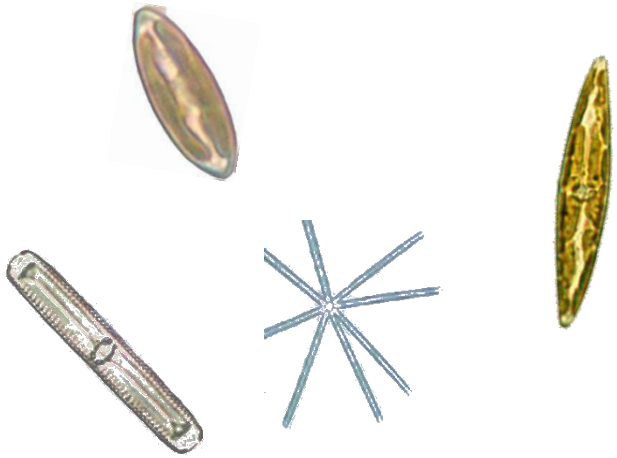
Relevance of Biogeochemistry in Bio-resource Management

Dr. A C Anil
CSIR-National Institute of Oceanography, Dona Paula, Goa 403 004, India
acanil@nio.org

Requirements of phytoplankton



Light

Temperature

Micro-nutrients

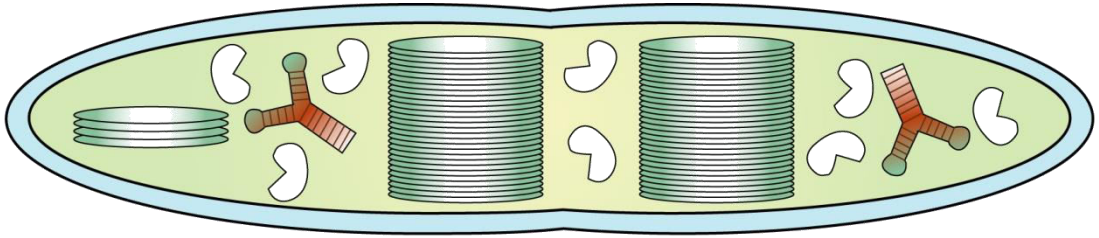
Trace metals
(Iron, Manganese, Zinc, Cobalt, Copper, Molybdenum, Nickel, Cadmium, Selenium)

Vitamins
(Thiamine, Biotin, Vitamin B12)

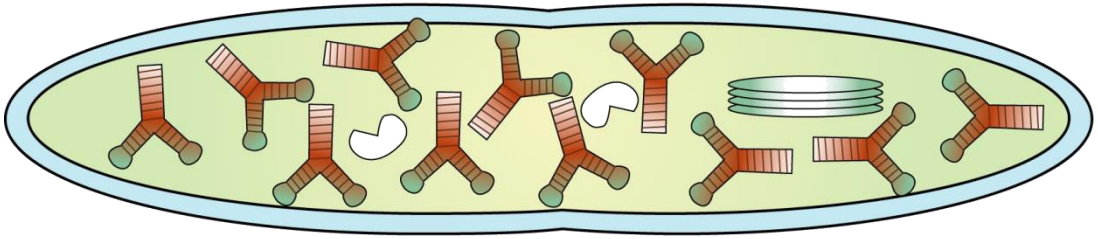
Macro-nutrients
(Nitrogen, Phosphorous, Silicon)

Three different phytoplankton growth strategies

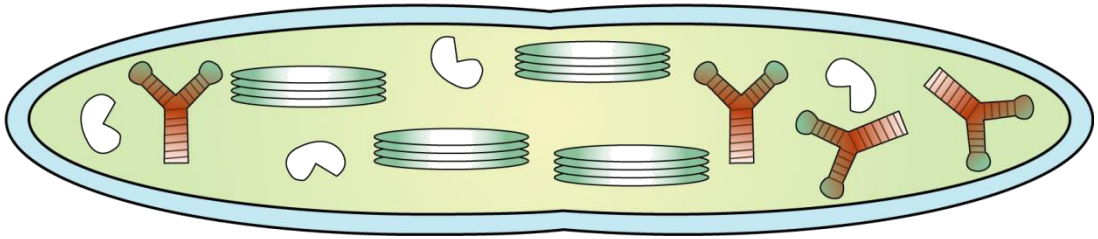
The ‘survivalist’
High N:P ratio (>30)



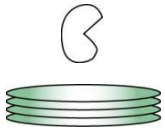
The ‘bloomer’
Low N:P ratio (<10)



