

## IV. Introductory Remarks

"Ohayo-gozaimasu (Good morning)," ladies and gentlemen.

It is a great honor for me to make the introductory remarks at this very first symposium of the North Pacific Anadromous Fish Commission (NPAFC), entitled "Assessment and Status of Pacific Rim Salmonid Stocks," here in Sapporo, Japan. My major field is planktology, not the biology of salmon. Therefore, some of you may wonder why I have been given the chairmanship of this symposium. Let me explain. Although I am not a salmon biologist, I am not a complete layman in the field either. Since relationships between plankton and salmon are very close in natural systems, plankton biologists and salmon biologists are also closely connected.

It was the famous planktologist, the late Professor Sigeru Motoda of the Faculty of Fisheries of Hokkaido University (FFHU), who repeatedly emphasized the importance of the systematic and quantitative investigation of the plankton communities in the subarctic Pacific. This is because the subarctic Pacific nurtures rich populations of commercially important fish, including Pacific salmon (cf. Taniguchi 1995). During his time at Hokkaido University, Dr. Motoda was always the leader of the long-term plankton investigation, starting from the inception in the 1950s (Motoda and Minoda 1974). He always encouraged FFHU people to continue this investigation. Such investigations were not easy in Japan in the years shortly after World War II. Because the fisheries harvesting salmon and many other species of fish were of particular economic importance in Japan, most people tended to quickly promote technical and practical work to increase the catch, rather than investigating the environmental factors that control fish production in natural systems. However, after much effort Dr. Motoda finally got agreement from the staff of FFHU and was able to draw financial support from the Fisheries Agency of Japan (JFA). Every year since then, the JFA has supported such plankton investigations as part of the ocean surveys of Pacific salmon, which were originally carried out by the FFHU's Training Ship *Oshoro Maru*, and later also by the *T/S Hokusei Maru*. The data obtained by these surveys have been regularly published in the Data Record of the Oceanographic Investigations and Exploratory Fishing, which has been published annually since 1957 by FFHU.

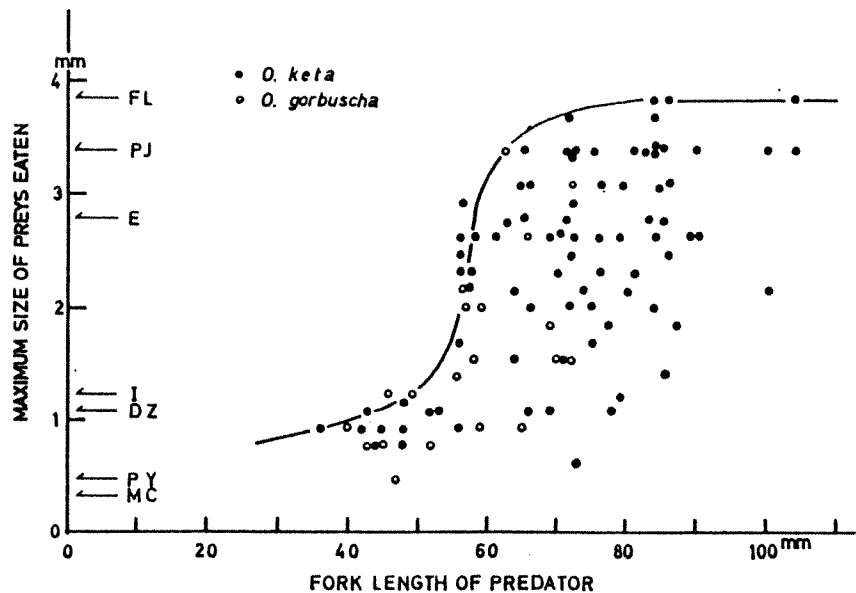
The accumulated data, begun under Dr. Motoda's leadership in the 1950s and continuing today, are now recognized as one of the longest ongoing studies of the biomass of summer zooplankton in the subarctic Pacific Ocean. This data set is now a shared treasure

among the Pacific Rim countries, and is frequently quoted in modern analyses of the long-term trend of plankton productivity (e.g. Brodeur and Ware 1992). I am very proud of my own contribution, though very small, to this data set which I made when I was a student of Professor Motoda. It is very regrettable that he passed away last year, on 24th September, 1995. If he were alive, he would be here and make us enjoy his invaluable, although sometimes dry and acerbic, comments on the salmonid studies of today.

