Food chains and biodiversity in ecosystem functioning

1. Ecological Importance of Estuaries

As defined by Pritchard, an estuary “ is a semi-closed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage”. The first requirement based on the definition is the estuary being “ a semi-closed system”. Its circulation pattern is largely affected by its lateral boundaries. This control by these boundaries is an important characteristic of an estuary which should be noted. Then the definition implies that an estuary is a feature of a coast, hence there should be a limit to size of the water bodies considered. In other words, the estuary is part of a coast and does not form the coast. With reference to this, the Baltic Sea, Gulf of Bothnia and Gulf of Finland should be excluded because they form the coastline than being part of it. The next requirement is that of “ a free connection with the open sea”. This indicates an adequate communication between the ocean and estuary in order to transport tidal energy and sea salts.

The estuaries like the tropical forests and coral reefs, areas of high productivity, even higher than the oceans and rivers that influence them on both sides. Due to a free exchange occurring, primary productivity is generated from the river and deep ocean waters which are both nutrient rich and the shallow coastal waters which are light infused. Likewise the mixing of lighter and heavier waters from the river and ocean, respectively trap and circulate the nutrients such that there is retention and recycling of these nutrients by benthic organisms makes the estuary a self-enriching system.

Estuaries are capable of generating primary production from macrophytes (seaweeds, sea grasses and marsh grasses), benthic microphytes (mud algae) and phytoplankton all year round. They also serve as beneficiaries of energy subsidies due to food and nutrient transport and waste removal. The vast primary productivity which is characteristic of an estuarine system is the foundation of the food chain. This helps in providing food for shellfish including clams, mussels or quahogs. In some cases the estuary's productivity may exceed that which can be used in sustaining life, regular tidal flushing help move the nutrients and organic materials to the adjacent coastal waters. As a result, their productivity is increased.

2. Diagram the flow of energy through BOTH a photosynthetic and chemosynthetic ecosystem.

In a photosynthetic system, solar energy is used to bond six separate carbon atoms from carbon dioxide into glucose which is an energy-rich molecule. The pigment, chlorophyll absorbs then stores briefly light energy that is necessary in driving the reactions. Water is split in the process releasing oxygen. In contrast, a chemosynthetic system such as eubacteria and archaebacteria, six molecules of carbon dioxide combine with six oxygen molecules and 24 hydrogen sulphide molecules forming glucose. The energy in binding carbon atoms into glucose is derived from breaking chemical bonds holding sulfur and hydrogen atoms in hydrogen sulfide.

3. Compare/contrast Food Chain and Food Webs. Explain the use of these diagrams to describe ecosystem structure and ecological relationships.

A food chain describes the sequence of energy as it moves from one organism to another organism. A food web on the other hand is the network of food chains that have overlapped which provides a more accurate

description of the feeding patterns and trophic levels. It can also be seen from a food web that organisms are interconnected within an ecosystem. From the linkages in the food web, scientists are able to define the trophic structure in which energy is transferred from the nutritional level to the next. Because food chains and food webs represent models of predator-prey relationships, therefore one would know which organisms are eaten and which organisms consume them.

4. Provide a diagram of a Marine Food Web that contains at least ten (10) organisms.

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LEOPARD SEAL WEDDEL SEAL

ORCA 1

CRAB EATER SEAL EMPEROR PENGUIN MINKE WHALE

ADELIE PENGUIN CRYSTAL KRILL TOOTHFISH PETRELS, SKUA

OTHER CRUSTACEA CRYSTAL KRILL SILVERFISH SQUID OTHER SMALL FISHES

MICROZOOPLANKTON

ICE ALGAL/MICROBE COMMUNTIY MID-WATER ALGAL/MICROBE COMMUNITY

5. Explain why the base of every food chain must be (a) primary producer(s).

In the food chain, the primary producer occupies the base of the food chain because it derives its own food from the primary energy source which is the sun. For every natural system to be operational there must be an energy source and it is the sun that is the primary source of energy in all biological

system except for a few species. Sunlight is captured by green plants during the process of photosynthesis to produce glucose, a carbohydrate from water and carbon dioxide. Also a by-product is oxygen. Because it is only the plants that are photosynthetic, they are capable of manufacturing their own food utilizing the energy coming from the sun. Hence they are called producers. The producers are essential as they utilize sunlight in the production of chemical energy. Then from one trophic level energy gets transferred from one trophic level to the next losing some of the energy.

6. Define Biodiversity and Explain why biodiversity is critical to ecosystem stability.

Biodiversity is a contraction of the phrase biological diversity. As defined by the Convention on Biological Diversity, biodiversity is " the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems." According to Williams and Humphires (1996), the source of variation at the individual, species, and population levels is genetic diversity. Thus, one could not discuss biological diversity without highlighting genetic diversity. The relationships and associations between individuals of a population or community such as parasitism, predation and the specializations organisms have in order to adapt to their immediate surroundings are the most functions aspects of biological diversity. In addition, biological diversity has a spatial component. In different areas in the world, it is expected to observe community and ecosystem structures variations. On a similar note, function of a community or ecosystem varies from each other from one area to another area. The patterns of biodiversity

in a given area are affected by abiotic factors such as climate, geology, and physiography (Redford and Richter, 1999). Purvis and Hector (2000) provided another definition of biodiversity. They said it is the " the sum of all biotic variation in the biosphere from the level of gene to ecosystem" which means that the concept is not only restricted to species richness, abundance, and the presence or absence of key species.

