CMFRI

Winter School on

Towards Ecosystem Based Management of Marine Fisheries – Building Mass Balance Trophic and Simulation Models

INFORMATION ONLY

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Technical Notes

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GLOSSARY OF TECHNICAL TERMS

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a	multiplicative term in a length/weight relationship
abiotic	referring to non-living structures, substances, factors, environments, etc
apex predator	a fish at the top of the food chain, relying on smaller fishes for food.
A_r	aspect ratio of caudal fin of fish. $A_r = h^2/s$ where h, height of caudal fin of fish and s, surface area
AS	artisanal Gear, operated mainly during monsoon season (indigenous) fishing undertaken by peoples native to an area.
ascendancy index	information content of an ecosystem. The product of total system throughput (T) times an index of the average mutual information.
asymptotic length	length the fish in a stock would attain if they were to grow for an infinitely long period. Not the largest observed size of a species.
asymptotic weight	a parameter of the von Bertalanffy Growth Function, q.v., expressing the mean weight the fish in a stock would attain if they were to grow for an infinitely long period.
b	exponent of a length-weight relationship
benthos	organisms which live on the bottom of a water body, in it or near it.
benthic infauna	benthic animals living in the soft bottom or substrate
biomass	or standing stock. The total weight of a group (stock) of living organisms in an area at a particular time
bloom	a rapid and localized increase in the density of plankton resulting from a nutrient-rich habitat. The nutrients may come from upwelling, mixing or pollution and the bloom can kill fish populations through toxins or oxygen depletion.
cannibalism.	eating members of one's own species
catch	the number or weight of fish caught by a fishery, by fishing gear or by angling. May be the total amount caught, only the amount landed, or not kept but released. Usually expressed in terms of wet weight.

combination vessel	a vessel capable of more than one type of fishing, e.g. longliner/trawler, midwater trawler/purse seiner, bottom trawler/purse seiner.
connectance index	for a given food web, the ratio of the number of actual links to the number of possible links.
continental shelf	the area of gently sloping sea bottom from the shore to a depth of 200 metres. It may be only a few kilometres offshore where the sea floor descends rapidly to great depths or may be extensive and form an accessible habitat for many commercial fishes.
continental slope	the steeply sloping sea bottom from 200 to 2000 metres (or 100-300 m to 1400-3200 m) and 3-6°C. Average angle of slope is 4° with a maximum about 20° near the upper margin.
density dependence	the dependence of a factor influencing population dynamics (such as survival rate or reproductive success) on population density. The effect is usually in the direction that contributes to the regulative capacity of a stock
detritus	debris, disintegrated material or particulate material that enters into an aquatic system. If derived from decaying organic matter it is organic detritus.
DGN	drift gill net
discard	the part of a fish catch that is thrown overboard, but which may be of important ecological or commercial value. Also the act of throwing fish overboard. The discard typically consists of "non-target" species, damaged specimens or undersized specimens. The fish may be alive or dead, whole or in parts. Estimates of discards are made by observers and logbook records. Also called discarded catch. Discarding lower value fish to increase the value of a catch is called high grading.
dynamic pool model	analytical yield-per-recruit types of fisheries models describing how growth, recruitment and mortality interact, resulting in biomass and yields.
E	exploitation rate; E = F/Z
ecotrophic efficiency	= EE - The ratio between what flows into it and what flows out of it Is that part of production that is exported from or is eaten within the system (t . km^{-2}. $year^{-1}$)
electivity	express the food preferences of consumers. Electivities scale from -1 (total avoidance) over 0 (non-selective feeding) to 1 (exclusive feeding). The electivity is calculated as standardized forage ratio.
ecosystem	the complex of living organisms and environmental conditions that function as a unit. Biocenosis plus biotope.

