Population structure of Dall's porpoises

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Cetacea, whales and dolphins, is a mammalian order containing about 80 species. Although this number is not large compared with other taxa in the marine environment, cetaceans are placed at the higher trophic level in a marine food chain, and many various organisms are required for the existence of an individual cetacean. This means that we have to conserve a whole ecosystem when we would like to conserve cetaceans. We call such kind organisms "umbrella species." Cetaceans are also regarded as "flagship species," since they have popularity that roses public attention to the conservation. Therefore, cetaceans are very important for conservation of marine ecosystem and biodiversity. Each organism plays an important role in its local habitat as a part of local ecosystem, and we have to think conservation very locally, or in a smallest unit, i.e. population. Thus, to know population structure is the basis of the conservation. I here look over some results of the studies on the population structure of the Dall's porpoise. Dall's porpoises are small toothed whales belong to the family Phocoenidae and distributed widely in the northern North Pacific. About fifteen thousand porpoises are hunted by the hand harpoon fishery in Japan and an unknown number is incidentally taken by the Japanese salmon drift net fishery operated in the Russian exclusive economic zone. The conservation and management of the species is a matter of global concern. Two distinct color morphs, *dalli*- and *truei*-types are known. The former has a small white flank patch and the latter has a larger patch. Sighting surveys found that the mother and calf pairs were found in particular areas after the calving season. It was suggested that these areas are calving grounds and different population uses each area. To test this, scientists examined morphological and genetic markers that may indicate inter-population differences. Skull morphology of the Sea of Japan porpoises was found to be different from that of other localities. Canonical discriminant analysis on external morphology clearly discriminated the Sea of Japan specimens from others. This was caused by the difference of size of the white patch, which is smaller in the porpoises from the Sea of Japan. This means that the third color morph exists in the Dall's porpoise. Although the results of genetic studies are various, they showed larger differentiation between the Sea of Japan specimens and others. The different color morphs were not discriminated by the genetic markers. These morphological and genetic results all suggested the uniqueness of the Dall's porpoises from the Sea of Japan. However, population differentiation in the *dalli*-type porpoises in the North Pacific and Bering Sea was not clear. The studies on the Dall's porpoise suggested that we should examine all possible markers, not depend on a small number of markers to determine the population structure. We should also consider that genetic markers are not always effective and ecological information is very important.

New approach to the biological study on marine animals

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The human beings has opened windows to the planet and space, and obtained the grand views on what is our earth in comparison to other planets to find out that the earth is very exceptionally unique with huge amount of water and a lots of diversified life. Increased information from the space on our planet has developed a new view on our earth as global system. The idea of global system requires huge amount of integrated information from all over the world, and simultaneously it require preciseness and quickness in collecting information on total system without lacking parts of the global system. Despite of advanced technologies of the global observing system like satellite observing system, marine system still remains very remote in the context of global system and global information, because the satellite system allow us to observe only earth surface. The world oceans occupy the major parts of our earth and important role in the global system yet only sea surface is monitored by space eye. No precise information on the marine system particularly regarding marine animals is available.

In above context, marine living animals are far beyond the understanding as objectives of the modern science. We still do not know how they live in the ocean, how they interact in the marine environment. How can we answer these questions? How can we develop the visions on the animals in dark and deep water? Unless we achieve this goal, global system will not be understood. On the other hand, once we can obtain information beneath the surface, we can use information from satellite and from the depth and we can obtain more complete system for observation and monitoring the whole system.

For large marine animal like whales and seals the satellite linked observation service like Argos system and GPS system has been used. Although it can allow us to know data on their geographical position, we still lack in spatial and temporal precise information. Further difficulty we face is under water positioning information. Once animals go into water, almost nothing is given by the satellite systems. Even acoustic techniques are used; it is far beyond the spatial and temporal preciseness. To open the views to the deep and dark marine world, animal-mounting data logger system was developed since early 1980s. Applying the advanced techniques of microelectronics, miniaturization of data logger (micro-data logger) has been achieved and it gave us eyes to look the marine animals in the sea.

By using the techniques of the micro-data loggers we could measured the precise swimming behavior including even three-dimensional movements of the marine animals without linking the satellite service. We also could measure foraging behavior, when and how much animal took the prey in the water and also precise monitoring of the animal behavior, when and how they behaved during their foraging trip. Now we can measure either the interaction between individuals or their prey condition by micro-image data logger.

Future direction of this research is to develop the precise measuring techniques of the bio-chemical and bio-physiological condition in free ranging animals simultaneously with their behavior and environments. As well as above direction, we need to make effort to realize further miniaturization of the loggers and further large memory capacity.

How do we know salmon behavior ? I. A microscale study: Behavior of individual salmon studied with data loggers

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Chum salmon *Oncorhynchus keta* is one of the seven species of Pacific salmon. Like other salmonid species, chum salmon exhibit a typical anadromous migration: they are born in the river, migrate to a feeding area in the Bering Sea and the northern North Pacific Ocean, and return to their natal river to spawn after four to six years. They are typical cold water fish; their upper lethal temperature does not extend beyond 24°C, and the critical temperature which defines the southern boundary of their feeding area is 10.2°C. Therefore, global warming due to the greenhouse effect of increasing CO_2 level in the atmosphere is a potential threat to the salmon life. It is important to clarify the physiological and ecological impacts of high water temperature on the salmon.

Coastal area of Iwate Prefecture, which is located at the central part of Sanriku Coast in northern Japan, is close to the southernmost natural spawning area of Pacific salmon. Returning season of chum salmon in this area is generally September to December. The surface sea water temperature is usually more than 18°C at the beginning of the season and decreases to about 12°C at the end, which appears to be unsuitably high for chum salmon. Moreover, in addition to the cold water mass of Oyashio, two other warm water masses of Tsugaru Warm Current and Kuroshio Current distribute off the Sanriku Coast complicatedly. How do chum salmon behave in such unsuitably warm water masses? Understanding of the homing behavior of chum salmon around the Sanriku Coast may provide an important insight to estimate the impacts of global warming on the salmon life.

To study salmon behavior in Sanriku Coast, we employed data logger tagging. The data logger tagging enables simultaneous recording of various data, such as depth, temperature and swimming speed of free ranging individual salmon, over a long time period in a broad area. Furthermore, the homing migration of salmon to their natal river promises high recovery of released loggers.

We found that the behavior of chum salmon drastically changed responding to the vertical thermal condition of sea water. In October, when the surface temperature was more than 18°C and sea water was thermally stratified, they preferred to stay deep water, making long dives to the bottom, but showed frequent ascents to the surface. In December, when the surface temperature was under 14°C and the thermally mixed layer was developed, they basically stayed less than 50 m deep, making restless descents and ascents. These data indicate that, in thermally stratified water with high surface temperature, chum salmon seek the coolest thermal refuge as they can exploit by their vertical movement. Since salmon are poikilothermic, the coolest thermal refuge leads salmon to minimize the metabolic energy cost. Thus the salmon regulate their body temperature, and hence the metabolic energy consumption rate, through seeking the coolest thermal refuge.

Then, why do salmon prefer shallow water in December? Why do they come back to shallow water even the temperature is unsuitably "hot" for them in October? It is generally accepted that salmon use olfactory cues to find their natal river. Since the river water is lighter than sea water, it distributes near the surface. Probably salmon are searching the odor of their natal river in the shallow water even if it is "hot". The minute to minute record by the logger allowed us to analyze the behavior of chum salmon in the surface water in detail, and we found the evidence which indicated that salmon were smelling the river water. In October, data loggers recorded the cool water masses that covered warmer sea surface in patches.