Just after I "hatched out" of his supervision, I did an investigation of the gut contents of the salmonid fry inhabiting the inshore water of southern Hokkaido, Japan (Okada and Taniguchi 1971). Fig. 1 is the main conclusion of that work, indicating that the feeding capability of salmonid fry suddenly increases during their life in inshore waters. Development of their feeding capability is not a simple linear function of their body size. This trend was clear when their prey size was expressed in body width, instead of body length, which may explain the relative difficulty for the fry to bite their prey organisms. In other words, the predatory capacity of salmon fry may not be determined only by the swimming or escaping ability of the prey organisms, which is related as a linear function of their body length. Instead, the development of predation capability of the salmon fry may be much more important. This capacity may follow discrete stages, or steps, as a result of a possible stepwise development in the function of feeding organs like the mouth and eyes, as well as their swimming ability.

Lying in the background to this symposium is the question of the future of the Pacific salmonid populations, and the uncertainty concerning the healthiness of these rapidly growing populations. Although an increase in stock size is basically welcomed, concurrent declines in body size and increasing age at maturity, plus the slump in the market value resulting from increased catches are causing anxiety about the future. To resolve this issue, it is necessary to determine and monitor the size and status of the salmonid stocks. Therefore, the subject of this symposium is quite suitable for the first NPAFC symposium. I sincerely hope for all participants that this symposium will be a forum leading to continual cooperative international investigations on Pacific Rim salmonid populations. Of course, planktologists will also contribute to these investigations in various aspects. For example, I expect that planktologists may predict changes in the taxonomic composition of the subarctic zooplankton community under increasing predation pressure by salmonid populations.

Fig. 1 Prey-predator relationship in size between chum and pink salmon fry and food organisms observed in inshore waters of southern Hokkaido, Japan. Sigmoid curve traces size of the largest prey ingested by fry of various fork lengths. Arrows indicate the maximum size (measured as body width) of common prey organisms: micro-copepods (MC), young *Parathemisto* spp. (PY), decapod zoea (DZ), insects (I), adult euphausiids (E), adult *Parathemisto japonica* (PJ), and fish larvae (FL). (After Okada and Taniguchi, 1971).



In the subarctic Pacific, nutrients are hardly depleted by primary producers even in summer (Anderson et al. 1969; Taniguchi 1972; Shiimoto 1994; Saito 1996; Kasai et al. 1997). The stock of nutrients in summer is quite large compared to those of phytoplankton and net zooplankton (Table 1), except in the Oyashio region where intensive diatom blooms occur in April/May (Kasai et al. 1997). This indicates that the primary production in summer in these sea areas is controlled by other factors than nutrient limitation. Zooplankton grazing is the most probable factor (e.g. Frost 1983, 1991; Shiimoto et al. 1997). It was recently reported that microzooplankton are major grazers in the Gulf of Alaska (Miller et al. 1991; also cf. Banse 1995; Landry et al. 1997), where net zooplankton biomass is particularly low among the subarctic Pacific sea areas (Table 1). Grazing pressure by net zooplankton alone is not large enough to control the phytoplankton growth there (Miller and Nielsen 1988: cited from Miller et al. 1991). On the other hand, there have been some indications that the daily food requirement of net zooplankton is relatively large compared to daily primary production in the Oyashio region and the Bering Sea (cf. Taniguchi 1973; Ikeda and Motoda 1978a,b). If the latter is the case, net zooplankton control the primary production in these sea areas. This seems to be supported by the fact that net zooplankton biomass is apparently large in the Bering Sea and Oyashio region (Table 1). Dominant herbivorous zooplankters in these areas are not microzooplankton (Taniguchi, 1984), but large-sized

crustaceans such as *Calanus* spp., amphipods and euphausiids.

