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## Ocean Salmon Survey Methods, 1995-1997

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# Ocean Salmon Survey Methods, 1995-1997

## Abstract

The Methodology Standardization Working Group (MSWG) was formed in 1995 to focus on methods presently in use for ocean salmon surveys by North Pacific Anadromous Fish Commission-member nations. The survey methods considered in this summary were conducted by Canada, Japan, Russia, and the United States on their respective ocean salmon research cruises from March 1995 to August 1997. This summary includes methods for collecting data on hydrography, zooplankton, and juvenile and adult salmon. From 1995 to 1997, juvenile or adult salmon surveys have been conducted in inshore and offshore waters of the western, central, and eastern North Pacific Ocean, Okhotsk Sea, and Bering Sea. Hydrographic sampling commonly employed CTD casts, but less often included water sampling for collection of chlorophyll, silicate, or phosphate levels. Zooplankton was sampled using a variety of vertically or obliquely towed nets including Norpac, WP-2, SCOR, Judey net, Bongo, and Melnikov and Tucker trawls. All nations used trawl gear to capture juvenile or adult salmon. An identical midwater rope trawl (CanTrawl) design was used by both Canadian and U.S. salmon researchers. Gillnets were used for capture of salmon aboard Japanese and Russian salmon research vessels. In addition, trolling and jigging gear were used on board Russian vessels, and longlines were used on Japanese research vessels to catch salmon. Salmon sampling includes sorting and counting by species, length and weight measurements, scale and otolith collections, stomach content examination, and collection of tissues for genetic studies. These data were collected either on shipboard or the fish were frozen in the round and brought back to the laboratory for detailed examination and collection of tissues. Recognizing the limitations of each research program, which is dictated by the capability of the research vessel, the limitations of the scientific crew, and the sampling priorities of each individual research program, the MSWG makes preliminary recommendations in the following areas: (1) sampling gear and methodology used on salmon research cruises should be widely and regularly reported; (2) methodology standardization could be improved in areas of hydrography, zooplankton, and collecting data on salmon and non-salmonid catches; and (3) gear intercalibration experiments should be continued and expanded.

## Introduction

In 1995, at the Research Planning and Coordinating meeting of the North Pacific Anadromous Fish Commission (NPAFC), the Methodology Standardization Working Group (MSWG) was formed to focus on salmon research survey methods presently in use by member nations (NPAFC 1995). The objective of this report by the MSWG<sup>1</sup> is to provide a summary of each nation's survey methods as a basis for future discussions regarding data quality, ease of application of particular methods, and data continuity and comparability over time for a given program, and among different research programs. Survey methods considered in this summary include the following data types: hydrography (CTDs and water samplers), zooplankton (size and taxonomic range), juvenile and adult salmon, and others (satellite images, current meters, sediment trap moorings, climatology). The national summaries were based on information compiled from questionnaires and

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<sup>1</sup> This report was prepared jointly by MSWG members and the listed order of authorship is alphabetical by country.

interviews with salmon scientists who conducted NPAFC-related salmon research during the period March 1995 to August 1997.

This document is divided into sections summarizing the survey methods used in the ocean salmon research program of each country (Sections I-IV). The MSWG preliminary recommendations are given in the final section of the document (Section V).

## **I. Salmon Survey Methods Used in the Research Program of Canada**

To develop a summary of field sampling methods used on salmon surveys in the North Pacific, the Canadian author prepared a sampling methods questionnaire (Appendix 1). This questionnaire was sent to the four Department of Fisheries and Oceans scientists responsible for recent (1995-present) Canadian oceanic salmon surveys. Note that this questionnaire is restricted to "methods presently in use"; it's a listing of what Canadian salmon researchers are doing rather than a prescription for what methods and tools they or others should be using.

Full questionnaire responses were given in March 97 to working group members and to the NPAFC Secretariat. Results are summarized by measurement category.

### **1. Research vessel**

All recent Canadian surveys have been from the 1104-tonne stern trawler *R/V WE Ricker*.

### **2. Hydrographic sampling**

Canadian researchers have used a variety of instruments (Guildline, SeaBird, and Applied Microsystems; set by instrument availability) and maximum profile depths (ranging 300-1000 m; choice set by project objective, location, and time availability). Data are catalogued and archived in a standard format (using computer programs developed at the DFO, Institute of Ocean Sciences). Existing procedures for laboratory CTD sensor calibrations and post-survey data quality evaluation have occasionally proved inadequate. Plans are underway to standardize on a single instrument manufacturer (probably SeaBird) and to make calibrations and collection of sea-truth samples more frequent and systematic.

### **3. Zooplankton sampling**

All Canadian researchers sample zooplankton using upper-ocean vertical and/or oblique hauls with medium sized (circa 0.5 m<sup>2</sup> mouth area) plankton nets (Table 1). Within this general category, they have used several different net types and tow depths (Table 1). There is a need for internal calibration studies of relative capture efficiency by the various net types. Some of these (SCOR vs. NORPAC vs. bongo 150 m vertical hauls) are scheduled to be done in 1996 through 1998 by the Canadian Global Ocean Ecosystem Dynamics (GLOBEC) program. Data cataloguing and archiving is at present in a variety of formats and by the individual researcher, but data will gradually be converted to a common format using a commercial database.

