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JARE-The Sea Ice Ecology and Flux Study (SIEFS Program, 1991-1994)

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During the last decade several international programs of the Southern Ocean biology, such as BIOMASS, were strongly promoted and biological information has increased remarkably. Nevertheless, our knowledge of sea ice biology in this region is still scarce and limited. The biological process characterized by the prominent seasonal variation and sea ice is unique, and significance of the sea ice study is increasing in relation to recent concerns on the global change.

Taking above into consideration, Scientific Committee on Antarctic Research (SCAR) established a new specialist group "Group of specialist Southern Ocean Ecology". The new group identified the urgent need of developing a coordinated multidisciplinary research program to investigate how the Antarctic sea ice and it's dynamics influence the marine biological process, ecosystem and matter cycling. The group held two workshops on "Ecology of Antarctic Sea Ice Zone" and noted that the exisitng Southern Ocean JGOFS (SOJGOFS) program, one of the SCAR-IGBP programs, is an important component of the group's program.

In parallel with the SCAR-SOJGOFS developement, Japanese IGBP program was also formalized in several disciplines. The Japanese National Committee for IGBP was established as a special committee of the Science Council of Japan. Among seven marine research working groups issued by Special Committee of IGBP, the marine process working group "Matter cycling and biological production in the ocean" recognized the important role of the polar regions in the global environmental change. The research item of "Biological processes and matter cycling in polar region" was included as one of five main items.

Concurrently, the Japanaese National Committee for JGOFS was also formally established as subcommittee of the Liaison Committee for Oceanic Research of the Science Council of Japan. While the Japanese JGOFS is focusing its main interests into western North Pacific Ocean, the Polar region is also recognized as an important JGOFS related research area.

In accordance with above activities, Japanese Research Expedition (JARE) developed a new program Sea Ice Ecology and Flux Study (SIEFS) which aims to understand the biological process of this unique biosphere. In the program along wiht the biological and ecological studies, the flux study will be conducted as a major part of Southern Ocean JGOFS. SIEFS starts from 1991/1992 season as five years program of JARE. During the first three years the program will be conducted through a year at Syowa Station area where first ice prevails.

The Antarctic sea ice play important roles in the Antarctic marine biological process and ecosystem. The sea ice cover the vast area of the Southern Ocean and it extends and retreats seasonally (16×10^6 6km^2 at maximum and 2.5×10^6 6 km^2 at minimum, ZWALLY *et al.*, 1979). Sea ice gives important habitat to many organisms and, a unique ice biota is formed within and just beneath ice. Ice algae is known as dominant organisms among the ice biota. In the brine socket of sea ice, many micro-organisms are found and Antarctic krill strongly graze on the ice algae and others within ice biota during the

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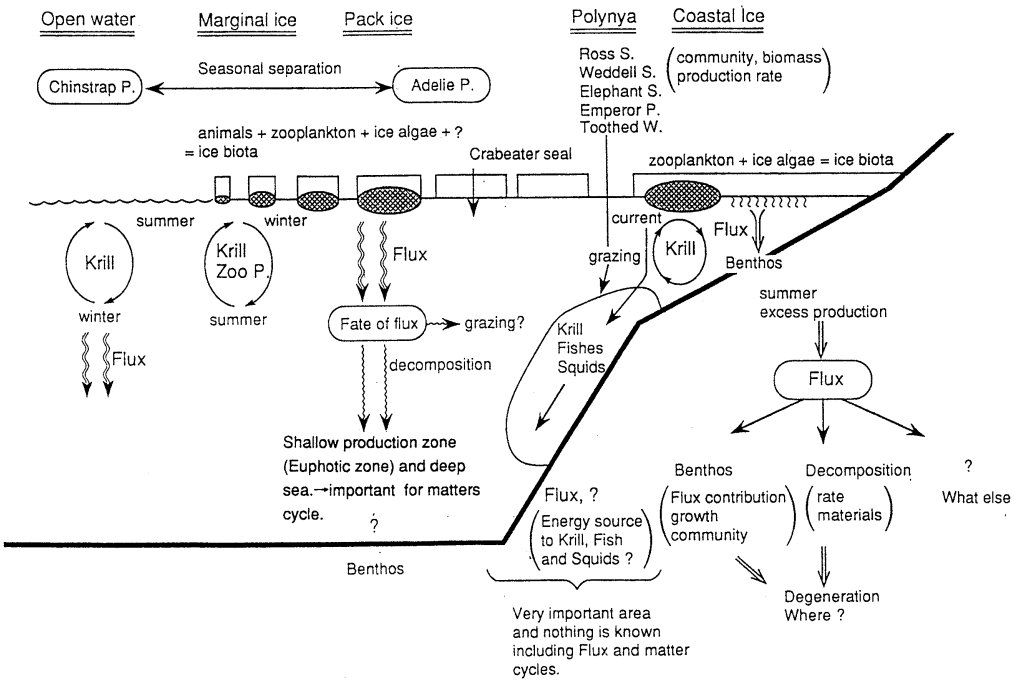