The ‘generalist’
N:P ratio near Redfield



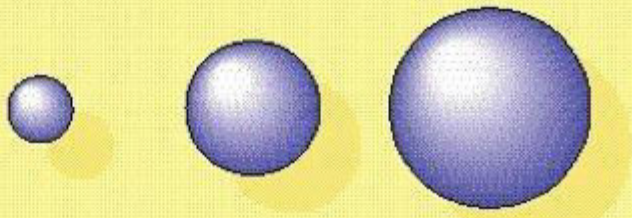
Ribosomal RNA has low N:P ratio



Enzymes
Pigment/proteins
Have high N:P ratio

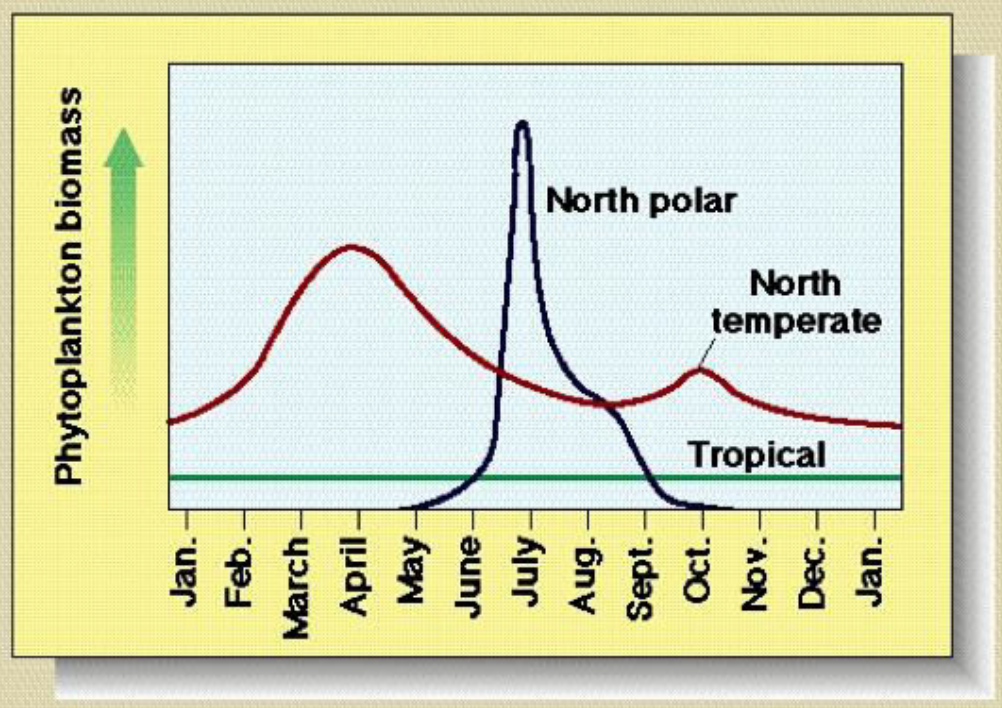
So: Arrigo K.R., Nature, 2005

Surface-to-Volume Ratio

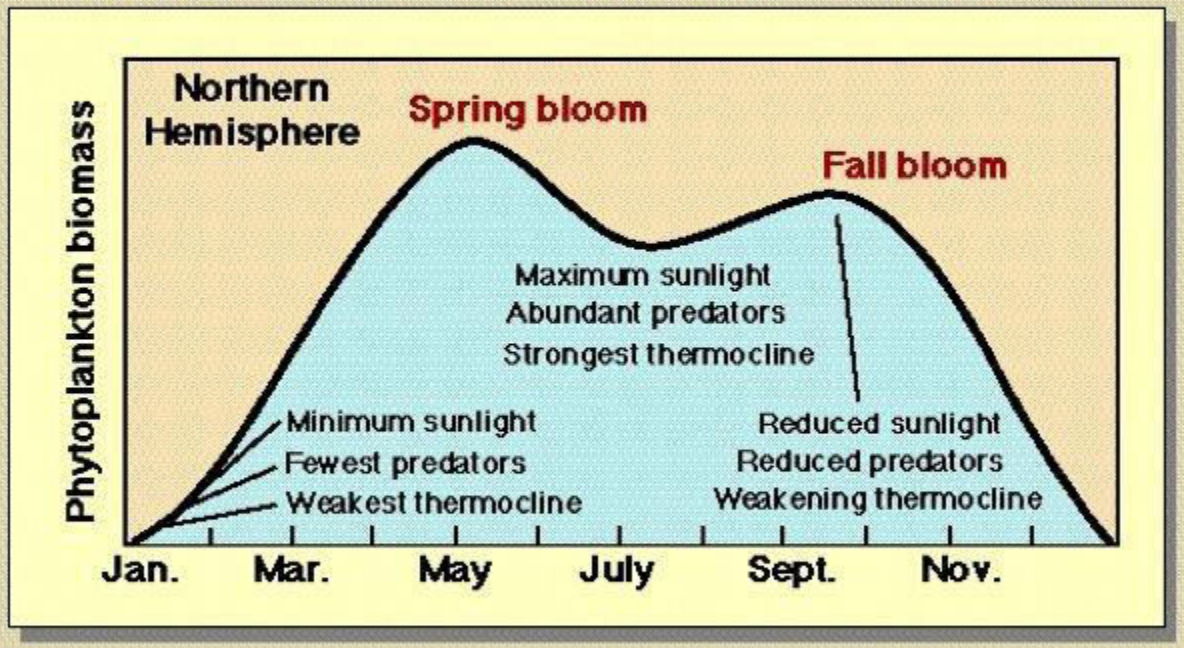


Diameter (cm)	0.5	1.0	1.5
Surface area (cm^2)	0.79	3.14	7.07
Volume (cm^3)	0.06	0.52	1.77
Surface-to-volume ratio	13.17:1	6.04:1	3.99:1

Seasonal Variation in Phytoplankton



Phytoplankton Blooms in Temperate Settings



Influence of phytoplankton on higher trophic levels

Phytoplankton

- Primary producers forming the base of marine food chains
- Important role in global climate

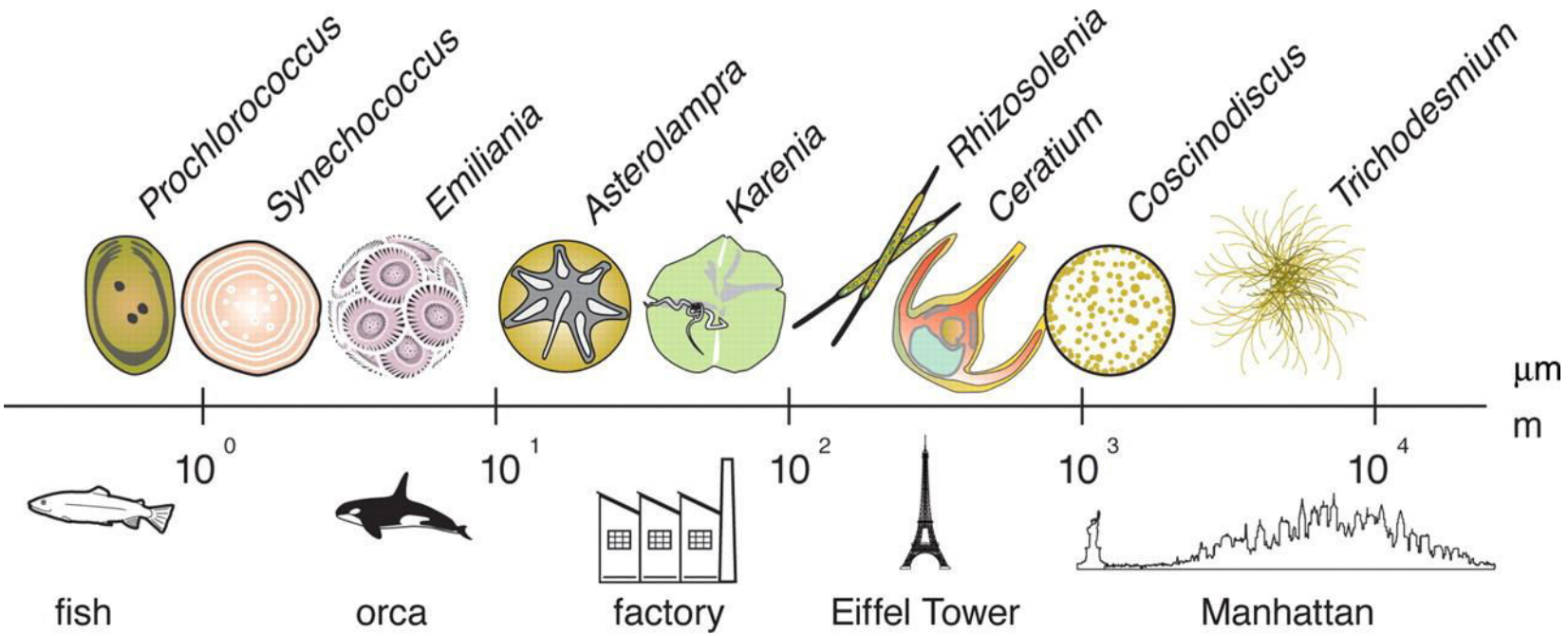
Phytoplankton groups based on size

0.2 - 2 μm : Picoplankton (cyanobacteria, picoeukaryotes, bacteria)

2 - 20 μm : Nanoplankton (diatoms, dinoflagellates, coccolithophorids, silicoflagellates)

20 - 200μm : Microplankton (diatoms, dinoflagellates)

