recruited to the merotelic foci and increase the turnover of these kinetochore fibers. This will increase the chance for the malattachments to be corrected. The specific molecules involved in this process are still not clear; however, the current work shows that the Aurora B substrate MCAK is enriched at the merotelic foci in an activated form. It will be interesting to look at other components of the microtubule attachment machinery as well as additional Aurora B substrates as they are identified.

As any good science often does, we are left with just as many if not more questions than when we started. What molecules are upstream of Aurora B and how do they act? What are the signals and the mechanisms by which increased amounts of Aurora B are recruited to the merotelic kinetochores, or are their turnover dynamics just altered such that they are preferentially retained at these sites? Which phosphatase antagonizes Aurora B at the centromeres to turn off the kinase and perhaps assist in maintaining stable attachments? Is it chromatin-associated protein phosphatase 1, which antagonizes Aurora B phosphorylation on H3 [18]? Further studies are needed to reveal the answers to these puzzles.

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Marine Ecology: Gelatinous Bells May Ring Change in Marine Ecosystems

Gelatinous plankton are critical components of marine ecosystems. Recent studies are providing evidence of increased population outbursts of such species. Jellyfish seem to respond when an ecosystem is over-fished, and their ecology is under-researched.

Steve Hay

Warnings sound as climate change influences global and regional marine ecosystems [1], while the awareness of pressures, vulnerabilities and failures of marine resource management and conservation increase. There is increasing concern about the consequences of anthropogenic pressures, such as over-fishing, eutrophication, chemical pollution and the transport and introductions of exotic species [2,3]. The recent *Current Biology* paper by Lynam *et al.* [4] highlights concern that the ecosystem switch that they have observed — to jellyfish biomass dominance rather than fish in the productive Benguela ecosystem — may be a consequence of over-fishing. Internationally, integrated ecosystem approaches to assessment and management are being adopted and incorporated into active policies and directives. This approach acknowledges

that ecosystem health depends on diversity and functional complexity, and that unsustainable pressures must change the balance of species, biomass and energy flow in communities, whether they do so slowly or quickly.

The new ecosystem approach requires us to seek indicators of change, and interest in marine cnidarians and other gelatinous species is growing. These enigmatic, ubiquitous and at times overwhelmingly abundant animals are now recognised as key marine ecosystem elements, often as critical indicators and drivers of ecosystem performance and change. But we do not yet know enough to quantify effectively the species or their roles in food webs, or their importance relative to better known and abundant groups, such as fish. One problem with observation of a major predator switch from fish to jellyfish, such as that in the Benguela reported by Lynam *et al.* [4], is an inability to be sure of the cause or to predict the stability of the changed ecosystem. Without the knowledge to understand and predict such ecosystem change, managing fisheries consequences or recovery is guesswork, no matter how precautionary the approach.

While the plight of coral reefs is emphasised in the news, apparent increases of the free-living gelatinous cousins of corals also raises concerns. Occasional and episodic swarms of gelatinous plankton are well known historically, but reports of such events are increasing in frequency, and they appear linked to other ecosystem changes. Massive population outbursts have been reported for medusae, siphonophores and ctenophores, as well as for other gelatinous groups, which include the salps, appendicularians and larvae of many benthic fauna.

Gelatinous species range from the surface to great depths in every sea, and in sizes from microns to metres. Often they are too fragile and damaged to record or identify in traditional plankton nets and trawls, or they are simply ignored. Significant advances in net systems, submersibles, diving,

video and new acoustic methods, such as those developed and used in the new Benguela study [4], now allow extensive observations and counts of these species. The results are underlining the major roles of gelatinous plankton in marine ecosystem dynamics. Taxonomic specialists, such as those on a recent Census of Marine Zooplankton cruise [5], bring us the joy of seeing new species; yet this also exposes our broad ignorance of their diversity, abundance, distribution and functions. Concerns for endangered and charismatic species such as turtles and seabirds also highlight the role of jellyfish on which many such species depend for food.

The few marine scientists with active interests in these gelatinous groups have responded to new observational evidence and to the political and policy emphasis. Special science meetings, theme sessions and workshops have been held [6–9] and science reviews have been recently compiled [10–13]. Despite increasing awareness of their importance, research on gelatinous organisms is just a small fraction of that driven by resource management needs for fisheries, pollution assessments or ocean weather forecasting. If we are truly to adopt ecosystem approaches, then we clearly need to learn more about the often dominant gelatinous plankton. What then do we know of the gelatinous plankton in relation to ecosystems and socio-economic areas of concern?