ecosystem maturity	a number of statistics describing an ecosystem as a whole which can be of use for assessing the status of an ecosystem, e.g., to express its state of maturity
effort	the total fishing gear in use for a specified period of time; when two or more kinds of gear are used, they must be adjusted to some standard type before being added.
equilibrium	when fishing and natural mortality, exploitation pattern, growth and recruitment do not change from year to year; when such factors have been in effect long enough to affect all ages for the whole exploited life. Also called steady state.
equilibrium yield	the yield in weight taken from a fish stock when it is in equilibrium with fishing of a given intensity, and (apart from effects of environmental variation) its biomass is not changing from one year to the next (Ricker, 1975). Also called sustainable yield, equivalent sustainable yield. No stock is really in balance with fishing effort because effort cannot be maintained at the same level and the stock is always changing in response to environmental variables.
productivity/ primary productivity	a measure of the capacity of a biological system, the amount of fish supported or produced by a given area in a given time. Also used as a measure of the efficiency with which a biological system converts energy into growth and production. A highly productive stock of fishes has high birth, growth and mortality rates resulting in high turnover and production to biomass ratios. Such a stock can be exploited fully and can recover more easily if depleted.
exports	sum of fishery catches plus migration to/from adjacent ecosystems
exploitation rate	the proportion of a population at the beginning of a given time period that is caught during that time period (usually on a yearly basis). A catch in a year of 10 fish out of a stock of 100 is a 10% exploitation rate. Also the ratio of fish caught to total mortality (= F/Z when fishing and natural mortality take place concurrently (Ricker, 1975)). Also called rate of exploitation. Abbreviated as E.
F	Instantaneous rate of fishing mortality (mortality due to fishing)
fishing effort	effective fishing effort, abbreviated as f or *f* (Ricker, 1975).
fishery model	a representation of a fishery, usually simplified and may be mathematical.
flow diagram	graphical representation of trophic flow from one group to another in an ecosystem model
Fmax or F_{max}	the rate of fishing mortality for a given exploitation pattern, rate of growth, and natural mortality that results in the maximum yield per recruit; the point that defines growth overfishing. This mortality would give the maximum catch year after year. $F_{0.1}$ is often preferred as F_{max} is difficult to estimate.

FMSY or F_{MSY}	the fishing mortality rate which, if applied constantly, would result in maximum sustainable yield. Can be estimated from simple biomass-aggregated production models or from age-structured models that include a stock-recruitment relationship. Reality applies, however, and as the ocean conditions change a constant fishing mortality of F_{MSY} would give varying catches and eventually overfishing would result. A $2/3F_{MSY}$ is used to avoid overfishing. Fishing at this level means fishermen use only two-thirds of the effort needed to achieve maximum sustainable yield but they catch 80-90% of the MSY. Their catch rate is higher.
forage	the diet of a fish species.
F_{opt}	optimum (effective) fishing effort corresponding to fMSY, Used as biological reference point
generation time	T_g, the average age of parents at the time their young ones are born. In most fishes L_{opt} is the size class with the maximum egg production $t_g = t_0\text{-}\ln (1\text{-}L_{opt}/L_8) / K$.
GN	Gill net
gonadal products	the products by sexual organs, ovary and testis, producing the primary sexual products (eggs and sperm).
gross efficiency of the fishery	ratio between the total catch (landing + discards) and the total primary production in the system. Value will be higher for systems with fishery harvesting fish low in the food chain than fisheries concentrate on apex predators
growth model	a mathematical description or representation of the size of a living organisms at its various ages, e.g. the Von Bertalanffy growth model.
habitat	the place a species lives, defined by necessary biological and physical parameters, e.g. tidal pool, marsh, reef, continental shelf
K	curvature parameter of the VBGF (increase in weight of a fish per year, divided by the initial weight).
km	kilometre (0.621 mi).
L-25	length at which 25% of the fish will be vulnerable to the gear (left hand selection)
L-50	length at which 50% of the fish will be vulnerable to the fishing gear
L-75	length at which 75% of the fish will be vulnerable to the fishing gear
L_8	asymptotic length, i.e., the (mean) length the fish of a given stock would reach if they were to grow forever

L_c	mean length of fish at first capture; equivalent to L_{50}
L_m	mean length first maturity (or massive maturation)
L_{max}	maximum length reached by the fish of a given stock, may also be predicted from the largest specimens of several samples using the extreme value theorem
L_{mean}	mean length of fish computed from L' upward in catch curve
L_{opt}	the length class with the highest biomass in an unfished population, where the number of survivors multiplied with their average weight reaches a maximum (Beverton 1992)
L_r	mean length at first recruitment
landings	the weight of a catch as fish or fish products brought to a wharf or beach. Also called landed weight. Note that the catch is different and may include discards.
length Frequency	a breakdown of the different lengths of a kind of fish in a population or sample
length-weight relationship	mathematical formula for the weight of a fish in terms of its length. When only one is known, the formula can be used to determine the other.
linear relationship	used to described the variation of one variable as a liner function of another variable, e.g., total length and body weight of a fish
M	Instantaneous rate of natural mortality, i.e., due to all causes except fishing
maturity	fish of a given age/size capable of reproduction; attainment of first spawning
mechanised fishing sector	organized sector which uses crafts fitted with in-board engines, such as purse siener, trawler; mechanized fishing is banned during monsoon season.
MDF	multi-Day Fishing Fleet, Trawlers which undertake voyages lasing two days or more
mortality rate	the rate at which the numbers in a population decrease with time due to various causes. The proportion of the total stock (in numbers) dying each year is the annual mortality rate. To facilitate calculations, mortality is expressed as an exponential rate (called instantaneous rate) thus Nt/N0 = e-Z = e-(M+F) in which Nt/N0 is the survival rate, M the natural mortality rate, F the fishing mortality rate, and Z the total mortality rate (of deaths due to predation or disease).
n	number of items in a sample