### **4. Salmonid sampling**

Usually surface-layer hauls with the CanTrawl rope trawl or Bernard-Sigmund beam trawl are used to collect juvenile salmon (Table 2). Abundance estimates are per swept volume. Some work is underway to estimate relative capture efficiency as a function of salmon age. Surface, midwater, or bottom trawls with CanTrawl rope trawl is used to capture adult salmon. Capture of adult salmon is done coincident with juvenile salmon sampling or with groundfish surveys. The principal salmon biological characters that are

measured include fork length, body weight, sex, and weight of stomach contents. Whole fish, scales, otoliths, and stomach contents are sampled (Table 3).

### 5. Sampling for other variables

Sampling other variables are occasionally performed using hull-mounted RDI doppler acoustic profiler for determination of current velocity and vacuum filtration on GF filters for chlorophyll and C, N stable isotope analyses to collect data on phytoplankton.

## II. Salmon Survey Methods Used in the Research Program of Japan

This report was compiled in order to satisfy two purposes. The first purpose was to list the current methods used in Japanese governmental offshore salmon research and the second purpose was to show Japanese views on the methodology standardization of salmon research in the frame-work of the NPAFC.

The Japanese author collected information on methods used in current Japanese offshore salmon research using a simple questionnaire. In some cases, responses to the questionnaire were further clarified by interviews with the senior researcher. In addition, gear specialists were sought for their advice about desirable methodology for each research item, and comments were made with a view towards standardization of methodology based on the present state of research methods and advice from gear specialists.

### 1. Research vessels and cruises

**Present state.** Fisheries Agency of Japan (FAJ) used six research vessels to investigate salmon stock assessment in the North Pacific and its marginal seas in the 1996 fiscal year (Table 4). The research vessels *Kaiyo maru* and *Shunyo maru* belong to FAJ and were engaged in stock assessment of juvenile salmon. Both are stern trawlers. Their research areas were the Sea of Okhotsk and coastal waters off the Kuril Islands.

The *Wakatake maru*, *Hokko maru*, *Hokusei maru*, and *Oshoro maru* were engaged in gillnet research for stock assessment of immature and maturing salmon (Table 4). These vessels conducted surveys in the offshore waters of the Pacific Ocean and the Bering Sea, and performed multiple functions for fisheries research. The *Hokko maru* belongs to FAJ, and the *Wakatake maru* is a training ship for the fisheries high school students of Hokkaido. The FAJ chartered her for salmon research. In 1997, the (old) *Wakatake maru* (424 gross tons) was replaced by a substantially larger (new) *Wakatake maru* (666 gross tons). The *Hokusei maru* and *Oshoro maru* are the training vessels of Hokkaido University. They conduct salmon research to provide students with an educational experience (Table 4).

**View towards methodology standardization.** Research vessels are the most important instruments for salmon research. Knowledge of the vessel's capabilities helps in interpretation of research results. Accordingly, a simple description of the vessel including ship name, gross tonnage, ship type, research objectives, survey period, and area of operations should be reported just after or before the cruise.

### 2. Hydrographic sampling

**Present state.** All the research vessels were equipped with some CTD system (Table 5). Maximum depth of observations ranged from 500 to 1500 m. Variables measured included seawater temperature, salinity, and pressure (depth). Some CTD systems had dissolved oxygen (DO) sensors. Accuracy of the temperature values ranged from 0.002 to 0.004 and resolution of sea water temperature values ranged from 0.01 to 0.0004. Accuracy of salinity values ranged from 0.05 to 0.003 and resolution ranged from 0.01 to 0.0004. The CTD systems provided output on floppy disk. Most CTD systems were regularly overhauled by the manufacturers (Table 5).

**View towards methodology standardization.** The objectives of oceanographic observation in salmon offshore research is to collect data on ocean front structures and to confirm long term changes of ocean environments. Measurement accuracy of water temperature and salinity should be within 0.05, so that ocean front structures can be accurately determined. Moreover, the standard deviation of annual mean temperature and salinity in the upper layer (0-500 m) of the Subarctic North Pacific Ocean are more than 0.1°C and 0.05 psu (Levitus, 1982). Accordingly, the CTD system should be maintained whereby these objectives can be achieved (to an accuracy within 0.05 in temperature and salinity). Temperature and salinity should be recorded to the third decimal place according to the resolution of most CTD systems.

The length of wire that can be wound onto the winch of the vessel and the time that can be allotted for observations strongly limits the maximum depth of observations. For most Japanese salmon research vessels, oceanographic observations ranging from 0-1500 m are near the limit of their capacity of allotted time and wire length. Favorite et al. (1976) noted that seasonal changes in seawater density in the subarctic regions of the North Pacific Ocean occurred in the layer which is shallower than 300 m. They concluded that dynamic topographic charts of the 0 to 2000 m layer in these regions could be extrapolated and composed from data of temperature and salinity in the 0 to 500 m layer. Accordingly, CTD casts to 1500 m, or if this is impossible, casts to a minimum of 500 m is recommended.

The National Research Institute of Fisheries Science recommends that domestic oceanographers should produce data files on oceanographic observations according to an established format. This format includes information on depth, temperature, salinity, and other basic information on ocean and weather conditions (Appendix 2). Oceanographic data recording from the offshore salmon research program has not yet followed this guideline. However, there is a plan to begin using this format in the near future. Data files in accordance with this format are sent to the National Oceanographic Data Center (NODC)<sup>2</sup> through the Japan Oceanographic Data Center (JODC). This uniform format is useful for international data exchange and utilization.

