Theme 6 – Industrial Impact

Presentation: Controlling an Exotic Species in the Black Sea

Presenter: Dr. Richard Harbison

The problem that I hope to help solve is one posed by an exotic species, the ctenophore, Mnemiopsis leidyi. An exotic species is an organism that has been moved by human activity into a region where it did not exist previously. In principal this definition seems simple but in practice it is often quite difficult. There are two problems. First, one must have an extensive knowledge of the biogeography of the species in question and know all the species that are native to the new region. Second, there is the fact that Nature also moves species around. In the case of the Black Sea, the primary natural mechanism that altered the composition of species there has been the periodic opening and closing of the Bosphorus. Relatively recently, about 20,000 years ago, a spectacular ecological disaster occurred - the Black Sea lost its connection with the Mediterranean.1 This led to the extinction of all its marine plants and animals. Had people then had the technology that we have today, they might have attempted to keep the Bosphorus open, thereby preserving its marine life.2

After about 10,000 years as a lake, another ecological catastrophe occurred. The Bosphorus reopened, and the Black Lake was transformed once again into the Black Sea.3 As the salty water poured in, large areas of land were poisoned. The Black Sea became much as we know it today about 3,000 years ago.4 The Black Sea is now about half as salty as the Mediterranean, and the building of dams across the rivers that flow into it is helping to make it even saltier. Today, about 80% of the species in the Black Sea are immigrants from the Mediterranean. Even so, not all the Mediterranean invaders can survive in the Black Sea - in fact, most of them cannot. For example, there are about four times as many species of fish in the Mediterranean than there are in the Black Sea.5

Although the catastrophes caused by nature are the primary forces that created the present composition of the flora and fauna of the Black Sea, human beings are playing an increasing role in altering the list of species in the Black Sea. Shipping, which unintentionally brings in unwanted organisms on the hulls of ships and in their ballast water, is an important factor. So also are intentional introductions, such as aquaculture and introductions to improve the environment.

The way we live from day to day would be dramatically different without exotic species. Most of the foods on which the people of the world depend come from only a few areas of the Earth. For example, wheat comes from the Middle East, maize from Mexico, potatoes from Peru and rice from China. Most of our livestock comes from the Middle East and India. Any discussion of exotic species must recognise that exotic species have been a tremendous blessing to vast numbers of human beings. Indeed, the use of exotic species can be said, together with the prevention and control of disease, to have been one of the most important causes of the rapid increase in the number of human beings that has occurred over the past two centuries.6 Because we depend so heavily on exotic species in agriculture, people's attitudes toward exotic species that live on the land are often very different to their attitudes toward exotic species that live in the sea. Most gardeners in the United States think little of planting ornamental plants from New Guinea or Asia, yet most ecologists in the United States regard the intentional introduction of exotic species into the sea as a bad thing. However, some countries, like Japan, consider the intentional introduction of exotic organisms to be a valuable way to improve and enlarge their food supply.

Determining whether an exotic species is good or bad is not easy. In the past, the main criterion was its effect on human activities. Bad exotic species included organisms that caused disease, or organisms that decreased agricultural yield. For the marine environment, species that decreased the abundance of commercially valuable fish were considered bad. Recently, however, with the increase in environmental awareness, the concept of a bad exotic species has become broader, expanding to include species that have negative effects on local animal and plant communities, even if they appear to have no effect on human activities. In practice it has become increasingly difficult to draw a clear line, so that some ecologists now consider exotic species as intrinsically bad. The inherent paradox in this position can be illustrated by the fact that these same ecologists may sit down to a meal of bread, potatoes, broccoli and chicken, all of which were originally found in different parts of the world.

Exotic species with negative effects on plant and animal communities can be considered a form of biological pollution. However, this biological pollution differs in one important way from other kinds of pollution - it is self-replicating. This means that the problem cannot be solved by simply stopping further introductions. Once an exotic species becomes established, it will continue to alter its new environment unless steps are taken to reduce or eliminate it.

Since the Black Sea is now in transition from a freshwater to a marine environment, it is an easy target for an exotic species, if that species can live there. One of the major reasons that exotic species can become very abundant is that they leave their diseases, parasites and predators behind when they move into the new environment and there is no control on their abundance except the availability of food and environmental conditions. The Black Sea has a very small species list, and appears to be particularly vulnerable to exotic species.

The most spectacular example of the devastating effect of an exotic species on the marine environment took place in the Black Sea when the ctenophore, Mnemiopsis leidyi, arrived in 1982, probably in the ballast water of ships moving cargo between the Black Sea and the Americas. By the summer of 1988, it had become the most abundant organism in the Black Sea. As its numbers exploded, stocks of two commercially important fishes, the anchovy and the Azov Sea kilka, plummeted. It soon spread into the Mediterranean. Since its peak in 1988, its abundance has declined somewhat, although there is little data available to document this decline. Catches of anchovy have increased, although the significance of this is difficult to interpret, since there is practically no fishing effort from fleets of the former USSR. Catches of Azov Sea kilka remain low. There can be little question but that the introduction of this ctenophore into the Black Sea has drastically altered the structure of the Black Sea ecosystem.