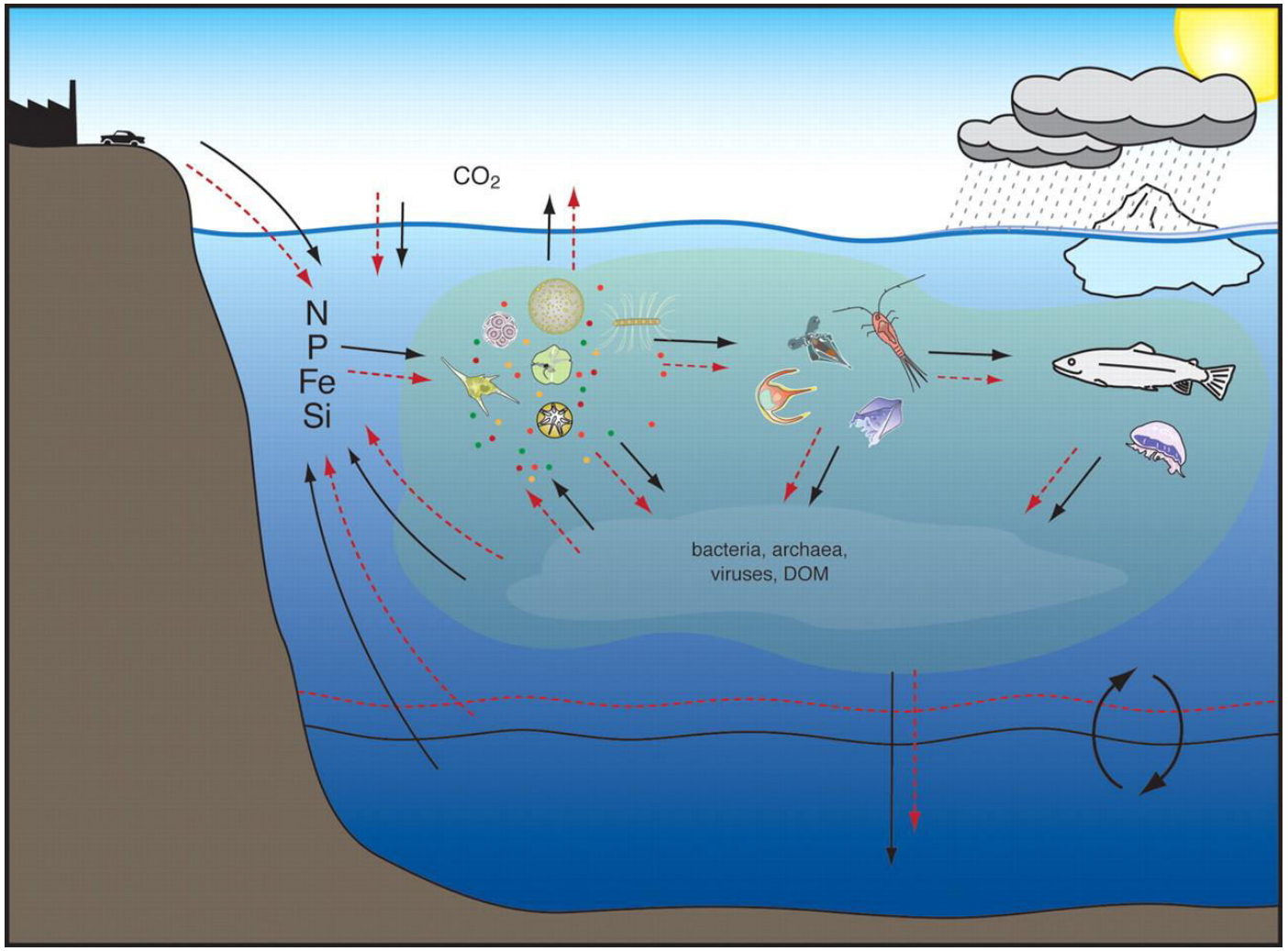
A comparison of the size range (maximum linear dimension) of phytoplankton relative to macroscopic objects.



Finkel Z V et al. J. Plankton Res. 2010;32:119-137

Journal of Plankton Research

The interactions between phytoplankton cell size, elemental stoichiometry, marine food webs and biogeochemistry.



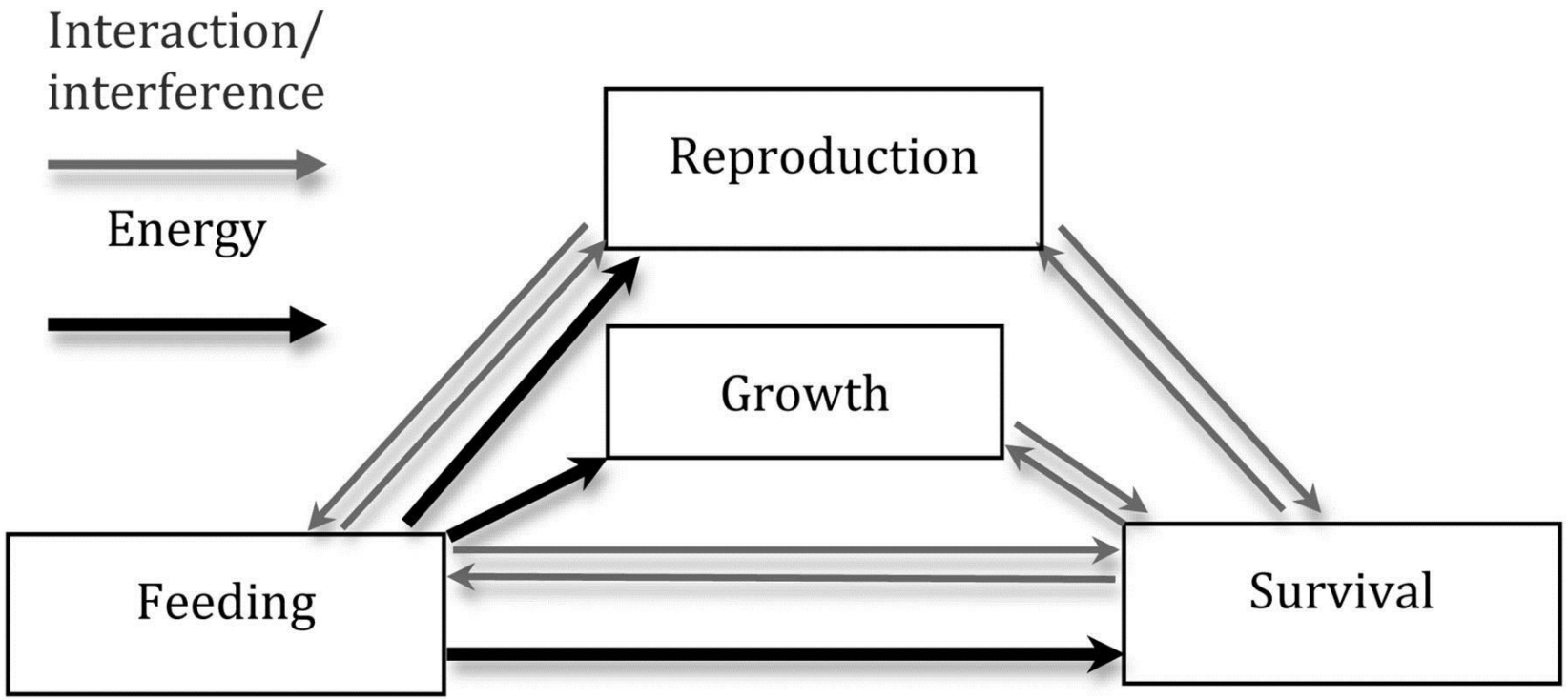
Finkel Z V et al. J. Plankton Res. 2010;32:119-137

Journal of Plankton Research

Importance of picoplankton

- Recent studies have shown that autotrophic (photosynthetic) picoplankton are a source of organic carbon for large zooplankton such as copepods and for the particulate organic carbon pool that fuels the flux of particles sinking to the deep ocean.
- Export fluxes probably involve the formation of organic aggregates from picoplankton, consumption of those aggregates by large zooplankton, and the production of fecal material by pelagic tunicates grazing on the picoplankton.