Biodiversity is critical to ecosystem stability. In the definition of Pimm (1984), an ecosystem is stable when collectively, it can resist disturbance, is able to recovery after disturbance, and stability can be sustained over long periods of time. Proving that diversity influences stability has been one of the debates in ecology in the past 30 decades. The studies of Clements (1916), Smuts (1926), Odum (1953), and MacArthur (1955), Elton (1958) showed that when diversity is high, stability in the ecosystem is also observed to be greater. This means that species are less susceptible to introduction of exotic species. This concept was also supported by Pimentel (1961) and Margalef (1969). Also, when the ecosystem exhibits great biodiversity, the likelihood that at least some species would be able to survive when there are large scale changes in environmental factors is high. However, May (1972) and Gardner and Ashby (1970) hypothesized that greater diversity results in lower ecosystem stability

7. Explain the importance of a Keystone organism (in an ecosystem). Provide at least one specific example of a Keystone organism.

Power et al. (1996) defined a keystone species as " a species whose effect is large and disproportionately large relative to its abundance". To illustrate the importance of a keystone species in an ecosystem, we can cite the work

of Paine (1966) about a rocky shore community in California. When the starfish, Pisaster ochraceus was removed, the number of species assemblage was reduced from 15 to 8. The collapse of the ecological balance as a result of removing one member of the system is much the same as removing the keystone from an arch. Likewise, the triton (Charona sp.) and a starfish (Acanthaster planci) play very important roles in the Great Barrier Reef found in northeast Australia (Paine 1969). The diet of Acanthaster is mainly stony corals while Charona feeds on Acanthaster. Their specific roles in the ecosystem help preserve but in instances when Charona is taken out from this web, the result is catastrophic because it leads to increase in the starfish population resulting in massive coral disappearance.

8. Describe how physical factors of light, temperature, and depth affect the distribution of biota (living creatures).

No species is adapted to survive in all environmental gradients since every organism has specific limits to tolerate physical factors which are vital for its survival or reproductive fitness. In ecology there is the concept known as the range of tolerance. This is the range of factors over which the organism can survive or is able to live.

Penetration of light to the sea floor contributes to total primary production. In the benthic substrates that receive adequate radiant energy to sustain primary production have photosynthetic organisms such as seagrasses, algae, corals, and microflora in sandy and muddy bottoms.

Because environmental temperature affects metabolic rate in organisms, it is a a key factor that explains distribution of organisms. There are only few organisms that are able to maintain active metabolic activity at very high or

low temperatures. To allow some organisms to survive in environments with temperature ranges not hospitable for most organisms, extraordinary adaptations must be made.

In the aquatic ecosystems, it is the light intensity that limits the distribution of photosynthetic organisms. It was found that every meter of water depth absorbs 45% red light and 2% blue light; as a consequence, photosynthetic activity in these environments occurs near the surface.

9. Define Niche and provide at least three (3) examples of types of niches found in marine ecosystems.

In ecology, a niche refers to the status of an organism in its immediate environment or community. It may also be defined as how an organism interacts with the environment therefore it is closely associated with environmental tolerance curves. It also has behavioral (such method of locomotion which could be swimming, flying, or running) as well as environmental aspects (for instance temperature and salinity limits).

Ecological niche can be characterized into three: habitat, diet, and and seasonality. In theory, a species occupies its own niche while it is also possible the two species share niches that are close to them. Theoretically, each species has its own ecological niche and two species sharing close niches. In northwestern Mediterranean Sea (NWMS), sperm whale (Physeter macrocephalus), the long-finned pilot whale (Globicephala melas), Risso’s dolphin (Grampus griseus) and Cuvier’s beaked whale (Ziphius cavirostris) are considered to be teuthophageous or they preferentially or exclusively prey on cephalopods (Astruc and Beaubrun, 2005). The first three are commonly occurring in the NWMS while the other whale species seemed to

have a restricted distribution (Azzellino et al., 5 2003; Gannier, 1999; Podesta et al., 2006). Surveys showed that the Cuvier's beaked whale was observed thrice. Gut analysis of the animals showed overlapping of diet in the sperm whales, pilot whales and Risso's dolphins. The major prey items were 10 species of bathypelagic cephalopods of the Histioteuthidae and Ommastrephidae families (Astruc and Beaubrun, 2005). The sperm whale according to notable investigators is an opportunistic feeder exploring only those with steep slopes and offshore waters (Gannier et al., 2002; Gannier and Praca, 2007). The Risso dolphins were found to prefer slopes ranging from 500 to 2000m (Bompar, 1997; Gannier, 1998), while the pilot whale prefer deeper waters (> 1000m).

10. Identify at least three environmental issues facing the World Ocean and how humans can protect this vital resource.

The first issue facing world oceans is oil spills. The consequences immediately following oil spills are mass mortality and contamination of marine life. Its long term outcomes would include poisoning organic substrate both in the marine and coastal regions which disrupt food webs on which fish and other marine life depend. Their reproductive success will also be affected leading to mass extinction because it is impossible for the species to perpetuate. Moreover small- and large-scale fishing industries will be permanently affected. The second problem is eutrophication caused by fertilizer runoffs. This phenomenon leads to depletion of oxygen in the water bodies suffocating marine organisms creating dead zones in the Gulf of Mexico and the Baltic Sea. The third issue is garbage. Solid waste when present in high concentrations in the oceans is ingested by marine animals blocking their air passages and stomach. There have already been

documented cases of whales, dolphins, sea turtles, and other marine life to have ingested or been choked by these non biodegradable waste material. These instances have led to several marine life mortalities. What humans do to help solve these problems is to stay informed about environmental issues, participate actively in environmental advocacies, and adopt a sound and environment-friendly solid waste management scheme.