When the increasing salmon populations feed on these crustaceans, phytoplankton released from the grazing pressure can increase by taking advantage of the rich nutrients (Cooney 1988; Shiimoto et al. 1997). In such a situation, it can be possible that the production of zooplankton increase again. This is analogous to the cattle-farming technique that thins out excess cattle from a limited area of the grazing land. In nutrient rich areas like the subarctic Pacific, the thinning-out process of net zooplankton (in this case by increasing salmon predation) may enhance total plankton production (Taniguchi 1992). In other words, it is not impossible that the increasing salmonid biomass can expand the carrying capacity of their own habitat. However, this does not necessarily mean that the increased plankton production expands in a directly-proportional manner with the carrying capacity. Again the relationship between these two may be non-linear.

Zooplankton populations which emerge after intensification of salmonid predation would not be exactly the same as those before the predation. *Calanus*, amphipods, and euphausiids possess a life span of one year or more and usually spawn at depth in cold seasons. Although their young are abundant in the surface layer in spring and early summer, they all descend to depth well below the surface layer by late summer (e.g. Heinrich 1957; Ponomareva 1963; Fulton 1973; Miller et al. 1984). Therefore, if predation removes them from the surface layer during

**Table 1. Average values of stocks of nitrate-nitrogen, phytoplankton chlorophyll *a* and net zooplankton wet weight (>330  $\mu\text{m}$ ) in surface layer of different open sea areas of the subarctic Pacific in summer. Equivalent carbon weight of each stock is also given.**

Sea area (Reference)	$\text{NO}_3\text{-N}^{\text{a}}$		Phytoplankton <sup>b)</sup>		Net zooplankton <sup>c)</sup>	
	( $\mu\text{M}$ )	( $\text{mgC m}^{-3}$ )	( $\mu\text{gChl l}^{-1}$ )	( $\text{mgC m}^{-3}$ )	( $\text{mgWW m}^{-3}$ )	( $\text{mgC m}^{-3}$ )
Bering Basin (3, 5)	15	1193	0.9	45	450	22.5
South of Aleutian (2, 5)	13	1034	0.3	15	200	10.0
Gulf of Alaska (1)	11	875	0.3	15	100	5.0
Oyashio Region (2, 4, 5)	2	159	0.5	25	340	17.0

Conversion factors to carbon weight: <sup>a)</sup>  $12 \times 10^{16}$ , <sup>b)</sup> 50, <sup>c)</sup> 0.05

Reference: 1 Frost (1983), 2 Kasai et al. (1997), 3 Motoda and Minoda (1974),  
4 Saito (1996), 5 Taniguchi (1972)

warm seasons, their population cannot recover until the next winter/spring. Opportunistic zooplankters which can increase during warm seasons should be those which possess shorter life spans and rapid growth rates. Apart from the microzooplankters, which have been confirmed to predominate in the Gulf of Alaska (loc.cit.), small-sized copepods, for example, *Acartia*, *Oithona*, *Pseudocalanus*, and most gelatinous zooplankters, such as hydromedusae and salps, are the most probable components of the latter type of zooplankton (Fig. 2). Lower abundance of large-sized copepods in the years when abundance of pink salmon is high is actually found south of the Aleutians (Shiomoto et al. 1997). This shift in zooplankton species composition should alter its value as food stock for different salmonid species. Such an alteration then will change the carrying capacity in a