### 3. Zooplankton sampling

**Present state.** The NORPAC and the remodeled NORPAC nets (Motoda, 1994) were the main sampling gear (Table 6). Both NORPAC nets were generally towed vertically from 0 to 150 m. Samples were preserved with 10% seawater formalin (buffered). Filtering volume was measured using a flowmeter. IONESS nets (this gear has the same function as the MOKNESS net) and BONGO nets were sometimes used. However, the use of these nets was not a standard practice. Methods for sorting and listing samples collected were different among researchers.

**View towards methodology standardization.** Recently, there were discussions regarding plankton nets suitable for offshore zooplankton research among FAJ fisheries scientists, and it was agreed that the remodeled NORPAC net should be used (Mori, 1992; Motoda, 1994). The remodeled NORPAC net performs well in terms of the open area ratio (6.5) and the filtration ratio (91.4%). On the basis of on this agreement, scientists at the Tohoku National Fisheries Research Institute (TNFRI) of FAJ wrote a manual of techniques for everything from collection of zooplankton to arrangement of data for Japanese fisheries scientists (TNFRI, 1994). The National Research Institute of Far Seas Fisheries has conducted plankton sampling and sorting of offshore samples in accordance with this manual. Zooplankton are sorted and identified into 12 categories (Appendix 3) and weighed (mg/m<sup>3</sup>). This procedure was not followed in some recent Japanese salmon

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<sup>2</sup> National Oceanographic Data Center, NOAA, Washington DC.

research cruises. However, it has been recommended to Japanese fisheries scientists that they follow this manual for their basic plankton sampling for offshore fisheries research.

To compare the historical data and domestic data in other fields of fisheries, the plankton sampling conducted during offshore salmon research should follow the manual of TNFRI. Various kinds of plankton nets have been used for sampling zooplankton in other countries, therefore, it is necessary to develop a conversion table of efficiencies among the currently employed and widely-used plankton nets in order to compare the zooplankton data among the NPAFC-member countries.

#### 4. Salmonid sampling gear

**Present state.** Trawls and gillnets were used to collect salmon and other large-sized organisms (Table 7). Basic information about the sampling operation is recorded in a standard format (Appendix 4). The trawl has a pair of trawl doors to force the mouth of the net open. The size of trawl nets are comparatively large and their towing velocity is about 5 kts. Two types of trawls are effective in collecting not only juveniles, but also immature and maturing salmon (Table 7).

In summer, gillnets were the main sampling gear used to collect salmon in offshore habitats. Two types of gillnets were used. The first gillnet consisted of 18 mesh sizes (19-157 mm) and the second gillnet consisted of 10 different mesh sizes (48-157 mm; Table 7). The standard gillnet now in use is the second design and includes 3 tans each of the following (10) mesh sizes: 48, 55, 63, 72, 82, 93, 106, 115, 121, 138, and 157 mm (Table 7). These mesh sizes follow a geometric series. The standard gillnet was devised in 1966 and improved in 1971 (Ishida et al., 1966; Takagi, 1975). This gillnet is thought to be non-size selective in surface waters for salmon that range from 25 to 70 cm fork length. The gillnet with 18 mesh sizes includes some of the same meshes as the 10-mesh gillnet. Additional gillnets, or panels of different size meshes are attached at both ends of the standard gillnet (10 meshes) as an aid in spreading the gillnet.

Longlines are sometimes used for tagging experiments because often these salmon are caught alive and in good condition. Longlines are also used when other fishing gear is not permitted (Table 7).

**View towards methodology standardization.** Current widely-used fishing gear for offshore salmon research include trawls and gillnets. The trawl is used mainly for collecting juvenile salmon and for wintertime research. Gillnets are used for summer offshore research that targets on immature and maturing salmon. Advantages of both types of fishing gear are listed in Appendix 5.

In many cases, a large mid-water otter trawl was used for recent offshore salmon research (for example, Ueno et al., 1994; Shuntov et al., 1993; Morris, 1991). These nets are towed at about 4 to 6 kts. It is difficult to standardize among trawls because power and equipment for operation are different among vessels. However, when the height and width of the trawl opening and the towing speed is known, the swept area can be roughly estimated. Therefore, it is desirable to add information on the size of the opening and the towing speed of the trawl to the items routinely recorded during research vessel operations (Appendix 4).

Generally, there are difficulties in comparing efficiencies among sampling gear. For example, it is assumed that the efficiency of a large trawl is higher than a small trawl. Moreover, the efficiency of the gillnet may vary depending on swimming speed of fish and weather conditions. It is recommended that an efficiency conversion table be developed for the salmon sampling gear, requiring an examination of trawls and gillnets fishing efficiency conducted in offshore waters.

The ratio of the fishing efficiency of a unit of gillnet (tan) to a unit of longline (hachi) is about 1.26, with the coefficient of variation of 0.63 (Takagi and Ishida, 1971). However, at present the longline is not considered a standard salmon sampling gear

because there has been a small amount of fundamental research on longlines, and the number of longline operations currently conducted in offshore waters is few.

## 5. Salmon biological measurements

**Present state.** Fork length (FL, mm), body weight (BW, g), sex, and gonad weight (GW, g) are the standard items for biological measurement (Table 8). The number of individuals from which measurements are collected is 60 by species by mesh size. Scale samples are routinely collected from all individuals that are measured. Scales are routinely collected for the purposes of age determination and stock identification. The preferred body area for scale collection is the second scale row above the lateral line along an imaginary diagonal line that extends downward from the posterior insertion of the dorsal fin towards the insertion of the anal fin. Age is described according to the European formula (Davis et al., 1990).

