

FIS 310 : OCEANOGRAPHY (2 UNITS)

Biological Activities And Their Distribution

Biological oceanographers study all forms of life in the oceans, from microscopic plants and animals to fish and whales. In addition, biological oceanographers examine all forms of oceanic processes that involve living organisms. These include processes that occur at molecular scales, such as **photosynthesis**, respiration, and cycling of essential **nutrients**, to largescale processes such as effects of ocean currents on marine productivity.

A distinction is often made between the fields of biological oceanography and marine biology. Although there is considerable overlap between the two disciplines, the field of marine biology traditionally deals with the study of individual organisms, including their taxonomy, behavior, physiology and other aspects of their biology. In contrast, the emphasis of biological oceanography is the ocean and organisms as a system. As such, biological oceanographers tend to utilize a multidisciplinary approach, drawing on knowledge from various fields in addition to biology including, for example, physics, chemistry, and geology.

Biological Oceanography (BIO) focuses its research on the planktonic food web structure and dynamics comprising phytoplankton, prokaryotes, micro- and mesozooplankton and viruses. Planktonic food webs and particularly the interactions between the individual functional groups within the food webs are the main driving forces of oceanic biogeochemical fluxes. The research performed in BIO ranges from autecological to food web studies including a modelling component. Research is conducted under controlled laboratory conditions and at sea.

Three major research themes are currently addressed:

1. Planktonic activity as the major driver of the upper ocean biogeochemistry.
2. Ecology of harmful algal blooms and invasive species
3. Functional stability and phylogenetic diversity of plankton systems

CLASSIFICATION OF MARINE ENVIRONMENT

life in our planet is dependent upon the oceans, which are the sources of wealth, opportunity and abundance. About 71% of the surface of this planet is covered by salt water. The water depth averages 3.8km, a volume of $1370 \times 10^6 \text{ km}^3$. They provide us food, energy and water and sustain the livelihoods of hundreds of millions of people. They are the main highway for international trade as well as the main stabilizer of the world's climate. According to the **Global Seas and Oceans**

The oceans are originally the great mass of salt water, supported to encompass the disk of the earth. They are considered to be ancient formations in the morphology of the earth and are mainly separated from each other by the continents. On the other hand, the seas are varying

extents separated from the oceans by island chains or by submarine ridges rising from the sea floor, subjected to considerable changes in the course of geological history. The ocean is divided into large five areas, Antarctic ocean, Arctic ocean, Atlantic ocean, Indian ocean and Pacific ocean, while the nomenclature of sea expands to North sea, Mediterranean sea, Red sea, Black sea, Arabian sea, Caribbean sea, Baltic sea *etc.* Owing to their extreme separation from the oceans, the seas have certain special characteristics, which are closely correlated with the reduced exchange of water masses, they show considerable differences between each other, because their water masses react more markedly than the open oceans to the local climatic conditions.

