in the red algae and cyanobacteria that transfers light energy to chlorophyll a
phyllodes	the feeding structures located on the oral pole (underneath) side of a sand dollar, heart urchin, or cake urchin; collectively, the phyllodes form a flower-like pattern
Phylum	taxonomic level below Kingdom and above Class
physiology	body function or functions; examples: respiratory system, nervous system, cardiovascular system, digestive system, urinary system, etc.
physodes	small refractile tannin-filled vesicles that occur in the cells of some brown algae that aid in herbivore resistance
phytoplankton	photosynthetic bacteria and unicellular to colonial algae that occur in the pelagic zone of a marine or freshwater environment
pinnate	feather-like, having branches closely aligned on each side of a common axis such that the axis is flattened
pinniped	any member of the Suborder Pinnipedia, which are aquatic, carnivorous mammals whose feet are modified into flippers; examples include seals, sea lions, and walruses
pinnule	lateral branching(s) of the echinoderm crinoid (sea lily) arm
placental mammal	any member of a group of mammals (including humans) that completes its embryonic development in the uterus; the developing embryo is joined to the mother by the placenta

plankton	organisms, microscopic and macroscopic, which drift passively or swim feebly in the water column
planula larva	a very young, flattened, oval or oblong, free-swimming ciliated cnidarian
pleopod	crustacean abdominal swimming limb (as in shrimp)
ploidy	the sets of chromosomes that an organism possesses: one set is haploid, two sets is diploid, etc
plurilocular	multichambered, said of mitosporangia or gametangia in the brown algae that bear many chambers, each producing a single spore or gamete
pneumatocyst	an air-filled float that helps seaweeds to float - enabling exposure to greater light
pod/podia	foot/feet
polar	relating to the northern geographical pole or the area around it
pollen	grains that contain the male gamete in seed plants. Pollen grains carry 2 haploid nuclei, one to fertilize the egg nucleus and the other to fertilize the 2 endosperm nuclei.
pollination	the act of pollen landing on the stigma of a female carpel and forming a tube that reaches the female gametophyte, enabling fertilization to take place
polychaete	segmented marine worm with fleshy, bristled appendages that are used for swimming
polyp	sessile form of the Cnidarian body; the medusa is the alternate form
polysiphonous	a tiered appearance in red algal filaments caused by each cell of the axis being surrounded by a whorl of cells of the same length as the axial cells (e.g., *Polysiphonia)*
polystromatic	being more than 1 cell layer thick; used when referring to the veins of some membranous red algae
population	members of one species residing in a particular geographic area
Porifera	phylum of the sponges
preen	to trim or primp one's self; a bird preens its feathers with its beak
primary consumer	herbivores that feed upon primary producers (plants, algae, and some bacteria)
primary producer	an autotroph (Plantae, some Chromista, certain single-celled animals, and some Bacteria and Archaea); primary producers make up the foundational trophic level of most marine ecosystems
primary production	the quantity of light energy that is converted into chemical energy of organic (i.e., carbon-containing) compounds by primary producers (autotrophs) during a given time period
proboscis	any of various, elongated, tubular processes of an invertebrate oral (i.e., mouth) region

prokaryote	single celled organisms (Bacteria and Archaea) that lack membrane-bound cell organelles (like a nucleus)
prokaryotic	cells without membrane bound organelles such as occurs in the Archaea and Bacteria
proliferous	producing new blades from old blades as in some seaweeds -- or new individuals from old as in budding in some animals.
prostrate	lying along the substratum (as opposed to erect), said of some seaweeds
protein	three-dimensional, biochemical substance composed of amino acids; enzymes, biochemical catalysts that tremendously increase the rate at which biochemical reactions reach equilibria, are perhaps the most important proteins
pseudoparenchymatous	tissue that mimics a true parenchyma that is actually composed of intertwined filaments
pseudoperennial	a condition where one part of a plant or alga is perennial and another part is annual or ephemeral
pyrenoid	proteinaceous refractive (shiny) body in the chloroplasts of some algae that is associated with the formation of storage products.
rachis	the portion of the stipe that bears sporophylls in some brown algae, or the axis of an elongated inflorescence in Anthophyta
radula	rasping, strap-like, feeding organ characteristic of certain mollusks (e.g., limpets and snails) used to scrape food items off of surfaces or to drill through shells of mussels or clams
receptacle	in the brown algal order Fucales, a swollen fertile area that bears conceptacles; e.g., the swollen branch tips of *Fucus*.
red tide	sea water discolored by the presence of a great number of unicellular, typically photosynthetic, organisms
redd	fish spawning ground or nest
respiratory system	in animals, the structures (e.g., lungs or gills) and mechanisms which underlie the bringing of oxygen into the body while simultaneously removing carbon dioxide from the body
respiratory trees	found in sea cucumbers, a system of two tubular structures (each consisting of a main trunk and its branches) located within the animal and running along the right or left side of its digestive tract; water pumped through these trees functions to facilitate respiration.
rhizoids	small branched root-like structures that occur in seaweeds and help to anchor the thallus
rhizome	a horizontal stem that extends along or under ground and produces roots and shoots (e.g., in seagrasses)
rostrum	elongated, spine-like, anterior-most portion of a crustacean carapace (e.g., of a crab or shrimp)