nekton	organisms of relatively large size which have fairly strong locomotory powers (as compared to plankton) and swim in the water column independent of currents, e.g. most adult fishes.
net system production	or yield is the difference between total primary production and total respiration. System production will be large in immature systems and close to zero in mature ones.
niche overlap	an overlap in resource requirements by two species; is an overlap index which explains how a single prey (food) is shared between two predators
overhead	the difference between development capacity (C) and ascendancy (A). provides limits on the increase in ascendancy and reflect the strength in reserve from which it can draw to meet unexpected perturbations.
over-capitalization.	where the amount of harvesting capacity in a fishery exceeds the amount needed to harvest the desired amount of fish at least cost. Too many boats, too much fishing effort. May be addition of new technology rather than new boats
over-exploitation	rate of exploitation where the resource stock is drawn down below the size that would, on average, support the long term maximum potential yield of the fishery.
P/B	equivalent to total mortality under steady state, when von Bertalanffy growth and exponential mortality are used
pelagic season	the September-November season when pelagic fishes like sardine and mackerel are exploited by gears specially designed to harvest them (eg., purse seine)
population dynamics	the study of fish populations and how fishing mortality, growth, recruitment, and natural morality affect them over time.
potential yield	the yield of fishes estimated to be available for exploitation.
	the yield in weight taken from a fish stock when it is in equilibrium with fishing of a given intensity, and (apart from effects of environmental variation) its biomass is not changing from one year to the next (Ricker, 1975). Also called sustainable yield, equivalent sustainable yield. Abbreviated as YE or Y_E. No stock is really in balance with fishing effort because effort cannot be maintained at the same level and the stock is always changing in response to environmental variables
primary consumer	a fish that feeds on the lowest level of a community's food web, namely plants. Also called first-level consumer.

production model	a population model that describes how biomass changes from year to year or how biomass changes in equilibrium as a function of fishing mortality. Three or four simple parameters are used in a deterministic model. Production models are used primarily in simple data situations where total catch and effort data are available but age-structured data is unavailable or less reliable
PS	purse seine- a seine used to encircle a school of fish in open water. It is set at speed from a large, powered vessel and the other end is anchored by a small boat. A purse line at the bottom of the net allows it to be closed like a purse.
Q/B	ratio of consumption over biomass where consumption is the intake of food by a group over the time period expressed as /year
r	product-moment correlation coefficient
recruit	an individual fish that has moved into a certain class, such as the spawning class or fishing-size class through growth, migration, etc.
R_n	goodness of fit index of the ELEFAN I routine ($=10^{ESP/ASP}/10$)
resilience	capacity of a natural system such as a fish community or ecosystem to recover from heavy disturbance such as intensive fishing.
respiration	a flow (flows) of mass or energy that is not directed toward, nor could be used by any other box (es). When Carbon is used as currency respiration appears as CO_2
Schaefer model	the basic form of production model in which the relation between yield and effort takes the form of a symmetric parabola.
SDF	single-Day Fishing Fleet, Trawlers which make daily trips
SL	starting length; one of two coordinates used to locate a growth curve in the ELEFAN I routine
size-at-first-maturity	length or weight at maturity. Maturity is defined as minimal size attained at maturity or the size at which 50% of the fish at that size are mature.
spawning stock biomass (SSB)	the total weight of the fish in a stock that are old enough to spawn; the biomass of all fish beyond the age or size class in which 50% of the individuals are mature. May be used instead of measuring egg production.
SS	starting sample the other coordinate used to locate a growth curve in the ELEFAN I routine