Tissue samples (muscle, heart, and liver) are collected for electrophoretic analysis. Otoliths are also sampled for age determination and other purposes. Weight of the stomach contents and the proportions (percentage) of each prey category<sup>3</sup> found in the stomach contents are measured and recorded. These samples or measurements are not standard items for measurement or collection.

**View towards methodology standardization.** There are seven types of length measurements used for salmon, but fork length is the type commonly used for ocean salmon research (for example, Shaw, 1994). Fork length, body weight, sex, and gonad weight are basic biological characteristics used to describe the condition of salmon. The preferred body area for scale collection and formula for age determination (European) are the same as those of the U. S. and Canada (Davis et al., 1990). It is recommended that collection of these biological measurements, sampling from the preferred area for scales, and using the same formula for age determination should be continued because they are already commonly in use among Japan, Canada, and U. S. and there has already been an enormous accumulation of these data.

Standardization of tissue samples, otolith collections, and stomach contents analysis is difficult at the present because standard methods are not yet established for these analyses.

## 6. Non-salmonid sampling

**Present state.** Non-salmonids in the catch are sorted and the number of individuals is recorded (Table 8). A subsample of these organisms is measured for body length. These catch data are not routinely compiled onto computer-readable files.

**View towards methodology standardization.** In order to estimate salmon stock condition accurately, it is important to learn the structure of ecosystems in the North Pacific Ocean. Accordingly, information on the non-salmonid catch is valuable. Basic information on non-salmonids (for example, number of individuals collected by species) should be recorded as a standard research item.

## 7. Others

A list of basic information on the research cruises conducted by NPAFC-member countries should be made each (NPAFC) fiscal year. This list would include contact persons, ship name, gross tonnage, ship type, and describe the research objectives, time period, geographical area, and a short summary of the cruise. This list will help to educate others about the ocean salmon research cruise activities of each country.

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<sup>3</sup> The prey categories are similar to the categories used for sorting zooplankton.

### III. Salmon Survey Methods Used in the Research Program of Russia

#### 1. Research vessels and cruises

The purpose of Russian ocean salmon surveys is to identify the abundance and time of spawning of the principal salmon stocks in the production areas of the Russian Far East. Ocean salmon research cruises were conducted by researchers from KamchatNIRO (Petropavlovsk) and from TINRO-Centre (Vladivostok) aboard several vessels between 1995 and 1997 (Table 9). The ship owners were the Fish Rain Company, Pilenga-Godo, both of Petropavlovsk, and TURNIF of Vladivostok. The summer research cruises began in May or June and usually finished in July or September, but the 1996 cruise of the *SRTM-K Kamchatka Salmon* continued its sampling until early October. The fall and winter cruises usually began in October and finished in December or January. The research cruises were conducted in the northwest North Pacific Ocean, Sea of Okhotsk, and Bering Sea (Table 9).

#### 2. Hydrographic sampling

Hydrographic data were collected for seawater temperature, salinity, and depth (pressure) using CTD casts from 0 to 200 m, or 0 to 500 m (Table 10). The CTD employed by TINRO-Centre included a rosette sampler that provided for collection of sea water at several depths for determination of DO, silicates, and phosphate levels.

#### 3. Zooplankton sampling

Zooplankton were collected using the Judey net or Melnikov trawl towed vertically or obliquely from 0 to 50 m, or collected with an IKS-80 net sampling from 0 to 50 m, or 0 to 100 m (Table 11). A vertically towed big Judey net was used to collect zooplankton from two depth layers: 0 to 50 m and 50 to 200 m. Samples were preserved in 4% formalin and organisms were identified to species.

#### 4. Salmonid and non-salmonid sampling

Salmon were caught using fishing gear that included gillnets, troll gear, jiggers, and a pelagic rope trawl (Table 12). The trawl has a 12-mm minimum mesh size and it was usually towed at 4.5 to 5.2 kts. Tow duration was usually one hour. The trawl towing depth was approximately 0 to 50 m, but the gillnets, troll gear, and jiggers routinely fish at a shallower depth, from 0 to 10 m (Table 12). The salmon catch was sorted and counted by species, and the length and weight were measured and the sex determined. Scales samples were collected, if possible, and live fish caught by jigging were tagged and released. Some tissue samples were collected for more detailed examination in the laboratory to determine the presence of disease abnormalities, or provide samples for histological examination. The pelagic rope trawl was designed to collect all nekton, not just salmon, so the abundance and biomass of other fish, squid, and jellyfish could be estimated from the catch (Table 12). During the cruise, researchers recorded marine mammals and seabirds caught in the fishing gear and observed in the water in the vicinity of the ship.

The researchers responsible for conducting the KamchatNIRO and TINRO-Centre salmon research cruises are listed Table 13.

## IV. Salmon Survey Methods Used in the Research Program of the United States

### 1. Research vessels and cruises

From March 1995 through August 1997, U.S. salmon research cruises were conducted by the Auke Bay Laboratory (ABL), Alaska Fisheries Science Center, National Marine Fisheries Service. Auke Bay Laboratory has two research survey programs related to ocean salmon research. One program is an inshore/offshore cruise series in the Gulf of Alaska and the Aleutian Islands area that is part of the Ocean Carrying Capacity Program (OCC). The second survey program is a monitoring cruise series in Southeast Alaska that is designed to coordinate with the U.S. GLOBEC program in the northeast Pacific Ocean. This section summarizes the methods used by researchers conducting these salmon research programs based on a compilation of responses from a questionnaire.