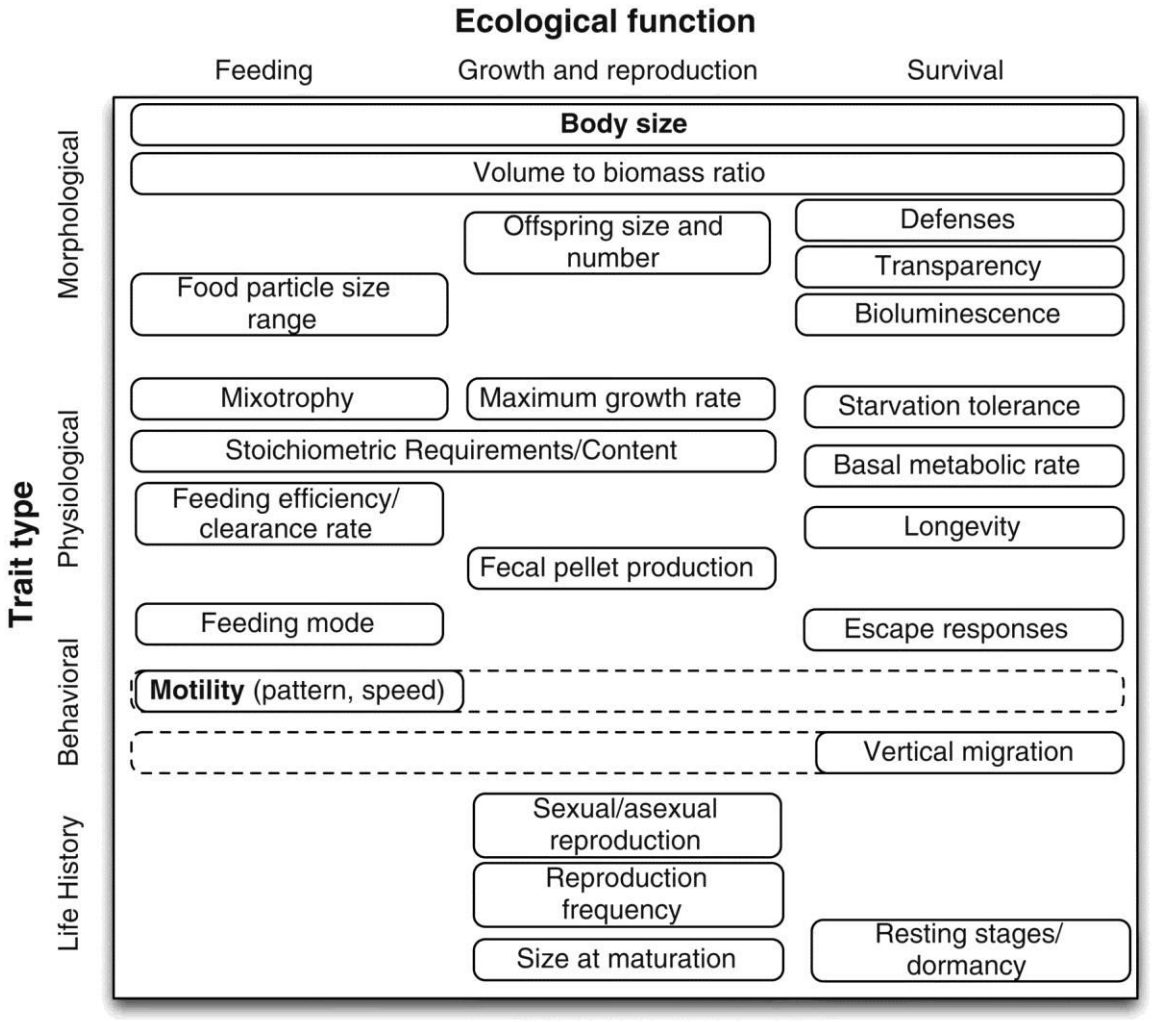
The fundamental Darwinian missions of an organism are to feed, survive and reproduce.



Litchman E et al. J. Plankton Res. 2013;35:473-484

Journal of Plankton Research

Zooplankton trait classification according to function and type.



Litchman E et al. J. Plankton Res. 2013;35:473-484

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Types of oceanic food chains

Gyre centre (nutrient poor pelagic environment)

Nanoplankton (small flagellates) → Microzooplankton (herbivorous protozoa) → Macrozooplankton (carnivorous crustacean zooplankton) → Megazooplankton (chaetognaths & euphausids) → Planktivores (lantern fish & saury) → Piscivores (squids, salmon & tuna)

Coastal environment

Microphytoplankton / Nanoplankton → (pelagic) Macrozooplankton (herbivorous zooplankton) → Planktivores (herring)

or

(benthic) Benthic herbivores (calms, oysters & polycheates) → Benthic carnivores (cod)

→ Piscivores (salmon & dogfish)