Division of the Marine Environment

The marine ecosystem is the largest aquatic system on the planet. Its size and complexity make it difficult to deal with as a whole. As a result, it is convenient to divide it into more manageable arbitrary subdivisions. Open ocean can be subdivided vertically and horizontally. The entire area of the open water is the pelagic realm; pelagic organisms are those that live in the open sea away from the bottom. This is in contrast to the benthic realm, which is a general term referring to organisms and zones of the sea bottom. Horizontally, the pelagic realm can be divided into two zones. The neritic zone encompasses the water mass that overlies the continental shelves. The oceanic zone includes all other open waters (Fig-1). Progressing vertically, the pelagic realm can be further subdivided. Two schemes are possible. The first is based on light penetration. The photic or euphotic zone is that part of the pelagic realm that is lighted. Its lower boundary is the limit of light penetration and varies in depth with clarity of the water. Generally, the lower boundary is between 100 and 200m. A synonym for this zone is the epipelagic zone. Because it is the zone of primary production in the ocean, it is of major importance. The permanently dark water mass below the photic zone is the aphotic zone. Some scientists prefer to recognize a transition zone between the photic and aphotic called the disphotic zone. This transition area has enough light for vision but not enough for photosynthesis and extends down to about 1000m. Disphotic is synonymous here with mesopelagic. Fig.1. Divisions of the oceans (not to scale) The pelagic part of the aphotic zone can be subdivided into zones that succeed each other vertically. The mesopelagic is the uppermost of the aphotic areas. Its lower boundary in the tropics is the 10°C isotherm, which ranges from 700 to 1000m, depending on the area. Next is the bathypelagic, lying between 10 and 4°C, or in depth between 700 and 1000m and between 2000 and 4000m. Overlying the plains of the major ocean basins is the abyssal pelagic, which has its lower boundary at about 6000m. The open water of the deep oceanic trenches between 6000 and 10,000m is called the hadal pelagic. Corresponding to the last three pelagic zones are three bottom or benthic zones. The bathyal zone is that area of bottom encompassing the continental slope and down to about 4000m. The abyssal zone includes the broad abyssal plains of the ocean basins between 4000 and 6000m. The hadal is the benthic zone of the trenches between 6000 and 10,000m. The benthic zone underlying the neritic pelagic zone on the continental shelf is termed the sublittoral or shelf zone. It is illuminated and is generally populated with an abundance of organisms constituting several different communities, including seagrass beds, kelp forests and coral reefs.

Coastal Zone

Two traditional areas exist, one between the marine environment and the terrestrial, and the other between marine and fresh water. The intertidal zone or littoral zone is that shore areas lying between the extremes of high and low tide; it represents the transitional area from marine to

terrestrial conditions. It is a zone of abundant life and is well studied Estuaries represent the transition area where fresh and salt water meet and mix. These are important breeding and feeding grounds for sea birds, shore birds and waterfowl.

Exclusive Economic Zone (EEZ)

The earliest use of the oceans by humans was probably for food. Early human populations living along the oceans captured various shore fishes and shellfishes for consumption with the advent of vessels and nets. In the decades of this century, the old ships and gear have been replaced by much larger and more powerful vessels, more effective nets and traps and electronic devices for detecting fish schools. The result has been a significant reduction in many fish populations and the disappearance or over exploitation of others at a time when increasing human populations are demanding more food. The decline of many world fisheries due to common access and the pressures of an increased demand for food by an ever-increasing human population have led to friction among fishing nations and various attempts to regulate fishery resources. Following the Third United Nations Conference on the Law of the Sea, a standard 200 nautical miles wide fishing areas from the 'base lines' called economic zone (EEZ) was established for the waters of each coastal nations. This means that individual nations now have full control of all fishery activity within 200 miles of their shores and they have sovereign rights over the resources of their continental shelves that, in some cases, can extend even further.

Continental Area

Continental area supports abundant benthic fauna and flora – the shelf communities. The water above the continental shelves and its fauna and flora are described as neritic. Neritic waters tend to be richer in plant nutrients and more productive than water of corresponding depths in the open sea. One reason for this is the greater mixing that occurs here as a result of turbulence, wave action, upwelling caused by offshore currents, winds etc., bringing plant nutrients into all strata of the water. Also additional nutrients are led from the substrate and washed in to the sea by rivers and streams from the adjacent land. Where the substrate is suitable for attachment, the shallow waters also support a rich growth of seaweed, turtle grass, eelgrass and in some areas, other plants. The increased plant growth is reflected in an increase in animal life.

Coral Reefs

Coral reefs are shallow- water tropical marine ecosystems characterized by a remarkably high biomass production and a rich floral and faunal diversities. Reef is formed by the millions of calcareous skeleton of corals (marine invertebrate of the phylum Coelenterata) cemented together over a period of few thousand to millions of years. Coral reefs are of three types *i.e.* Fringing reefs (project seawards directly from the shore), Barrier reefs (separated from the land mass by a shallow lagoon) and Atolls (rest on the summits of submerged volcanoes). An abundance of pelagic fish resources is found in the reefs, including food fishes as well as a variety of beautiful aquarium fishes such as parrot, porcupine, rainbow and surgeon.