For fish and fisheries, jellyfish are a mixed blessing. Valuable, ancient and largely artisanal fisheries exist in Asian seas for several edible species, mainly supplying Japanese and Chinese markets. Large jellyfish swarms interfere directly with effective fishing operations, they clog nets which can burst, and fish may avoid jellyfish swarms. Fishermen are affected by stings and survival of undersize fish escaping their nets may be impaired. Most medusae, siphonophores and ctenophores routinely compete for plankton prey with larval, juvenile and many adult pelagic

fish. Incidentally, these jellyfish also consume fish eggs, larvae and some adult fish. Conversely, jellyfish are increasingly being noted in fish diets. As with fish, some jellyfish feed mainly on others of their kind, and it seems that jellyfish and fish may form parallel and perhaps alternative guilds of predators in marine ecosystems. As Lynam *et al.* [4] point out; a switch from fish to jellyfish dominance is not a desirable change.

In contrast with fish, jellyfish are simple organisms. Fish may feed rapidly to satiation, have sophisticated storage reserves and may swim or migrate long distances to feed or to spawning grounds. Jellyfish largely drift with the currents, migrating only vertically in the water column as non-visual, ambush feeders. Able to feed effectively without saturation even when food is abundant, many jellyfish can subsist on absorbed dissolved organic matter or simply shrink when starved. Gelatinous species generally grow and reproduce very quickly, often with asexual as well as sexual reproductive stages, and alternative seasonal life strategies. Many species have sessile, planktivorous polyp colonies, which in some cases may remain dormant in cysts when stressed. Polyps produce sexual planktonic medusae, though oceanic species by-pass the polyp phase.

Jellyfish are naturally adapted to patchy and diffuse resources, responding to high food patches by rapid individual and population growth. Some fish species and juveniles use the shelter of the jellyfish for protection from predation by larger fish, and may feed on the jellyfish's prey and parasites. Jellyfish are likely intermediate vectors of various fish parasites. At local time and space scales, jellyfish swarms or invasions may exert strong influences on the recruitment and productivity of some fish populations. Given the evidence in the Benguela [4], and from other ecosystems, it seems this may propagate throughout an entire ecosystem.

For fish, jellyfish and other zooplankton, long term

distribution and abundance patterns have been correlated with climate change indicators; such as the El Niño-southern Oscillation, the North Pacific Decadal Oscillation, or the North Atlantic Oscillation. Occasionally, climate changes, which alter temperature distributions, nutrient fluxes and current fields, may induce rapid regime shifts in marine ecosystems, resulting in alternative environmental and community patterns. Causal mechanisms for such correlations are poorly understood, and biophysical modelling and prognoses are very limited. There is a lack of sufficient and essential field data on the biological components, and scientific understanding of their environmental sensitivities is sparse. There are many long term monitoring data on fish stocks. The new observations in the Benguela system [4] suggest an urgent need to monitor at appropriate temporal and spatial scales the responses of other key species groups to variable and changing environments.

In addition to climatic and environmental effects, over fishing, particularly on stocks of small, pelagic, planktivore fish, may lead to changes in plankton communities. Many fish stocks are in decline and from some regions there is strong evidence for coincident rises in jellyfish abundance [4,14]. Fish often reproduce when jellyfish are least abundant; however, overlaps and seasonal shifts in production of fish or jellyfish will have consequences. Once jellyfish become dominant in a region, annual cycles of strong jellyfish production may inhibit the revival of some depleted fish stocks. The effects of introduced jellyfish in the heavily fished Black Sea are a cautionary tale. In a Norwegian fjord, Lurefjorden, there are almost no fish; the jellyfish dominate [15].

Aquaculture is a global growth industry with intensive monocultures of a few species. This requires economic husbandry, production and harvesting through effective containment, appropriate food supplies and avoidance of losses from diseases and parasites. Swarming jellyfish, along with blooms of some harmful algal species are significant causes of production losses to the aquaculture industry today. Unlike agriculture, such losses cannot be controlled by chemical treatments or crop rotations. In practice, aquaculture simply adapts procedures to reduce or absorb these risks and impacts. Cnidarians' stinging cells are toxic with complexes equivalent to snake venoms, and are occasionally as lethal. Aquaculture farms, usually in sheltered inshore sites, may be exposed to local and seasonally large populations of toxic algae and jellyfish. Occasionally, and usually briefly, influxes of oceanic water and plankton are carried into productive shelf seas and around aquaculture facilities. Here they may form opportunistic blooms and thriving, toxic swarms. When these die off their mass decay may also briefly deoxygenate the water, which can also result in mortalities of natural local fauna and of farmed species. An ecosystem-wide change as observed in the Benguela [4] may increase the likelihood there of toxic plankton effects on aquaculture.