Coastal upwelling pelagic environment

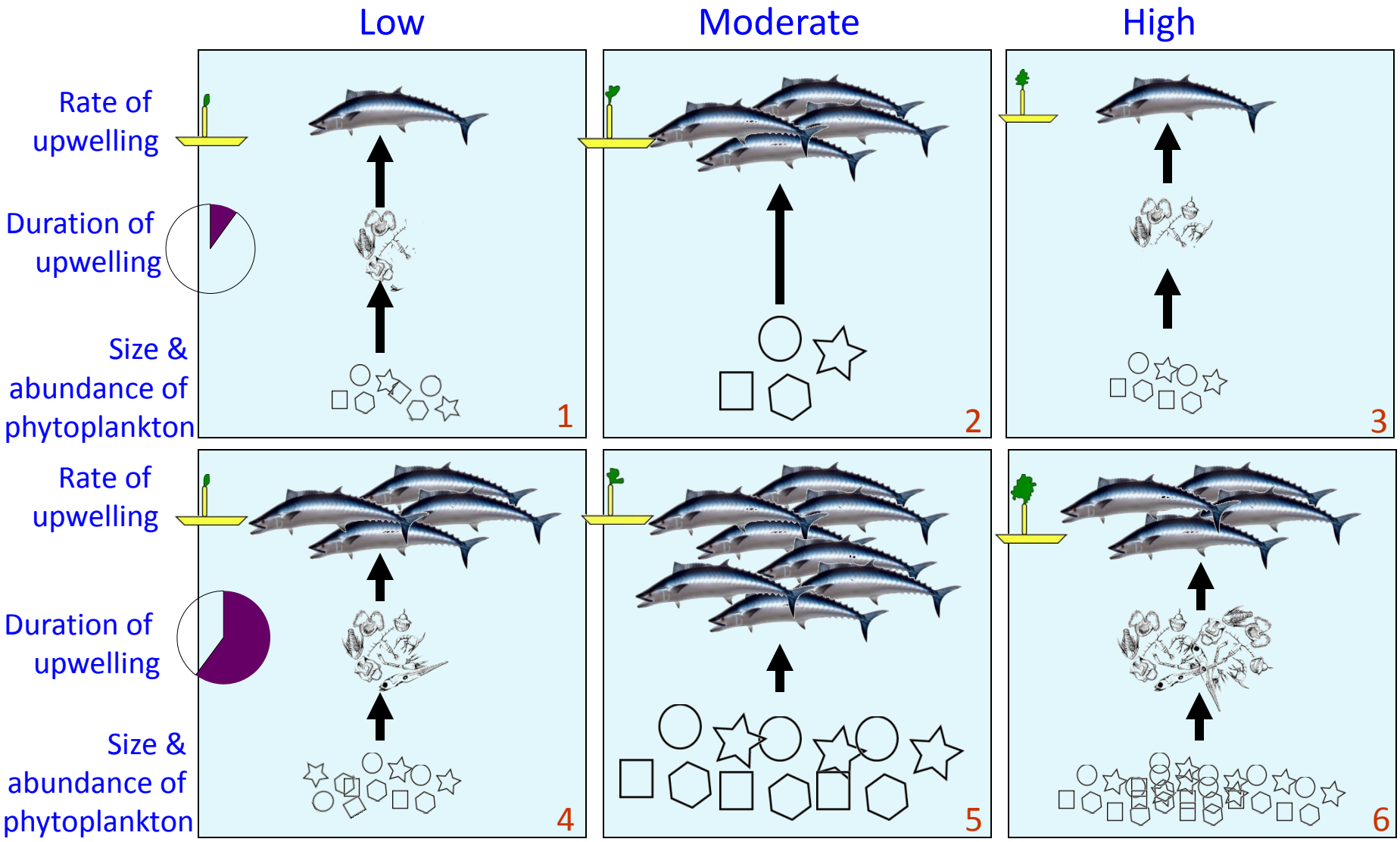
Macrophytoplankton → Planktivores (anchovy)

or

Megazooplankton (krill) → Planktivores (whales)

So: Ryther A., Science, 1969

Effects of Upwelling



So: Thurman, H.V., Introductory Oceanography, 1997

Effects of Upwelling

Blocks 2 & 5: moderate rate of upwelling for short or long duration

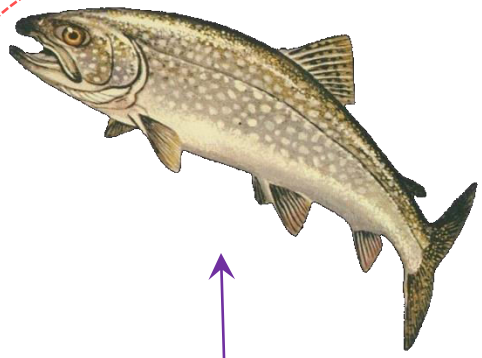
Large enough concentration of nutrients in non turbulent water to support large algal cells to be grazed directly by fish – Larger Fishery

Blocks 1,3,4&6: low or high upwelling for short or long duration

Not high enough concentration of nutrients to produce large algal cells, zooplankton must graze tiny algal cells, subsequently by fish – Smaller Fishery

So: Thurman, H.V., Introductory Oceanography, 1997

Classical food chain



Mesozooplankton

Microzooplankton

Bacteria

DOC

Nutrient/Environment

Mesozooplankton

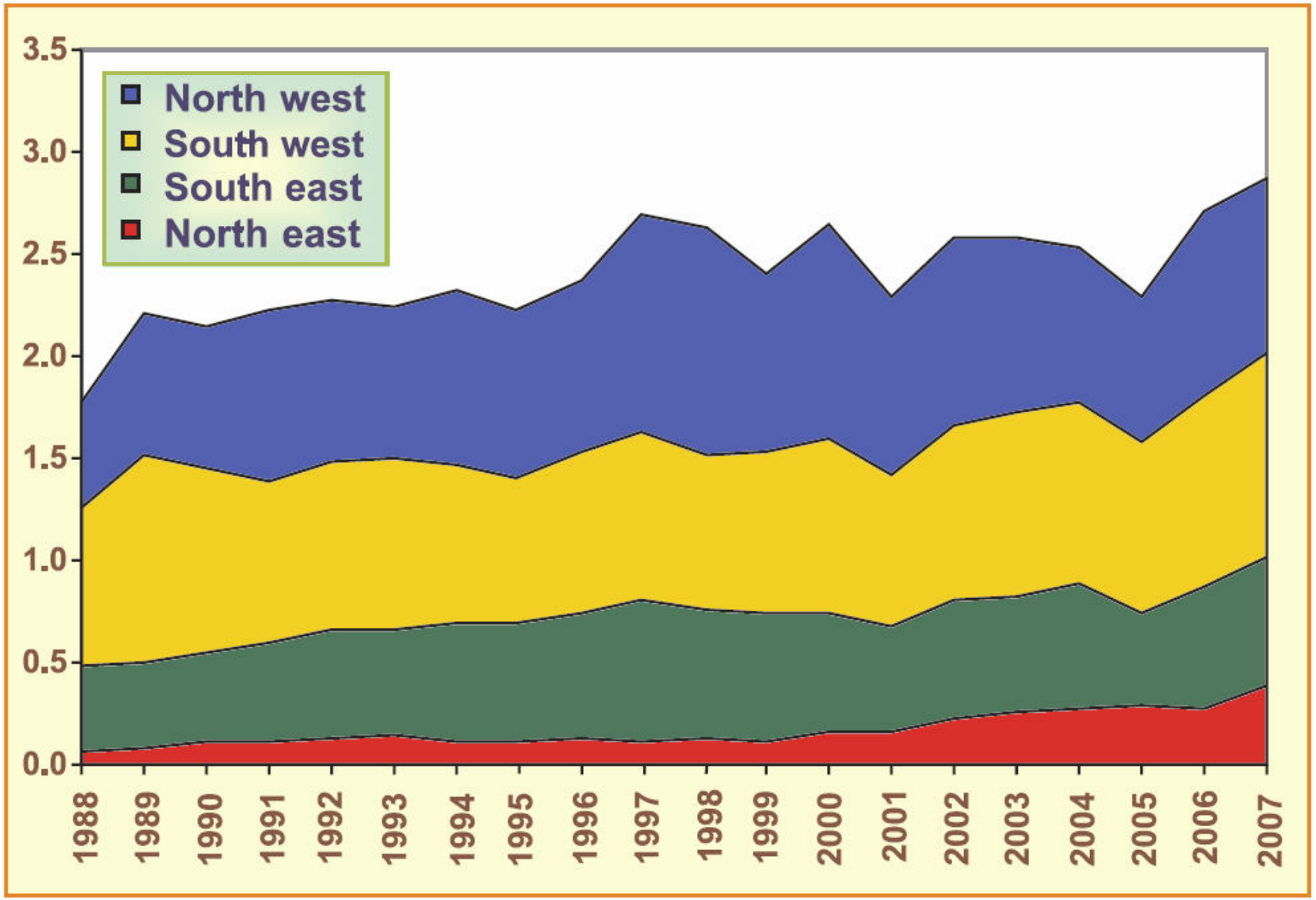
Phytoplankton Big

Mesozooplankton

Microzooplankton

Phytoplankton Small

Marine fish landings (Million tonnes)