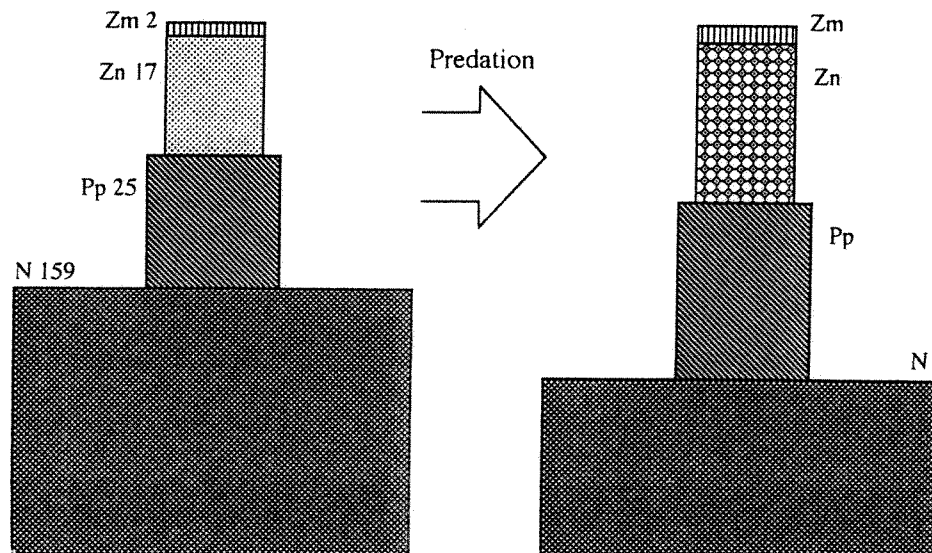
species-specific manner, and in the final analysis, change the salmonid populations' species composition.

The Steering Committee has accepted 71 papers from six countries for presentation: Canada, Japan, Korea, Russia, the U.K., and the U.S.A. Twenty-four of the 71 papers will be presented orally and the remaining 47 will be presented at the poster session. We hope this symposium will lead all participants to fruitful discussions and the consolidation of future cooperative research and management of our Pacific salmonid stocks.

Thank you very much.

Akira Taniguchi  
Chairman  
Steering Committee

**Fig. 2. Diagram illustrating a potential alteration in species composition of net zooplankton after intensified predation by salmon in the nutrient-rich subarctic Pacific in summer/fall. Dominant species of net zooplankton would change from larger crustaceans such as *Calanus*, amphipods, and euphausiids to small-sized copepods and gelatinous plankters such as hydromedusae and salps. For standing stocks before predation, average values in Oyashio region (listed in Table 1) are adapted to nutrient (N), phytoplankton (Pp) and net zooplankton (Zn). Biomass of microzooplankton (Zm) is assumed to be ca. 10% of Zn (cf. Taniguchi, 1984).**