Mangroves

Mangroves are tropical and sub tropical swampy forests bordering the sheltered seacoasts and estuaries. Mangroves are highly complex and dynamic ecosystems comprising salt tolerant intertidal halophytes and the adjoining waterways, supporting numerous terrestrial, arboreal, benthic and aquatic organisms forming a complex association of species, exchanging materials and energy with the system, between the system and near coastal waters. Mangroves are unique in possessing special adaptive structures to live in the saline coastal environments. They include specialized root-cell membranes which prevent or reduce the entry of salt; elaborate tube-like breathing structure called pneumatophores which grow vertically upwards from the roots; and

viviparous seedlings that germinate on the parent tree itself thereby decreasing their mortality in the unfavorable environment. Mangroves serve a wide variety of useful functions including prevention of coastal erosion, encouraging soil deposition, providing food, shelter and serve as a sanctuary of birds and mammals. They provide the vital spawning, nursery and forage ground for a wide variety of aquatic organisms and as organic food factory through litter production.

Wetlands

Wetlands are diverse in both form and function. They encompass the salt marshes and mangrove swamps of seacoast and estuary, the freshwater marshes of the prairie, the flood-plain swamps of rivers, and the littoral zone marshes of lakes. Wetland is an ecotone, the transitional zone between land and water, and it combines the characteristics of both these environs besides having some unique characteristics of its own. The heterogeneous wetland habitat broken into diverse microhabitat consists of permanent or seasonal shallow water bodies dominated by large aquatic plants. Wetlands are divided into four groups based on the dominant large vegetation, source of water and presence or absence of peat.

1. **Marshes** are characterized by emergent aquatic macrophytes.
2. **Swamps** are dominated by trees.
3. Acidic **bogs** are characterized in having low species diversity with a few higher plants and an abundance of the peat – moss *Sphagnum*.
4. The more alkaline **ferns** are often species that contain both mosses and aquatic macrophytes.

The main wetland types differ in their rates of primary production in the following order Marshes > swamps > ferns > bogs. To day, the preservation of wetlands is considered important by both scientists and the public. Therefore, considerable thought has gone into distinguishing wetlands from other aquatic and terrestrial habitats. The characteristics of shallow water, saturated soil and dominance by vegetation adapted to water logged conditions define wetlands. The scientific study of wetlands is difficult and much remains to be discovered. One reason is that wetlands are the most physically and chemically heterogeneous of all the major aquatic ecosystems. Wetlands are of considerable economic importance. They can be highly productive with large crops, of algae, macrophytes, trees, and aquatic invertebrates. This food supply and the cover and isolation from terrestrial predators provided by reef beds encourage nesting and rearing of waterfowl such as geese and ducks which are highly valued by hunters, bird watchers and politicians. Wetlands also serve as a natural buffer between land and water by acting as a sponge for sediments and nutrients, holding back inflowing matter. Finally, wetlands are now valued for their intrinsic aesthetic value and as distinct ecosystems for research by limnologists and ecologists.

The Value of Marine Ecosystem

The world's oceans are not only the domain of food for human being but also the legitimate concern of marine transport, offshore extraction of oil, gas and other minerals, climate control and recreation. Marine fisheries account for 85% of the global fish catch. Maritime shipping is involved in the transport of over 80% of the world's merchandise trade. An estimated 70% of the world's fish stocks are already being exploited at or beyond sustainable limits, but fishing generally continues unabated despite extensive regulatory arrangements for their management. In a few cases, emergency measures have been taken to defend stocks of marine wildlife. In 1985, for instance, the International Whaling Commission declared a moratorium on commercial whaling. Individual fisheries have similarly been closed for prolonged periods, but the threats to fisheries remain and continue to increase. The pressure on the oceans is not only due to over-harvesting but also to the cumulative impact of land-based activities. This includes many of

the effects of coastal development, especially the destruction of wetlands, mangroves and coral reefs, sedimentation and the dredging of sediments, damage to watersheds and the impounding of water supplies to support urban development in coastal areas. The oceans have also become the ultimate sink for discharges of waste of all sorts carried by rivers and winds from land-based sources, including coastal mega cities. Other threats come from the transport of hazardous wastes, operational and accidental spillage of oil, discharge of radioactive materials at sea, nuclear testing and the transport of alien species in the ballast water of ships. Harmful algal blooms, nourished especially by sewage and agricultural run-off, are becoming increasingly common, adversely affecting the recreational values of many coastal areas, and in some cases reducing fish populations and producing anoxia in the water column.