Fig. 1. In relation to ice condition and geographical topography, Antarctic sea ice area is sperated into the pack ice area, the coastal polynya area and the fast ice area and schematic zones are given.

winter season (MARSCHALL, 1988). Not only such smaller organisms but larger predators such as penguins and seals have strongly association with ice. They either rest and breed on it or forage beneath ice.

As well as sea ice, prominent seasonal variation of the solar radiation also influence the Antarctic marine process and ecosystems. Strong solar radiation in summer and poor in winter make large difference in primary production between both season and give unique overwintering strategies to the higher producers. The seasonal variation is more prominent in higher latitude. In general, fast ice develops in the coastal water within the coastal shelf zone and pack ice extends toward north from fast ice. The coastal polynya develops frequently between the fast ice and the pack ice area where shelf break or shelf zone are found. As shown in figure 1, different schematic zone is given in relation to sea ice, bottom topography and oceanographic features in the Southern Ocean and features of the biological process and ecosystem are different between these zones.

In the coastal zone, ice algae contribute to the primary production more than the primary production in the water column (WATANABE and SATOH, 1987). Released algae in summer when ice melts sank to bottom as the excess production. The fate of these flux, mostly ice algae is unknown, however primary production seems to linked directly to the benthos. The biomass of the benthos in this area is very high (NUMANAMI *et al.*, 1986). In winter, almost nothing of primary production occurs in this area (Fig. 2), and the Antarctic krill (*Euphausia superba*) feed on detritus on the bottom (KAWAGUCHI *et al.*, 1986).

Ice algae grow in the pack ice zone and become major component of the flux. However, it is not certain when and how ice algae of in pack ice is released and grazed. The facts we know is that the Antarctic krill feed on the ice algae and some others