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## REFERENCES

- Anderson, G.C., T.R. Parsons, and K. Stephens. 1969. Nitrate distribution in the subarctic northeast Pacific Ocean. *Deep-Sea Res.* 16: 329-334.
- Banse, K. 1995. Community response to IRONEX. *Nature* 357: 112.
- Brodeur, R.D., and D.M. Ware. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. *Fish. Oceanogr.* 1: 32-38.
- Cooney, R.T. 1988. Distribution and ecology of zooplankton in the Gulf of Alaska: A synopsis. *Bull. Ocean Res. Inst. Univ. Tokyo*, 26: 27-41.
- Frost, B.W. 1983. Interannual variability of zooplankton standing stock in the open Gulf of Alaska, p 146-157. In: W.S. Wooster (ed.) *From year to year*. Washington Sea Grant Program, Univ. Wash., Seattle.
- Frost, B.W. 1991. The role of grazing in nutrient-rich areas of the open sea. *Limnol. Oceanogr.* 36: 1616-1630.
- Fulton, J.D. 1973. Some aspects of the life history of *Calanus plumchrus* in the Strait of Georgia. *J. Fish. Res. Bd Can.* 30, 811-815.
- Heinrich, A.K. 1962. The life history of plankton animals and seasonal cycles of plankton communities in the oceans. *J. Cons. int. Explor. Mer* 27: 15-24.
- Ikeda, T., and S. Motoda. 1978a. Estimated zooplankton production and their ammonia excretion in the Kuroshio and adjacent seas. *Fish. Bull.* 76: 357-367.
- Ikeda, T., and S. Motoda. 1978b. Zooplankton production in the Bering Sea calculated from 1956-1970 Oshoro Maru data. *Mar. Sci. Comm.* 4: 329-346.
- Kasai, H., H. Saito, A. Yoshimori, and S. Taguchi. 1997. Variability in timing and magnitude of spring bloom in the Oyashio Region, the western subarctic Pacific off Hokkaido, Japan. *Fish. Oceanogr.* 6: 118-129.
- Landry, M.R., et al. 1997. Iron and grazing constraints on primary production in the central equatorial Pacific: An EqPac synthesis. *Limnol. Oceanogr.* 42: 405-418.
- Miller, C.B., B.W. Frost, H.P. Batchelder, M.J. Clemons, and R.E. Conway. 1984. Life histories of large, grazing copepods in a subarctic ocean gyre: *Neocalanus plumchrus*, *N. cristatus* and *Eucalanus bungii* in the northeast Pacific. *Prog. Oceanogr.* 13: 201-243.
- Miller, C.B., B.W. Frost, P.A. Wheeler, M.R. Landry, N. Welshmeyer, and T.M. Powell. 1991. Ecological dynamics in the subarctic Pacific, a possibly iron-limited ecosystem. *Limnol. Oceanogr.* 36: 1600-1615.
- Miller, C.B., and R.D. Nielsen. 1988. Development and growth of large, calanid copepods in the oceanic subarctic Pacific. *Prog. Oceanogr.* 24: 275-293.
- Motoda, S., and T. Minoda. 1974. Plankton in the Bering Sea, p 207-241. In D.W. Hood and E.J. Kelley (eds.) *Oceanography of the Bering Sea with emphasis on renewable resources*. Inst. Mar. Sci., Univ. Alaska, Fairbanks.
- Okada, S., and A. Taniguchi. 1971. Size relationship between salmon juveniles in shore waters and their prey animals. *Bull. Fac. Fish. Hokkaido Univ.* 22: 30-36.
- Ponomareva, L.A. 1963. The Euphausiids of the North Pacific, Their Distribution and Ecology. *Doklady Akademy Nauk, SSSR*, 142 pp. (Israel Programme for Scientific Translation, Jerusalem, 1966).
- Saito, H. 1996. Study on the seasonal variability in the productivity of lower trophic levels and diel feeding rhythm of copepods in the Oyashio Region. *Bull. Hokkaido Natl. Fish. Res. Inst. No. 60: 1-144.* (In Japanese with English abstract).
- Shiomoto, A., K. Tadokoro, K. Nagasawa, and Y. Ishida. 1997. Trophic relations in the subarctic North Pacific ecosystem: possible feeding effect from pink salmon. *Mar. Ecol. Prog. Ser.* 150: 75-85.
- Taniguchi, A. 1972. Geographical variation of primary production in the western Pacific Ocean and adjacent seas with reference to the inter-relations between various parameters of primary production. *Mem. Fac. Fish. Hokkaido Univ.* 19: 1-33.
- Taniguchi, A. 1973. Phytoplankton-zooplankton relationships in the western Pacific Ocean and adjacent seas. *Mar. Biol.* 21: 115-122.
- Taniguchi, A. 1984. Microzooplankton biomass in the arctic and subarctic Pacific Ocean in summer. *Mem. Natl. Inst. Polar Res. Spec. Issue* 32: 63-76.
- Taniguchi, A. 1992. The ecological importance of characteristics of plankton productivity: from a viewpoint of the fish. *Proc. Japan Sci. Coun. Fish. Resour.* 28: 1-10. (In Japanese with English abstract).
- Taniguchi, A. 1995. Dr. Sigeru Motoda (1908-1995). *Bull. Plankton Soc. Japan* 42: 101-103.