Researchers on board the inshore/offshore cruises (OCC) conducted experiments on ocean distribution of salmon and migration routes related to shelf, slope, and distance from shore; salmon relative abundance, stock identity, salmon size, growth, and feeding; and co-occurrence of salmon and other fishes (Table 14). A commercial fishing vessel, the *F/V Great Pacific*, is a 38-m long Bering Sea stern trawler chartered for cruises in July through August 1996 and 1997. The sampling areas included Southeast Alaska, from Dixon Entrance extending to central Alaska around the Gulf of Alaska, and west to Attu Island, including parts of the southern Bering Sea and Bristol Bay (Table 14).

Researchers on board the Southeast Alaska monitoring cruises conducted experiments on the species composition of juvenile salmon and ecologically related species; comparisons of a rope trawl and a paired trawl on the basis of catch composition; stock-specific migration and growth information on thermally-marked juvenile chum salmon; and possible wild and hatchery stock interactions. These cruises were in June through August (approximately 20 days per year in 1995-1996) and May through October (7 or 11 days per month in 1997) aboard the U.S. NOAA (National Oceanic and Atmospheric Administration) ship *John N. Cobb*, a 29-m long multi-gear research vessel. The sampling areas included the northern and southern region of Southeast Alaska in 1995 and 1996, and the northern region and coastal areas of Southeast Alaska in 1997 (Table 14).

### 2. Hydrographic sampling

Hydrographic sampling conducted on U.S. salmon research cruises consisted of CTD casts using a SeaBird Seacat model SBE 19 (Table 15). In 1996, depth, temperature and salinity data were collected at 1-m, or 0.5-m increments from 0-100 m by researchers on the *F/V Great Pacific* and the NOAA ship *John N. Cobb*. In 1997, the maximum depth of CTD casts was extended to 300 m on board the *F/V Great Pacific*, and extended to 200 m on board the *John N. Cobb*. Dissolved oxygen was measured at 1 m intervals from 0-100, or 0-300 m, or 5 m from the bottom in shallow areas by researchers on board the *F/V Great Pacific* (Table 15).

### 3. Phytoplankton sampling

A chlorophyll sensor was used in combination with the CTD on board the *F/V Great Pacific* (Table 15). In 1997, sampling for primary production was expanded to include filtration of surface waters for later analysis of C14 and C18 isotopes, a measure of energy transfer through the ecosystem (Table 16)

### 4. Zooplankton sampling

Zooplankton sampling on the inshore/offshore cruises increased from 0 to 20 m vertical Norpac net tows in 1996, to 0 to 200 m vertical WP-2 net tows (UNESCO, 1968) and oblique bongo net tows in 1997 (Table 17). The Southeast Alaska monitoring cruises

used 0-20 m vertical tows with a Norpac net, and expanded their sampling to include 0-200 m vertical tows with the WP-2 net and a 0-200 m oblique tow with a bongo net (Table 17). Samples were usually preserved in 5 to 10% formalin or alcohol, and half of the bongo samples (253- $\mu$ m mesh size) on board the *F/V Great Pacific* were partitioned into three size groups and frozen (Table 17).

### **5. Salmonid sampling methods**

The fishing gear used to capture salmon on the inshore/offshore cruises was a midwater rope trawl (CanTrawl model 400/580). This net design is identical to the rope trawl used on salmon research cruises of the Canadian research vessel *R/V WE Ricker* (PBS, Nanaimo). The midwater rope trawl was 198 m long and has a 1.2-cm mesh liner in the codend (Table 18). This trawl catches juvenile and adult salmon. Usually the trawl was towed for 30 min or 1 hr at 5 kts, and typically the net had a 0 to 13 m towing depth and a 44-m horizontal opening (Table 18). The fishing gear used in the Southeast Alaska monitoring cruises included a Kodiak pair trawl (1995-1996) and a Nordic rope trawl (model 264; 1996-1997; Table 18). The pair trawl was fished using a seine skiff and the net was towed for 10 min at 2 kts. The towing depth was 0 to 3 m with a 6-m horizontal opening in the trawl. The pair trawl caught only juvenile salmon. The nordic rope trawl was capable of catching juvenile, immature, and adult salmon. The rope trawl was usually towed for 10 to 20 min at 3 kts. When towing, the trawl generally operated with a 20-m vertical and 30-m horizontal opening (Table 18).

The salmon catch was sorted and counted by species, and the fork length measured (Table 18). On the inshore/offshore cruises, fish body weight was also measured on board. Juvenile salmon were frozen whole for later lab collection of samples for stomach content analysis, scales (when available), otoliths, and tissues for genetic analysis in 1996, but in 1997 much of this work was completed during the research survey. Adult salmon were sampled onboard ship for scales, stomach contents analysis, and tissues for genetic studies (Table 18).

### **6. Non-salmonid sampling**

The non-salmonid catch was sorted by species and counted, and a subsample was measured for length (Table 18).

### **7. Other data recording or sampling gear**

The small vessel size and crew complement has limited the capability for extensive use of other types of data recording equipment such as an acoustic doppler current profiling system, or for the deployment of sediment traps. Satellite imagery has not been used to find oceanographic conditions favorable for catching salmon because the location of stations was predetermined.

Unpublished cruise reports or NPAFC documents can be consulted to provide additional information about the methods and catches resulting from these cruises (Table 19).