So: CMFRI, 2008

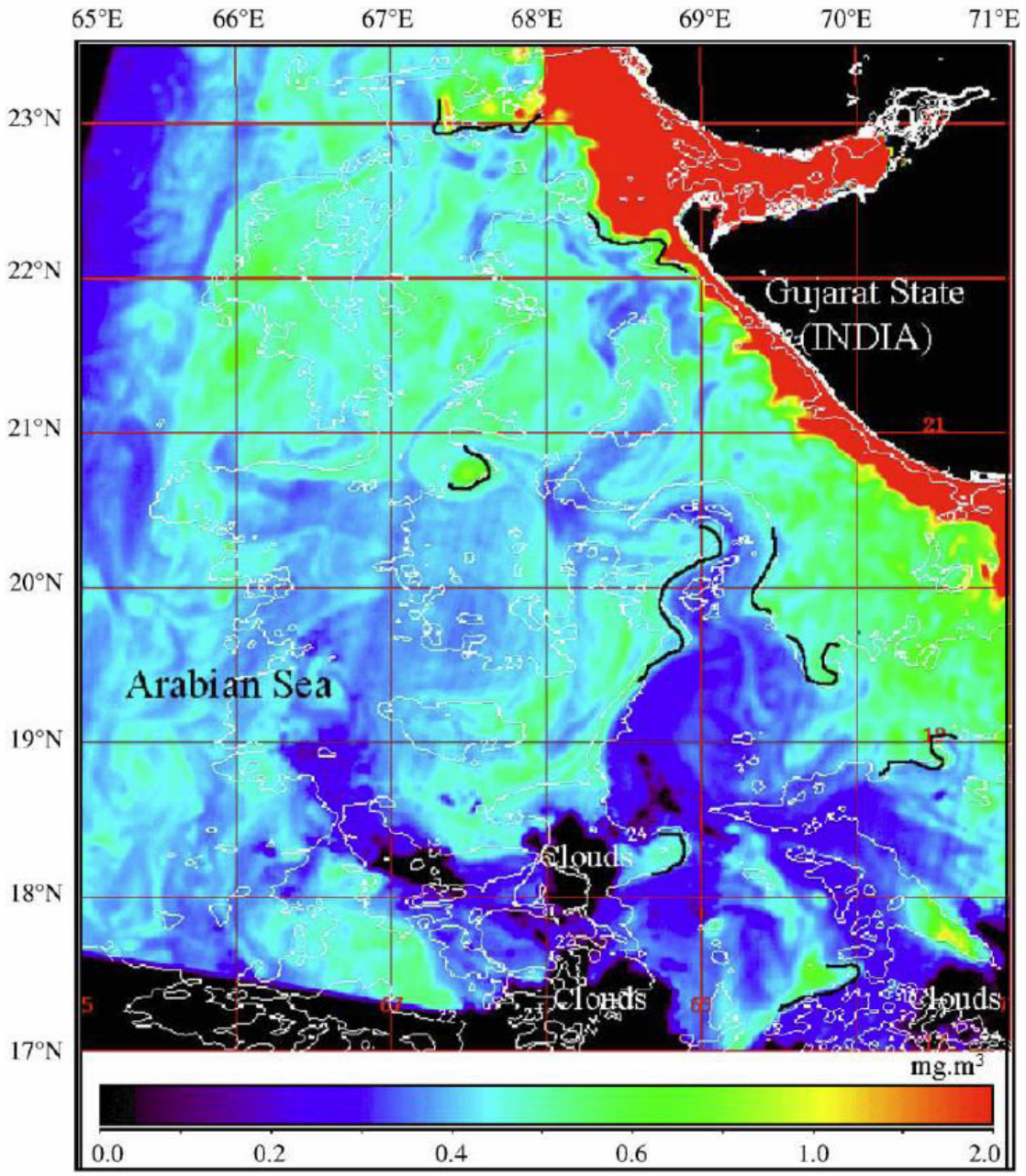
Potential fishing zone advisories

The fishing communities have developed over generations, a mental model for making their conclusions. The congregation of birds, color and smell of sea water, bubbles breaking on the sea surface, muddy and oily water with a calm sea and reflection in the night are some of the indicators used traditionally.

The scientific community, world over, make use of parameters such as sea surface temperature, chlorophyll, nutrients, dissolved oxygen, salinity, winds and currents to study the feeding and breeding habits of fish, and thus to evolve scientific indicators of potential fishing zones. Information on these parameters is derived from satellites and in-situ platforms.

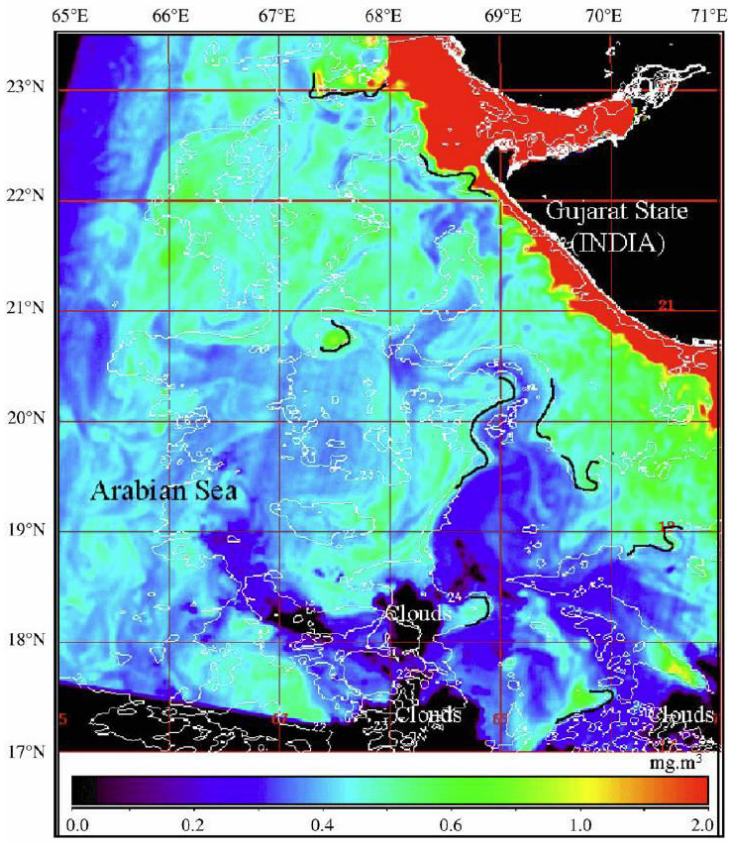
So: http://www.incois.gov.in/Incois/advisory_pfz_main.jsp