International Management Regimes for Marine Environment

Management regimes for coastal resources should be established at the appropriate geographical or political level. To address the complexity of management regimes, it is essential to develop a methodology and collect the information required for the systematic valuation of ocean assets and services. At the global level, the Law of the Sea Convention, the central regime for ocean governance, has established a new treaty system of ocean institutions. Under the umbrella of the convention, a number of 'sub-regimes' can be identified, each of which deals with specialized matters. The most important of these sub-regimes cover: The sustainable management of marine living resources, the focus for which is Food and Agricultural Organization of the United Nations (FAO), including its network of regional fisheries commissions and conventions;

- Shipping and marine pollution control, centered on International Maritime Organization (IMO) and several related convention-based institutions;
- The marine environment, the main responsibility for which has been assigned to United Nations Environment Programme (UNEP), including its network of regional seas agreements and action plans;
- Marine scientific research and associated ocean services and management, centered on Intergovernmental Oceanographic.

- Deep seabed mineral development, through the International Sea Bed Authority (ISBA).

The recommendations set out above are essentially directed at governments in recognition of the key role they must play in shaping a more effective systems of ocean governance.

Nekton

Incorporating the collection of [nekton](#) into a shallow water environmental sampling program can be a complex prospect despite their familiarity and demands extra considerations. Unlike other the other biota discussed previously, nekton provide a spatially and temporally integrative measure of the environmental conditions in a given sample area due to their mobility, relatively long life span, and typically high trophic position within the estuarine [food web](#).



Minnows in shallow water. Photo: Jane Hawkey, IAN Image Library

Most species of nekton receive exposure to their environment both directly from the water or sediment environments and indirectly through their food. Consumers typically accumulate any [contaminants](#) their prey items contain, which will persist over time, leading to contaminant levels that are orders of magnitude above ambient environmental conditions in a process referred to as biomagnification (see [VADEQ](#)).

Some species of nekton (e.g., mummichugs, grass shrimp, or hog chokers) exhibit a degree of site fidelity and provide a better indicator local conditions, while other, more motile or migratory nekton (e.g., spot, croaker, or menhaden) will be less indicative of localized environmental conditions.

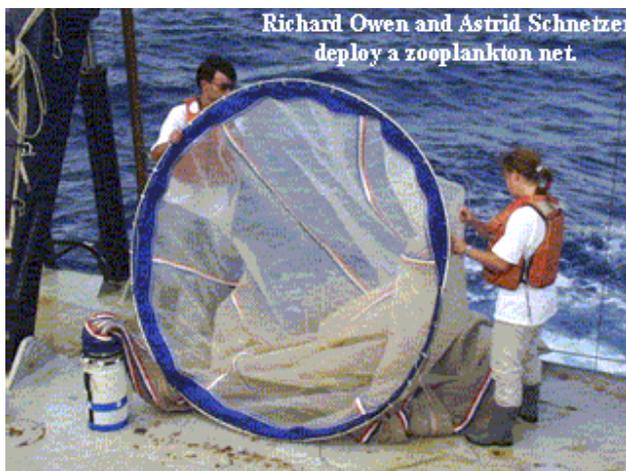
Abundance, biomass, and species composition of the nekton assemblage, particularly with consideration of age-class, have traditionally been used as metrics to evaluate environmental conditions in monitoring programs.

Additionally, with the advent of modern microbiological methods, cellular biomarkers (e.g., stress protein induction, detoxification enzymes, or DNA damage), growth condition indices, or the presence of infections/parasites can be used as indicators of the health of the nekton resources and the ecosystem as a whole.