## **V. Preliminary Recommendations**

The preparation of this report has prompted the MSWG to develop preliminary recommendations for standardizing sampling methods used in NPAFC-related salmon research cruises. Future MSWG discussions will likely refine and prioritize these recommendations. Recognizing the limitations of each research program, which is dictated by the capability of the research vessel, the limitations of the scientific crew, and the sampling priorities of each individual research program, the MSWG makes preliminary

recommendations in the following areas: (1) sampling gear and methodology used on salmon research cruises should be widely and regularly reported; (2) methodology standardization could be improved in areas of hydrography, zooplankton, and collecting data on salmon and non-salmonid catches; and (3) gear intercalibration experiments should be continued and expanded.

1. Sampling gear and methodology used on salmon research cruises should be widely and regularly reported.
  - a. Descriptions of NPAFC-related research cruises and methodology conducted over the previous year should be summarized in a systematic way. For example, an annual report by the MSWG could list the details for each research cruise including a description of the vessel, cruise objectives, methods used to collect hydrographic data, and the procedures for catching and sampling zooplankton, salmon and non-salmonids (for example, Table 20).
  - b. Cruise reports that include trawl operations should include data on the height and width of the trawl opening, towing speed, and tow duration so that swept area can be roughly estimated.
  - c. The MSWG could compile a set of schematic diagrams and specifications of gear currently used during salmon research cruises.
  
2. Methodology standardization could be improved in areas of hydrography, zooplankton, and collecting data on salmon and non-salmonid catches.
  - a. To be useful for physical oceanography, hydrographic measurements need to be more accurate than measurements required for characterizing the surface layer for salmon habitat and distribution. We suggest that the CTD should be used as the basic instrument for oceanographic observation, and that such a system should be maintained within an accuracy of 0.05 units of temperature and salinity. Ideally, improving the accuracy of CTD measurements to 0.01 or 0.005 would be desirable, thereby making the data more valuable to other users. If possible, temperature and salinity should be recorded to the third decimal place. In areas beyond the continental shelf, it is preferable that data be obtained from a greater depth, such as a minimum of 500 m, or preferably 1000 m. Oceanographic data should be sent to the national oceanographic data center of each country, so that it will be available for international data exchange and utilization.
  - b. Most researchers are using zooplankton nets to measure secondary production and to estimate the abundance of salmon prey organisms. However, plankton nets designed to estimate secondary production may not be suitable to estimate the abundance of salmon prey organisms. The MSWG could inquire of plankton experts to report on the specifications of currently used zooplankton nets and ask for their comment on the suitability of these nets for study of salmon prey abundance.
  - c. Gillnets used for salmon research should conform to the specifications standardized in the scientific activities of the International North Pacific Fisheries Commission (INPFC) (for example, Takagi, 1975 ).
  - d. Fork length, (mm), body weight (g), sex, and gonad weight (g) should be the minimum items for salmon biological measurement. If present, scales should be collected from the INPFC-preferred area.
  - e. In order to collect data on the ecology of the North Pacific, it is useful to record the species and the count of non-salmonids caught in salmon fishing operations.

3. Gear intercalibration experiments should be continued and expanded.
  - a. Efforts should continue on intercalibration of gear, especially methods for which there is no obvious primary standard, for example, capture efficiency among the several plankton samplers in use, and the various gears used to collect fish.
  - b. The *R/V WE Ricker* and *F/V Great Pacific* use the same CanTrawl trawl design. Therefore, a coordinated experiment of the two vessels fishing in close proximity to one another, perhaps in the Gulf of Alaska, would provide an opportunity to evaluate the variation in fishing efficiency between two vessels.
  - c. Several vessels conducting simultaneous fishing operations in close proximity with the standard gillnet and trawls would be useful in comparing the catches among these gear. Such an experiment, if possible, could enlist several trawlers such as the *Kaiyo maru*, *F/V Great Pacific*, and a Russian trawler, fishing in conjunction with the gillnet operations of the *Wakatake maru* in the Bering Sea.

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Table 1. Zooplankton sampling methods used during ocean salmon research cruises of the *R/V WE Ricker*.

Net type	Tow types	Depth range	Flow metering
Bongo (most common)	vertical or oblique	0-50, 0-150, 0-500, or 0-bottom	TSK, General Oceanics, or none
SCOR	vertical or oblique	0-150 or 0-500	TSK or General Oceanics
Tucker Trawl (rare)	stratified oblique	0-500	General Oceanics

Table 2. Characteristics of the trawls used for salmon sampling by the *R/V WE Ricker*.

Trawl type	Dimensions	Tow timing and duration	Tow depth	Tow speed
Hexagonal mesh rope trawl (Can Trawl Pacific)	36 x 12 m or 30 x 20 m	mostly day, each haul 60 min or 30 min	surface or midwater	2-5 kts
Bernard Sigmund beam trawl (Redden Nets Inc.)	Paired, each 6.1m wide by 12.2 m deep.	day and night; continuous fishing, samples removed from alternate codends at 30-60 minute intervals	0-8 or 7-15 m	usually 3.2-4 knots

Table 3. Salmon biological characteristics measured on board the cruises of the *R/V WE Ricker*.

Principle measurement variables	Principle sampling items
fork length (mm), body weight (g), sex, and stomach content weight (g)	whole fish, scales, otoliths, and stomach contents

Table 4. Description of the Japanese salmon research vessels including research objectives and areas of operation.