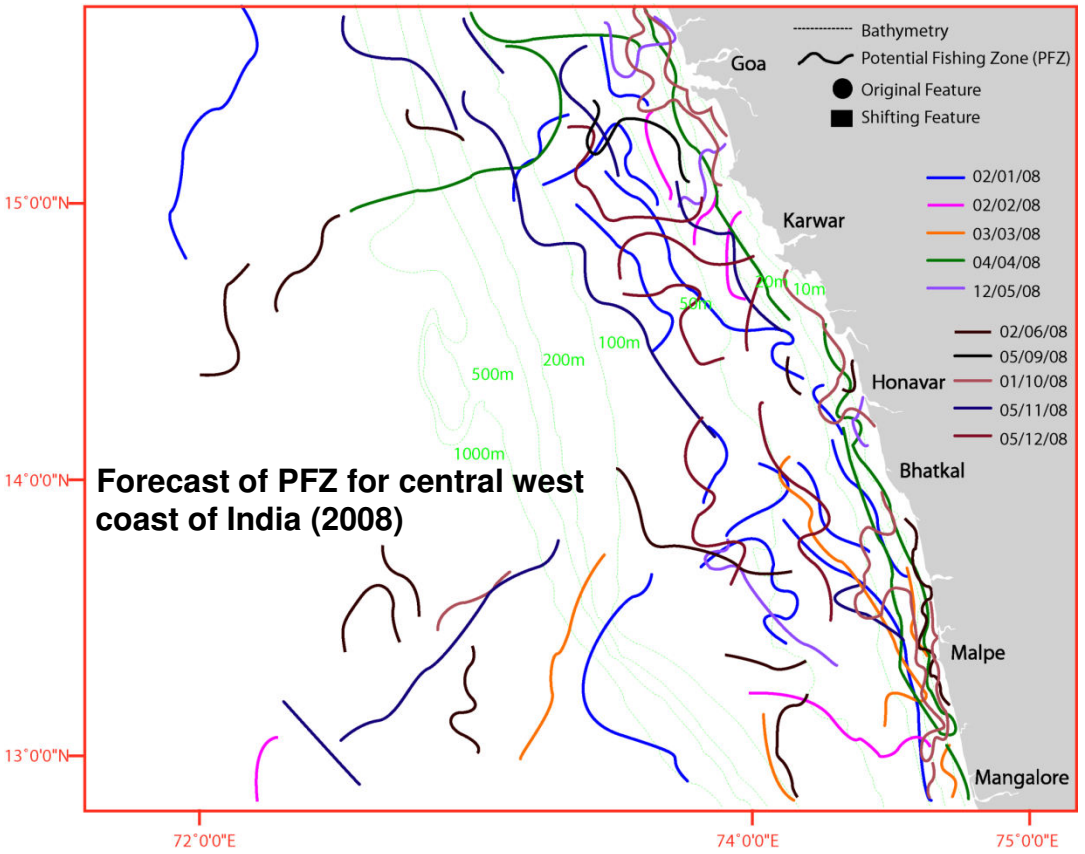
Typical composite image generated from satellite-derived chlorophyll concentration image (background image) and sea surface temperature (SST in 1C) contours. Synchronous near-real-time satellite data of 8 March 2000 was used. The image shows matching features of chlorophyll and SST. Black lines in the images indicate the suggested PFZs.



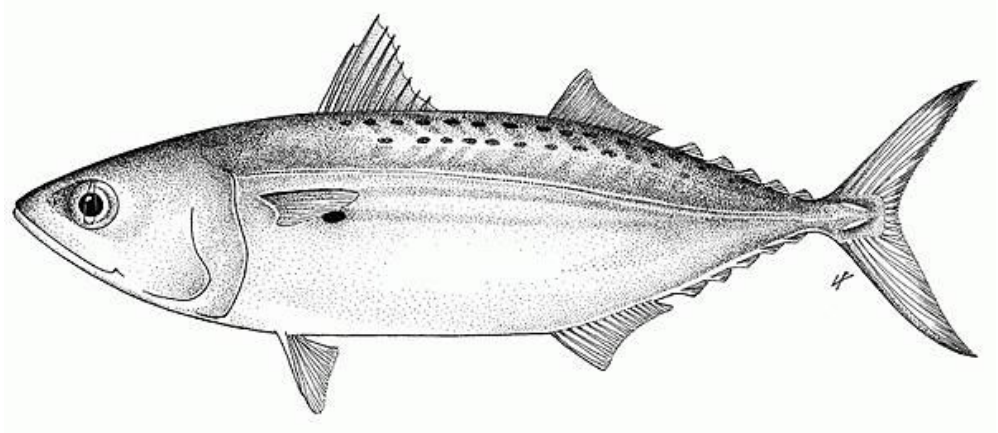
So: Solanki et al, Cont. Shelf. Res., 2005

Forecasting Potential Fishery Zones (PFZ) : connection between sea surface temperature, chlorophyll & fish catch

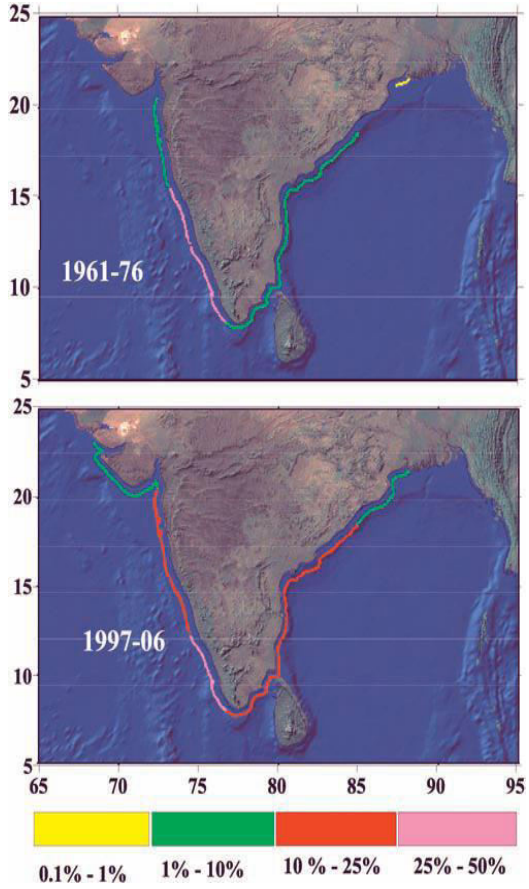




What is the basis for this connection?