standing stock	biomass; weight of a stock. May apply to a part of the stock such as spawning fish, fish in a particular area or at a particular time stochastic = having components affected by random variability, e.g. future recruitments in a fishery are projected with a stochastic component (random variables) to allow for unexplained effects.
steady state population	is a theoretical construction never occurring in reality. Can be approximated by averaging time series data over longer periods if there are no major changes in biomass or size
stock	the part of a fish population which is under consideration from the point of view of actual or potential utilization; stock (noun) = a distinct genetic population, a population defined by movement pattern, part of a population potentially harvestable, i.e. an assessment or management unit, or a quantity of fish from a given area; usually isolated from other stocks of the same species
summer monsoon	the south-west monsoon occurring during the June-September period
surplus production model.	an estimate of the catch in a given year and the change in stock size. The stock size could increase or decrease depending on new recruits and natural mortality. A surplus production model estimates the natural increase in fish weight or the sustainable yield
sustainable yield	the yield (in weight or number) taken from a fish stock when it is in equilibrium with fishing of a given intensity, and (apart from effects of environmental variation) its biomass is not changing from one year to the next. Also called equilibrium yield, equivalent sustainable yield.
system omnivory index	average omnivory index of all consumers weighted by the logarithm of each consumer's food intake, is a measure of how the feeding interactions are distributed between the sexes.
t	abbreviation for tonne (metric ton, 1000 kg, 2204.62 pounds (lb), 0.984 long tons)
total length	length from the anterior-most part of the head to the tip of either lobe of the caudal fin when that fin is normally splayed.
total system throughput (T)	sum of all flows into and from the boxes in an ecosystem including imports and exports of usable materials or energy (i.e., catches or emigration) expressed as t./km^2/year
t_0	the age the fish would have had at length zero if they had grown always according to the VBGF
t_c	mean age at first capture, corresponding to l_c
t_{max}	longevity, approximate maximum age that fish of a given population would reach. $t_{max} = t_0 + 3/K$
trophic	pertaining to nutrition.
trophic level	(Troph),Classification of organisms or natural communities

	according to their place in the food web, trophic = 1+ mean troph of the food items
upwelling	an upward movement of cold, nutrient-rich water from the ocean depths, often associated with great production of fish and fisheries. For fisheries, the most important types are wind-induced coastal upwelling where the upward movement is a consequence of wind stress (along shore) and Ekman transport (offshore).
virtual population analysis	an algorithm for computing historical fishing mortality rates and stock sizes by age or length, based on data on catches, natural mortality, and certain assumptions about mortality for the last year and last age group. Essentially reconstructs the history of each cohort or year class over its life in a fishery, assuming that the observed catches are known without error. Abbreviated as VPA. Also called cohort analysis.
winter monsoon	The North-East monsoon which occurs during November-January period
W_8	asymptotic weight, i.e., the (mean) weight the fish of a given stock would reach if they were to grow forever
yield	catch in weight. Catch and yield are often used interchangeably. Amount of production per unit area over a given time. A measure of production. The sustainable yield is the quantity of fish which can be taken from a stock (usually on an annual basis) without severely depleting or eliminating that stock
yield-per-recruit analysis	analysis of how growth, natural mortality, and fishing interact to determine the best size of the fish at which to start fishing them, and the most appropriate level of fishing mortality. The yield-per-recruit models do not consider the possibility of changes in recruitment (and reproductive capacity) due to change in stock size. They also do not deal with environmental impacts.
Z	Instantaneous rate of total mortality (the sum of natural and fishing mortalities)
F ’	phi-prime, i.e., length based index of growth performance (F ’= $\log_{10}(K) + 2\log_{10}(L_8)$
B_i	Biomass of group (i)
C_i	Catch of group (i) UNIT time^{-1}
DC_{ij},	The fraction that prey j constitutes in predator i's food intake; is weighted over species, sizes and seasons included in a box. UNIT time^{-1}
DC (N1,i)	Diet composition of detritus box, Dimensionless
EE_i	Ecotrophic Efficiency is production that goes to predation and

	catches (including exports); same as (1 - other mortality)
GE_i	Gross efficiency (of food conversion); Dimensionless
E_i	The coefficient for other exports than fishery, time^{-1}
MO_i	Other mortality coefficient; time^{-1}
$M2_i$	Predation mortality of (i); time^{-1}
P/B	Production/biomass ratio of (i). Equals the total mortality; time^{-1}
P_i	Production rate of (i). UNIT time-1
PP_i	Proportion of production of (i) that is attributed to primary production 0 PP 1 >0 for consumers; Dimensionless
Q_i	Consumption rate of (i); UNIT time^{-1}