Ship name	Gross tonnage	Ship type	Ship owner or employer	Objectives	Research period	Research areas	Number of stations
<i>Kaiyo maru</i>	2,630	stern trawler	FAJ <sup>1</sup>	juvenile salmon	October 4 - November 11	Okhotsk Sea, Pacific waters off the Kuril Is.	51
<i>Shunyo maru</i>	397	stern trawler	NRIFSF <sup>2</sup> , FAJ	juvenile salmon	August 26 - September 30	Okhotsk Sea, Pacific waters off the Kuril Is.	29
(old) <i>Wakatake maru</i> (replaced April, 1997); (new) <i>Wakatake maru</i>	424 666	multiple function	FAJ <sup>3</sup>	immature and maturing salmon	June 8 - July 24	Central North Pacific Ocean and Bering Sea	28
<i>Hokko maru</i>	466	multiple function	HNFRI <sup>4</sup> , FAJ	immature and maturing salmon	June 28 - July 22	Western North Pacific Ocean	12
<i>Hokusei maru</i>	893	multiple function	Hokkaido Univ.	immature and maturing salmon	June 1 - June 15, June 20 - July 4, July 10 - August 10	Western North Pacific Ocean	30
<i>Oshoro maru</i>	1779	multiple function	Hokkaido Univ.	immature and maturing salmon	June 3 - August 19	North Pacific Ocean	19

<sup>1</sup>FAJ: Fisheries Agency of Japan

<sup>2</sup>NRIFSF: National Research Institute of Far Seas Fisheries

<sup>3</sup>The owner is the Hokkaido Training Ship Administrative Bureau

<sup>4</sup>HNFRI: Hokkaido National Fisheries Research Institute

Table 5. Methods of hydrographic data collection used on Japanese salmon research vessels.

Ship name	Gear or instrument	Vertical range of observations	Measurement items	Accuracy/resolution of temperature	Accuracy/resolution of salinity	Data recording	Evaluation of data quality
<i>Kaiyo maru</i>	Sea Bird SEB 9 plus CTD	0-1500 m	Temperature, salinity, pressure, DO, others	±0.004/0.0003	±0.003/0.0004	Data output to computer disk	CTD overhauled regularly by the manufacturer
<i>Shunyo maru</i>	Neil Brown Mark III B CTD	0-500 m	Temperature, salinity, pressure	±0.005/0.0005	±0.005/0.001	Data output to computer disk	CTD overhauled one time per two years by the manufacturer
<i>Wakatake maru</i>	Alec Electronics Co., Ltd. AST-1000 (CTD)	0-1000 m	Temperature, salinity, pressure	±0.02/0.01	±0.05/0.01	Data output to computer disk	CTD overhauled sometimes by the manufacturer
<i>Hokko maru</i>	Neil Brown Mark III B CTD	0-1500 m	Temperature, salinity, pressure	±0.005/0.0005	±0.005/0.001	Data output to computer disk	?
<i>Hokusei maru</i>	Neil Brown Mark III B CTD	0-1500 m	Temperature, salinity, pressure, DO	±0.005/0.0005	±0.005/0.001	Data output to computer disk	CTD overhauled one time per two years
<i>Oshoro maru</i>	Neil Brown Mark III B CTD	0-1500 m	Temperature, salinity, pressure, DO	±0.005/0.0005	±0.005/0.001	Data output to computer disk	CTD overhauled one time per two years

Table 6. Zooplankton sampling methods used on Japanese salmon research vessels.

Ship name	Net type	Filtering cloth and mesh size	Hauling method	Vertical sampling range	Sample preservation	Measurement of filtration volume	Remarks
<i>Kaiyo maru</i>	remodeled NORPAC	GG54, 0.315 mm	vertical	0-150 m	10% seawater formalin (buffered)	flowmeter	IONESS nets were also used at some stations
<i>Shunyo maru</i>	remodeled NORPAC	GG54, 0.315 mm	vertical	0-150 m	10% seawater formalin (buffered)	flowmeter	
<i>Wakatake maru</i>	remodeled NORPAC	GG54, 0.315 mm	vertical	0-150 m	10% seawater formalin (buffered)	flowmeter	sampled at nighttime
<i>Hokko maru</i>	remodeled NORPAC	GG54, 0.315 mm	vertical	0-150 m	10% seawater formalin (buffered)	flowmeter	sampled at nighttime
<i>Hokusei maru</i>	NORPAC	GG54, 0.315 mm	vertical	0-150 m	10% seawater formalin (buffered)	flowmeter	
<i>Oshoro maru</i>	NORPAC	GG54, 0.315 mm	vertical	0-150 m, and 0-500 m	10% seawater formalin (buffered)	flowmeter	

Table 7. Salmon fishing methods used on Japanese salmon research vessels.