Mackerel



Rastrelliger kanagurta

- An epipelagic, neritic species
- Spawning occurs from March to September
- Juveniles feed on phytoplankton (i.e. diatoms) and small zooplankton
- With growth they gradually change their dietary habits, a process that is reflected in the relative shortening of their intestine
- Adults prey primarily on macroplankton such as larval shrimps and fish

So: FAO, 2010

Preliminary observations on the dietary composition of commercial marine species

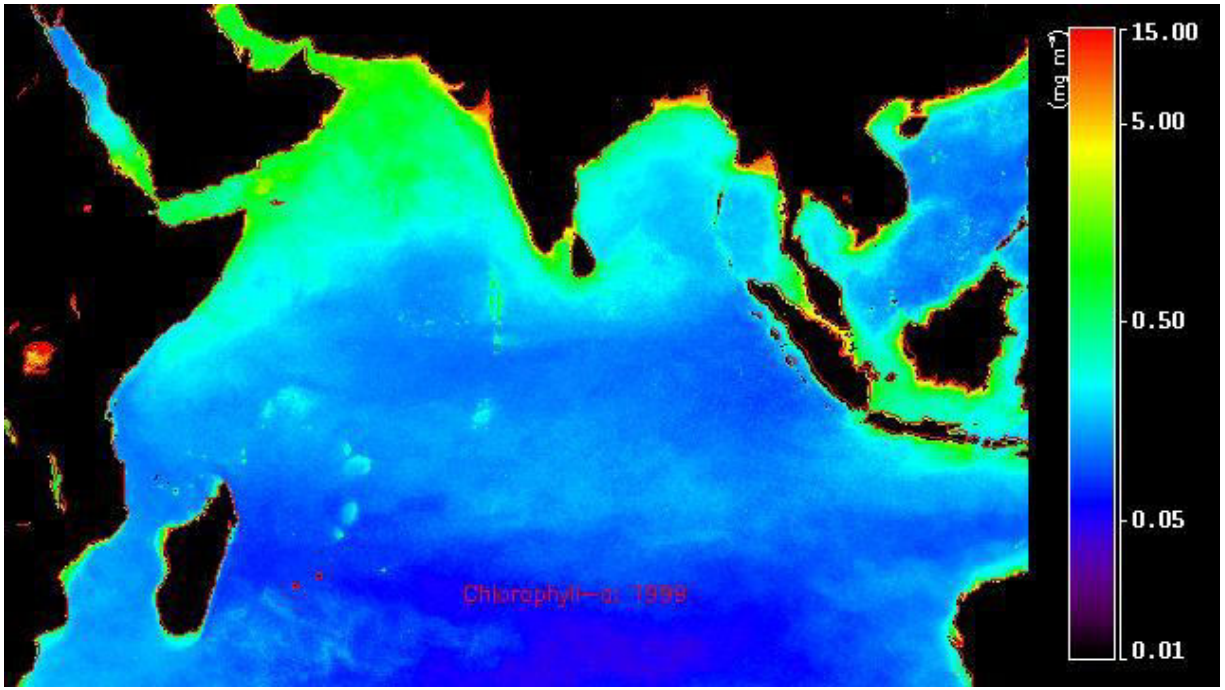
		Northwest coast		Southwest coast	
Major trophic groups	Constituent species	Average (metric tonnes)	% biomass	Average (metric tonnes)	% biomass
Carnivores (C)	228	471293.80	58.90	270405.50	36.70
Phytoplanktivores (P)	10	7244.10	0.91	173995.85	23.61
Zooplanktivores (Z)	1	645.85	0.08	1.05	0.00
Omnivores (O)	152	317945.95	39.73	292092.20	39.64
Detritivores (D)	7	3056.90	0.38	330.40	0.04
Grand total	398	800186.6	100	736825.00	100

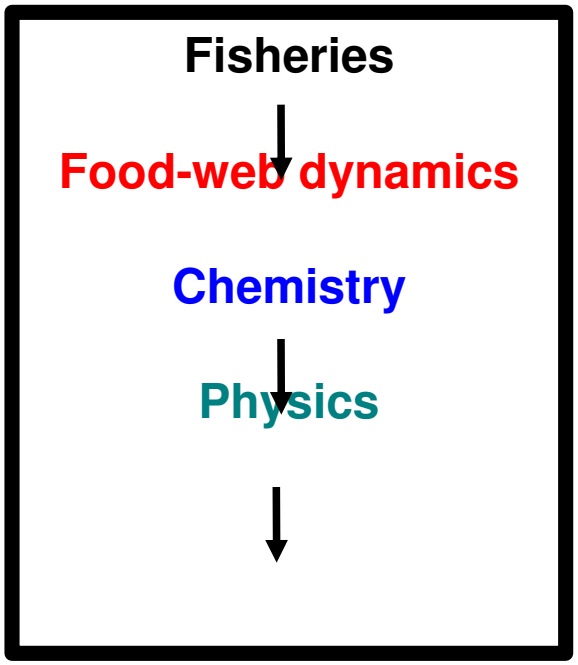
So: CMFRI, 2008

Spatial variability

- Nature of fisheries changes along the coast of India
  - Differences between east and west coasts
  - Differences along the coast

- So does the nature of the physics and biogeochemistry





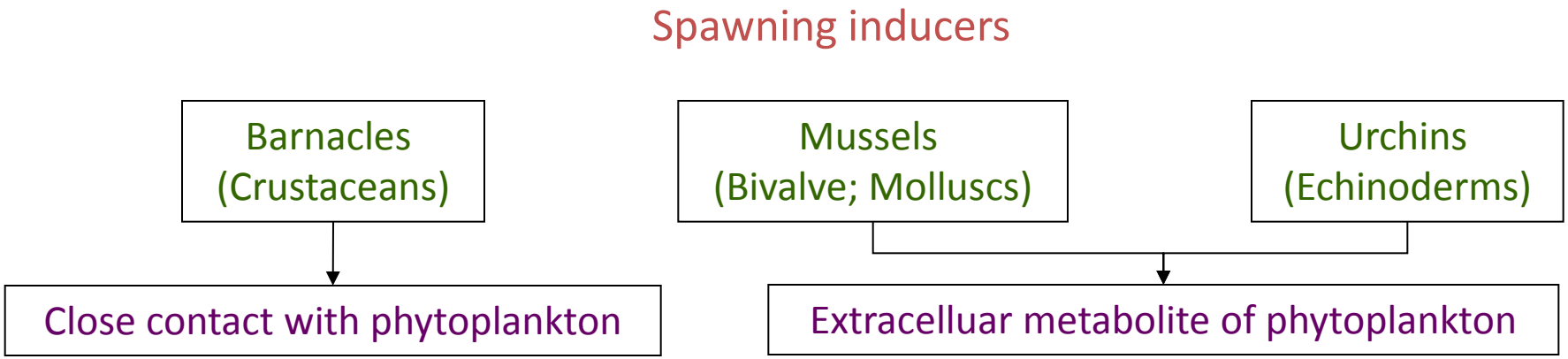
Fishing down marine food webs and spatial expansion of coastal fisheries in India 1950-2000

- Indian shelf fisheries, covered by 2000 four times the area they covered in 1970
- It is apparent that Indian fisheries are not on a sustainable trajectory and that the increases of the 1980's and 1990's were due to offshore expansion
- Deep waters around India cannot be expected to be as productive as the shelf waters (Longhurst & Pauly, 1987)
- This expansion has apparently met its natural limits, and catches can be expected to stagnate and ultimately decline

So: Bhathal & Pauly, Fisheries Research, 2008

Invertebrate spawning and phytoplankton

- Marine invertebrate spawning coupled with phytoplankton blooms
- Planktotrophic larval success - influenced by food
- Phytoplankton blooms of short duration - advantageous if spawning occurred at the beginning of the bloom



So: Starr et al., Nature, 1990; J. Plankton Res., 1991

Pressure: Inter-tidal & Estuarine regions

Anthropogenic

Recreational

Climate change


Thank you!