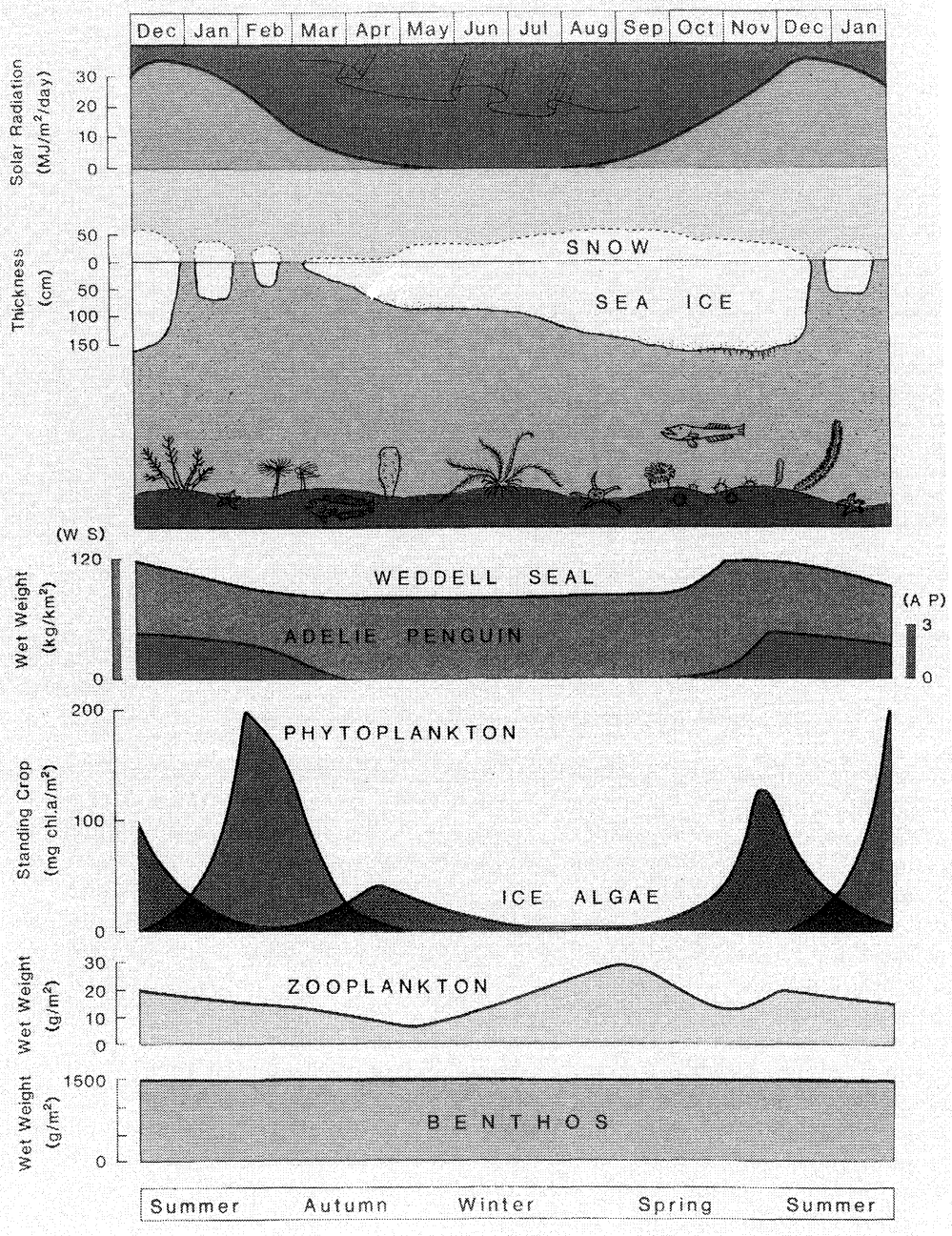

Fig. 2. Seasonal variation of solar radiation influences the biomass of the marine organisms.

beneath the ice during winter (MARSCHALL, 1988) and Adelie penguin and crabeater seal, of which diet is the krill, are distributed within the pack ice while some penguins do not come into the pack ice zone (AINLEY and DEMASTER, 1990). In summer the pack ice retreat and primary production increase in water column in the pack ice area. These area also important source of flux. The fate of flux is still unknown.

The shelf and shelf brake zone where coastal polynia develops is a kind of hot spot. According to ICHII (1990), the high concentrations Antarctic krill and minke whale are found in this area. Also subantarctic southern elephant seal migrate to this area to forage benthic animal, mostly cephalopods (HINDEL *et al.*, 1991. in press) Emperor penguin also forage this area through a year. However productivity, biological process and fate of flux of this area is not known due to logistic difficulty for observation.

During SIEFS program JARE will conduct several filed experiments to estimate biological production and to determine the source nad fate of flux using the several mooring buoy system which are equipped sediment traps, fluorescent meter, current meter and etc. SIEFS's particular interest is focussed on the role of ice in the above relevant subjects in different zones as mentioned.

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