The introduction of an exotic organism into an ecosystem is analogous to the introduction of a new disease into a human population. Just as with public health, the most cost-effective way to control the spread of an exotic species is with quarantine. Methods are being developed to control the spread of exotic species through ships' ballast water and protocols have been developed to control intentional introductions. However, the problem still remains - what do we do about an exotic species once it has become established? On land, pesticides are often used to protect crops, but we do not have this option in the sea. The problem in the sea is that the physiology of the pest is very similar to the physiology of the crop, so any pesticide that kills the one will probably kill the other. Also, even if a highly specific pesticide could be developed, its effects would be diluted, since pesticides do not stay in one place in water as they usually do on land.

Biological control is one option. This means introducing a disease, parasite or predator of the pest species. The place one usually looks to find such a control agent is the home range of the pest, since it is there that its enemies also evolved. I may have found a biological control agent that can reduce the harmful effects of Mnemiopsis leidyi on the Black Sea ecosystem. This animal is a predator, the commercially useful fish, Peprilus triacanthus. Commonly called the butterfish in the United States, this fish evolved in parts of America where Mnemiopsis leidyi lives and has evolved to feed on it and on other gelatinous animals. Besides ctenophores, it eats medusae and salps, which are also gelatinous. Since gelatinous animals are mostly made of water, it has to eat large amounts of prey. In fact, it eats its own body weight in ctenophores every hour.7 In addition to its feeding being very specific, it can live in water that is almost fresh, just as the ctenophore can. This means that it can seek out and feed on the ctenophore wherever it occurs in the Black Sea - the ctenophore has no refuge from this predator. Whether it can in fact not only survive but reproduce in the Black Sea will require many more experiments in collaboration with scientists in Black Sea countries. Even if it does not eliminate the ctenophore, it will be converting the ctenophore into a commercially valuable fish, which can be used by people for food.

The intentional introduction of yet another exotic species into the Black Sea poses serious ethical questions. We must face the fact that when we introduce a new species, we alter the nature of the biological community. My suggestion is that we alter it in a way that is beneficial to humans and other organisms by converting ctenophore biomass into fish biomass. We do have to face the possibility that something could go terribly wrong and we have the responsibility to do everything in our power to avoid a negative outcome. However, as it is impossible to predict everything that could go wrong, we are faced with the choice of action or inaction.

Some might advocate inaction as the most prudent solution. Certainly it is the easiest. However, such a decision means that we have decided to let the ctenophore reproduce unchecked in the Black Sea, doing nothing to clean up the mess it is causing. Doing nothing seems to me to be the same as dumping oil into the sea and saying, 'Let nature clean it up.' For most of our history humankind has had this attitude. I think that it is now time for a change. We have to take action.

Notes

1. According to Degens and Ross (Degens, E.T,. Ross, D.A. (1972) Chronology of the Black Sea over the last 25,000 years, Chemical Geology10: pp.1-16), the transition to fresh water was evident at 25,000 BP (Before Present), and the Black Sea was truly fresh at 22,000 BP.
2. The idea of keeping the Bosphorus open to preserve the marine life in the Black Sea is not all that far-fetched. For example, the construction of a dam across the Strait of Gibraltar was recently proposed (Johnson R.G. (1997) Climate control requires a dam at the Strait of Gibraltar, EOS 78(27), pp.279-281).
3. The date of the reopening of the Bosphorus has been variously estimated as occurring as recently as at about 7000 BP (Glenn, C.R., Arthur, M.A., (1985) Sedimentary and geochemical indicators of productivity and oxygen contents in modern and ancient basins: the Holocene Black Sea as the "type" anoxic basin, Chemical Geology 48, pp. 325-354), and as long ago as at 9800 BP (Jones, G.A., Gagnon, A.R. (1994) Radiocarbon horology of Black Sea sediments, Deep-Sea Research 1, 41(3) pp. 531-557).
4. Degens and Ross, op. cit.
5. Fischer, W., Bauchot, M.L., Schneider, M., eds. (1987) Fiches FAO d'Identification des Espèces pour les Besoins de la Pêche. (Révision 1), Méditerranée et Mer Noire, Zone de Pêche 37, Volume II Vertébrés, FAO, Rome; Svetovidov, A.H. (1964) Fishes of the Black Sea, Nauka Press, Moscow (in Russian).

6. It has been hypothesised that the increase in the population of Ireland between 1760 and 1840 from 1.5 million to 9 million occurred largely because of the introduction of the potato as a staple crop (Hobhouse, H. (1986) Seeds of Change, Five Plants that Transformed Mankind, Harper & Row, New York, pp. 205-206).
7. Harbison, G.R., Peharda, M., DeRobertis, A., ms. in preparation.