There are a variety of methodologies for quantitatively and qualitatively sampling nekton in estuaries. There is no one method that effectively samples for all species of nekton in all habitats and therefore, the best approach(es) will depend upon the research objectives of the project. Generally speaking, quantitative, area-based collections of nekton in shallow waters is best done with some manner of enclosure- (e.g., ring traps or pop-up nets) or seine-based method, with trawling working better in deeper waters. Non-area-based sampling (such as used in the biomarker or species composition surveys) in both shallow and deeper waters can be done with baited or un-baited traps or camera systems.

Beyond their use in assessing overall ecosystem quality, many species of nekton have direct commercial and cultural value to the variety of stakeholders in estuarine and coastal systems. As such, the abundance and overall health of a particular species of nekton (striped bass in the Mid-Atlantic US or penaeid shrimp in the Southeast US) may be of greater interest than the health and diversity of the entire shallow-water nekton assemblage. These types of data can be often be used as the focal point of a research program, tailoring the sampling protocol towards the target species, while also allowing for collection of concurrent data on other species with ecological, if not economic/cultural, value.

PLANKTON



Plankton

Nets

Plankton, Greek for "drifter", are small plants (phytoplankton) and animals (zooplankton) that drift with the ocean's currents. They form the bottom of the food chain in the sea and are very important in ocean food webs. Oceanographers use nets to catch these small creatures and study them. The nets are of a much finer mesh than fish nets, as the mesh openings must be small enough to concentrate the plankton while

still allowing water through. Phytoplankton nets have a very small mesh opening (about 36/1000 of a mm) and zooplankton nets have larger meshes (about one 1/3 to 1/2 of a mm). The nets are attached to the hydrowire and towed behind the ship. Plankton tows can be done at any depth or time of day, and can be used with opening/closing mechanisms to enable them to collect at a desired depth.

Sediment

Sediment traps are cone-shaped or cylindrical collectors that catch detritus that sinks down from the surface ocean to the deep sea. This material is made



Close-up of sediment trap tube

Traps

up of dead phytoplankton and zooplankton, the feces of zooplankton and fish, and many other different kinds of detritus. This material, often termed marine snow, is an important food source for organisms that live in the deep sea, as well as a mechanism for transporting material



Deployment of drifting sediment trap.

from the surface waters to the deep sea where it is eventually decomposed by bacteria. The sediment traps are attached to a line that has floats on the surface and a weight at the bottom to keep it vertical. Some sediment

traps have subsurface floats and a bottom weight that actually rests on the sea floor. After several days or weeks, oceanographers recover the traps, weigh the particulate material therein, and analyze the material's chemistry. The quantity of material divided by the collection area and the time the traps were deployed gives the particle flux.

Primary

Production

Array

One important measurement that oceanographers make is the rate of plant photosynthesis in the sea, also known as the rate of primary production. During photosynthesis, phytoplankton take up carbon dioxide that is dissolved in sea water. These tiny marine organisms thus provide the entry point for carbon into the marine food chain. Knowing how fast the phytoplankton grow gives oceanographers an idea of how much carbon they take up, and how rapidly.

To measure the rate of plant photosynthesis at the BATS site, the technicians collect water samples just before sunrise at various depths in the top 140 meters of the ocean. (Below this depth there is generally not enough light for photosynthesis.) They then pour these water samples into transparent bottles and add a tiny amount of radioactive tracer. Attaching the bottles to a line, they release them overboard at the depth from which the water in the bottle was originally collected. At sunset, they retrieve this floating array of bottles, and filter the water to collect any small phytoplankton. They then use a scintillation counter to measure the amount of radioactive tracer that the phytoplankton cells have incorporated during the day. The quantity divided by the number of hours that the bottles were deployed gives the rate of photosynthesis or rate of primary production.

A Note about Filtering Water!

Probably 95 % of oceanographic research involves filling bottles and filtering water! At BATS, technicians filter water to catch phytoplankton and extract their photosynthetic pigments to get a measure of plant biomass in the sea. They also filter water to catch small bacteria to count them, or to measure the total amount of particulate matter in the water. Sometime water is filtered to exclude the solid particles, so that dissolved nutrients (*e.g.* nitrate and phosphate) can be measured.



Filtering water aboard the Weatherbird II.