salinity	a measure of the amount of dissolved salt (especially those of potassium, sodium, or magnesium) in a solution
saxitoxin	a potent, non-protein toxin that is produced by dinoflagellates of the genus *Gonyaulax* and by some Cyanobacteria; it may cause normally edible mollusks to become poisonous
sea anemone	members of the animal Order Actiniaria that usually exist as a solitary polyp possessing bright colors and a set of tentacles surrounding the mouth; resemble a flower in appearance; reproduce sexually and occasionally by fission
seaweed	multicellular marine algae that range in size from microscopic filaments to as tall as a 10-story building
secondary consumer	that trophic level of an ecosystem consisting of carnivores that consume herbivores (primary consumers)
seed	the propagative structure of a seed plant; the matured fertilized ovule in a protective seed coat --consisting of a young embryo, endosperm, and the hardened ovule wall
sessile	permanently attached; organisms affixed to the substrate
sexual	of or related to sex; sexual life histories involve both gametic fusion and meiosis to regenerate the haploid stage.
sexual dimorphism	differences in secondary sex characteristics between females and males (e.g., male tanner crabs are larger than females; female spiders are generally larger than male spiders)
siphonaceous	filaments or cells that are multinucleate and without cross walls, except for the reproductive structures
slime molds	a Phylum of mobile saprophytic organisms that exist as a vegetative mobile plasmodium that reproduces through sporangia and spore formation; formally thought to be Fungi
smolt	young salmon or sea trout of approximately two years age that is beginning to take on or has taken on the silvery color of the adult
sorus/sori	a visible grouping of reproductive structures; common in brown and red algae and in ferns.
spadix	a short modified stem in some vascular plants that bears male and/or female flowers, found in seagrasses
spathe	a leaf-like structure that encloses the reproductive spadix, found in seagrasses
species	level of biological classification below genus; a status assigned to organisms that mate with one another (i.e., share a common gene pool) and produce viable, functional offspring that can survive under natural conditions
sperm	gametes produced by male animal organisms; the genetic component contributed by male animals for reproductive purposes
spermatangium/spermatangia	the male gametangium in the red algae, generally producing only 1 gamete/spermatangium

spermatium/spermatia	the non-motile male gamete in the red algae
spermatophore	among various lower animals, a packet of sperm that is transferred from the male to the female during copulation; can be stored for several years in certain crabs (e.g., Tanner crab)
spicule	minute, calcareous, siliceous bodies that support the tissue of certain marine organisms (e.g. sponges)
spiracle	a breathing hole in the dorsal surface of certain fish species of the Class Chondrichthyes
sponge	member of the Phylum Porifera, which are organisms made up of an elastic porous mass in which is embedded interlacing horny fibers that form the animal's internal skeleton
sporangium/sporangia	a reproductive structure that forms spores, found in some seaweeds, ferns, bryophytes, and fungi
spore	a diploid or haploid reproductive cell released from a parent plant or alga that germinates to form a new multicellular organism without first requiring union with another cell
sporophyll	a specialized blade that produces sporangia generally in a sorus (e.g, in the brown alga *Alaria*)
sporophyte	the spore-generating phase of a plant or algal life history; usually diploid
starch	a photosynthetic energy reserve found in the Plantae that consists of an alpha 1-4 and 1-6 linked glucose polymers
stellate	star-shaped
sternum	the breast bone; ventral bone where ribs converge
stichidium/stichidia	a short modified stem that bears reproductive structures -- found in some male and tetrasporangial red algae
stipe	the stem-like structure in a seaweed
striations	parallel-running grooves
subarctic	regions immediately below the arctic circle (the arctic circle is located 65^{o} N)
subglobose	nearly spherical or globose
subtidal	constantly submerged beneath the intertidal zone, applied to the marine environment
sushi	a vinegared-rice finger food that is often wrapped in a sheet of Nori (*Porphyra*,) eaten in Japan and elsewhere.
suspension feeding	the sifting of small food particles from the water; characteristic of some cnidarians and polychaete worms, a few gastropods, clams, mussels, scallops, cockle, oysters, some species of brittle stars and sand dollars
swim bladder	a gas-filled, buoyancy-regulating organ characteristic of many bony fishes (Class Osteichthyes) species; also called a gas bladder
swimmerets	small appendages (pleopods) beneath the crustacean abdomen that are used for swimming and commonly used to carrying eggs