Other economic impacts of jellyfish come from their effects on coastal industries and power stations, which use seawater cooling. In Japan and elsewhere, jellyfish have impeded or blocked the intakes and screening systems, affecting power supplies [16]. Often tourism has been seriously affected by jellyfish swarms appearing in coastal resorts. With increased travel, more, and often ill-informed travellers are exposed to the most dangerous jellyfish species in tropical seas. Jellyfish, however, have already proved of great value as a resource for pharmacology [17], providing active biochemical and genetic substances such as Aqueorin and Obelin.

Gelatinous species play many roles in marine ecosystems and communities. Herbivorous groups (salps and appendicularians) consume bacteria, phytoplankton and micro-zooplankton. This constricts the secondary productivity of the less fragile and better known crustacean plankton and fish food species, such as copepods and euphausiids. Excretion, egestion and decay supplies regenerated nutrients fuelling phytoplankton production, while faecal products and remains form major material transports from the productive surface waters to the seabed and ocean deeps. Gelatinous bodies and egesta form a three-dimensional matrix of bioactive surfaces in the water column. The pressures of jellyfish predation are felt across the heterotrophic food web from microplankton to fish and can exert strong control on production and on material and energy flow in food webs.

The gelatinous plankton cycle and recycle enormous amounts of matter in the oceans, and strongly influence food webs and elemental fluxes. Evidence indicates that ocean climate changes affect seasonal timing and production cycles in plankton and fish. Interactions with pressures from over-fishing, eutrophication and pollution may occur in ways we neither expect nor understand. As high level predators that integrate effects lower down the food web and have sensitive and rapid responses to change, jellyfish are good candidates to be informative indicators of the status and performance of marine ecosystems.

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Behavioral Endocrinology: Lighting up Peptidergic Neurons that Mediate a Complex Behavior

A recent study in which a calcium-sensitive fluorescent protein was expressed in transgenic *Drosophila* has shown that a command neuropeptide that turns on a complex behavioral sequence elicits a spatially and temporally complex pattern of neuropeptide signals.

John Ewer

Insects and other arthropods have an external skeleton that gives the animal its shape, supports its muscles and prevents desiccation. This rugged body design is likely to explain, at least in part, the great success of this incredibly diverse and prolific group of animals. Yet, as anyone who has outgrown their shoes knows, an external skeleton greatly constrains growth. Arthropods have solved the challenge of growth by periodically replacing their exoskeleton in a process called the molt. As they reported recently in *Current Biology*, Kim *et al.* [1] have identified ensembles of peptidergic neurons that control molting behaviors in the fruitfly *Drosophila* and provided new insights into their time course of activation. Beyond the significance of this work for insect biology, their findings provide insights into mechanisms by which neuropeptide hormones activate behaviors in all animals.

Most people are not impressed by insect molting because much of it is hidden from sight and occurs beneath the exoskeleton of the current stage. We are also not impressed because molting occurs so seamless and flawlessly that it appears to be a simple process. But events beneath the surface reveal instead a complex and highly regulated process. A particularly critical event in this process is the shedding of the old cuticle and the maturation of the new one, which is collectively referred to as ecdysis. Ecdysis, the most flamboyant example of which is the emergence of the adult butterfly from the chrysalis followed by the expansion and hardening of its wings, is caused by deliberate activation of a complex behavioral sequence that is controlled by a suite of interacting neuropeptides (reviewed in [2,3]).

Two neuropeptides are known to trigger ecdysis behaviors in intact animals: ecdysis triggering hormone (ETH) and eclosion hormone (EH). Both neuropeptides are normally released just before ecdysis, and injection of either peptide into an animal that is completing a molt causes release of both peptides and activates the entire behavioral sequence. What lies downstream of EH and ETH release remains unclear, but two pieces of evidence suggest that ETH plays a critical role. First, addition of synthetic ETH to an isolated central nervous system (CNS) turns on the ecdysis motor program in the moth *Manduca sexta* [4,5]. Second, a genetic deletion of the *eth* gene in *Drosophila* causes a fatal failure at ecdysis [6]. Assuming that ETH actions are conserved between moths and flies, these results suggest that ETH is necessary and sufficient for ecdysis. Knowing where ETH acts might therefore provide important clues into the neural bases of ecdysis and its regulation.

Kim *et al.* [1] have followed this lead by first identifying cells that express the ETH receptor. ETH acts via two G-protein coupled receptors that are produced by alternative splicing of a single ETH receptor gene, *CG5911* [7,8]. *In situ* hybridization experiments using isoform-specific probes revealed that these two receptor isoforms, ETHR-A and ETHR-B, are expressed in mutually exclusive populations of neurons. ETHR-B-expressing cells remain unidentified. By contrast, most ETHR-A neurons are peptidergic, and many of them are already familiar: they include the EH neurons, which are known to respond directly to ETH [9], as well as most of the neurons that produce crustacean cardioactive peptide (CCAP), a neuropeptide implicated in the control of ecdysis [5,10]. A subset of CCAP neurons