symbiont	smaller organism of a symbiotic relationship; the symbiont lives on or in the host
symbiosis	ecological relationship in which two different species live in direct contact with one another in harmony -- without one killing the other
syngamy	the fusion of 2 gametes to form a zygote; fertilization
taxonomy	the division of biology that names and classifies the diverse life forms
temperate	of or associated with a moderate climate
tentacle	any of elongate, flexible, tactile or prehensile processes borne about the mouth and/or head of various animal organisms (e.g., sea anemones and polychaetes possess tentacles)
terete	round and solid in cross section, said of many red and brown algae
test	shell
tetrasporangium/tetrasporangia	a specialized sporangium (a meiosporangium) in red algae that undergoes meiosis to produce 4 haploid spores (tetraspores)
tetraspore	one of four spores produced by a tetrasporangium; typically haploid
tetrasporophyte	the diploid free-living phase of red algae that matures to produce tetrasporangia
thallus, thalli	the plant body of an alga or a fungus; derived from the historical phylum Thallophyta that encompassed these organisms.
thorax	in mammals, the part of the body cavity containing the heart and the lungs; in arthropods, the body portion located between the head and abdomen
thylakoids	the flattened membrane sacks inside chloroplasts that hold the photosynthetic pigments and their associated proteins
tissue	integrated cells of similar structure and function
top predator	the last, highest trophic level organism of a food chain; killer whales are an example of a top predator in marine ecosystems
torsion	characteristic of certain gastropods, the rotation of the body during development (not to be confused with spiraling of the shell)
trichoblast	microscopic, uniseriate branched hair-like filaments that occur on some red algae and are often deciduous
trichogyne	the hair-like extension of the carpogonium in red algae -- the receptive site for spermatia.
trichome	a filamentous outgrowth; in filamentous Cyanobacteria, a filament or row of cells without the gelatinous sheath
triphasic	in the red algae, a life history with 3 distinct phases

triploid	3N, three sets of chromosomes as occurs in the endosperm of Anthophyte seeds
trophic	of or relating to nutrition
trophic level	any of several possible food chain levels; all higher trophic levels are supported by primary producers (autotrophs)
tube feet	in sea stars (Subclass Asteroidea), podia that emerge from the ambulacral groove and enable the organism to move
tubercle	small, raised section of a plant or animal
uniaxial	in seaweeds, complex filamentous thalli that structurally consist of a single main axis.(e.g. *Endocladia, Desmarestia*)
unilocular	having 1 chamber such as occurs in the meiosporangia of brown algae
uniphasic	in seaweeds, a sexual life history that has only 1 phase other than the gametes (e.g. *Codium*, *Fucus*)
uniseriate	a 1-cell thick filament
upwelling	In marine habitats, the process of deep, often nutrient-rich, waters rising to the surface
urinary system	structures (e.g., kidneys) and functions that process extracellular fluids (e.g., blood plasma) and thereby create a waste-laden filtrate (urine) that is voided from the body
uterus	female mammalian organ that contains and nourishes developing young
utricles	the club-shaped structures at the surface of some siphonaceous green algae (e.g., *Codium*)
vascular tissue	a tissue of specialized cells (xylem and phloem) in the ferns and seed plants that transports water and nutrients from the roots to the leaves and provides some structural support to these plants. A modified form of vascular tissue occurs in some kelps.
vein	visible structural lines that form in consistent patterns on the leaves and blades of some angiosperms and seaweeds
veliger	the larvae of some mollusk species (e.g., limpets, most snails, mussels, clams) that is characterized by having a protective shell and a ciliated foot in the form of a flap; this foot is used for feeding and swimming
ventral	lower portion of an animal body "front" is "cephalic"
ventral fin	either of a pair of fish fins located in the abdominal area or opposite the back and towards the front
viviparous	producing living young, instead of eggs, within the body; characteristic of mammals, many reptiles, and some fishes
water vascular system	unique to echinoderms, this is an interconnected system of hydraulic canals that branch from throughout an individual organism's interior on into the tube feet; the water vascular system is important for locomotory (movement), feeding, and gas exchange
wean/weaning	accustoming the young of a mammal to take food by means other than nursing

whorl	similar parts of organisms arranged in a circle
zooecia	the boxlike or tubelike dwelling secreted by bryozoan zooids
zooid	an invertebrate organism, especially one that lives colonially, in which members are joined to one another by living material and that reproduces asexually via budding or splitting..
zooplankton	planktonic animal life
zoospore	in green and brown algae, an asexual reproductive cell that is flagellated
zooxanthallae	any of various symbiotic dinoflagellates that live within the cells of other organisms (as reef-building coral polyps)
zygote	a cell that results from the fusion or syngamy of two gametes