Ship name	Targeted salmon life history stage	Gear type	Number of units used	Size of gear (per single unit)	Usual setting or towing time	Mesh size	Towing speed	Usual towing or setting depth	Remarks
<i>Kaiyo maru</i>	juveniles, immature, and maturing	mid-water trawl	1	vertical=60 m; horizontal=60 m	daytime	codend=11 mm	5.0 kts	sea surface	
<i>Shunyo maru</i>	juveniles, immature, and maturing	mid-water trawl	1	vertical=30 m; horizontal=30 m	daytime	codend=17 mm	5.0 kts	sea surface	
<i>Wakatake maru</i>	immature and maturing	multiple mesh-size drift gillnet	49 tans	1 tan: vertical=5 m; horizontal=50 m	nighttime	48, 55, 63, 72, 82, 93, 106, 115, 121, 138, and 157 mm	drifting	sea surface	
<i>Wakatake maru</i>	immature and maturing	longline	30 hachi	1 hachi length=112 m, with 49 hooks baited with salted anchovy	nighttime	-	drifting	sea surface	used for tagging
<i>Hokko maru</i>	immature and maturing	multiple mesh-size drift gillnet	49 tans	vertical=5 m; horizontal=50 m	nighttime	48, 55, 63, 72, 82, 93, 106, 115, 121, 138, and 157 mm	drifting	sea surface	
<i>Hokusei maru</i>	immature and maturing	multiple mesh-size drift gillnet	49 tans	vertical=5 m; horizontal=50 m	nighttime	19, 22, 25, 29, 33, 37, 42, 48, 55, 63, 72, 82, 93, 106, 115, 121, 138, and 157 mm	drifting	sea surface	
<i>Oshoro maru</i>	adult	multiple mesh-size drift gillnet	49 tans	vertical=5 m; horizontal=50 m	nighttime	19, 22, 25, 29, 33, 37, 42, 48, 55, 63, 72, 82, 93, 106, 115, 121, 138, and 157 mm	drifting	sea surface	

Table 8. Biological measurements and tissues sampled from salmon and non-salmonid catches measured on board Japanese salmon research vessels.

Ship name	Biological measurements recorded from salmon	Tissues collected from salmon	Measurements recorded from non-salmonids
<i>Kaiyo maru</i>	FL (mm), BW (g), SEX, GW (g), liver weight, stomach content weight (g), proportion (%) of diet by prey category	scales, muscle*, heart*, liver*, eye*, and otoliths	number of individuals by species, body length
<i>Shunyo maru</i>	FL (mm), BW (g), SEX, GW (g), liver weight, stomach content weight (g), proportion (%) of diet by prey category	scales, muscle*, heart*, liver*, eye*, and otoliths	number of individuals by species, body length
<i>Wakatake maru</i>	FL (mm), BW (g), SEX, GW (g), stomach content weight (g), proportion (%) of diet by prey category	scales, muscle*, heart*, liver*, eye*	number of individuals by species, body length
<i>Hokko maru</i>	FL (mm), BW (g), SEX, GW (g), stomach content weight (g), proportion (%) of diet by prey category	scales, muscle*, heart*, liver*, eye*	number of individuals by species, body length
<i>Hokusei maru</i>	FL (mm), BW (g), SEX, GW (g).	scales	-
<i>Oshoro maru</i>	FL (mm), BW (g), SEX, GW (g).	scales	-

\*These tissue samples are mainly used for electrophoretic analysis to identify the origins of chum salmon. In 1997, eye tissue was not collected.

Table 9. Description of Russian ocean salmon research vessels and their area and time period of operation.

Sponsoring agency	Ship name	Ship owner	Time period	Geographical area	Number of stations
KamchatNIRO, Petropavlovsk	<i>D/V Dezhnevo</i>	Fish Rain Company	1995: 5/26-8/16	northwest Pacific and Sea of Okhotsk;	65 drift gillnet stations
			1996: 5/25-7/15	northwest Pacific, and Bering Sea	46 drift gillnet stations
KamchatNIRO, Petropavlovsk	<i>SRTM Nazarovsk</i>	Fish Rain Company	1995: 6/1-7/18	northwest Pacific, and Bering Sea	14 stations
KamchatNIRO, Petropavlovsk	<i>SRTM-K Kamchatka Salmon</i>	Pilenga-Godo	1995: 5/31-8/1	northwest Pacific, and Bering Sea	41 drift gillnet stations
			1996: 5/2-10/2	northwest Pacific, Bering, and Sea of Okhotsk	103 drift gillnet stations
KamchatNIRO, Petropavlovsk	<i>RMS Yupiter</i>	Fish Rain Company	1996: 5/9-7/24	northwest Pacific, and Bering Sea	61 drift gillnet stations
TINRO-Centre, Vladivostok	<i>Professor Levanidov</i>	BIF TINRO (Research Fleet Base)	1995: 11/11(1994)-3/12 (1995) 1995: 6/19-8/28 1996: 7/28-8/21		40 315 78
TINRO-Centre, Vladivostok	<i>TINRO</i>	BIF TINRO	1995: 6/19-8/28		315
TINRO-Centre, Vladivostok	<i>Professor Kaganovsky</i>	BIF TINRO	1995: 6/19-8/28		315
TINRO-Centre, Vladivostok	<i>Professor Kizevetter</i>	BIF TINRO	1996: 7/18-9/15	trawl stations were situated at 40 miles (offshore zone), 30 miles, (slope zone) and 20 miles (shelf zone) offshore	85

Table 10. Hydrographic sampling methods used on Russian salmon research vessels.

Agency	Instrument type	Vertical range of observations	Variables measured	Number of stations
KamchatNIRO	STD 1000	0-200 m	temperature, salinity	34-61 stations
TINRO-Centre	CTD Neil Brown with rosette sampler	0-500 m, or 10 m from the bottom in shallow waters	temperature, salinity, density, dissolved oxygen, silicates and phosphates	?

Table 11. Zooplankton sampling methods used on Russian salmon research vessels.

Agency	Net type	Net specifications	Towing method	Vertical depth range	Method for sample preservation	Number of stations	Comments
KamchatNIRO	Judey net	?	vertical or oblique	0-50 m	4% formalin	?	organisms are identified by species
	IKS-80			0-50 m or 0-100 m		10-61 stations,	
	Melnikov trawl			0-50 m		45 stations	
TINRO-Centre	big Judey net	square mouth=0.1 m <sup>2</sup> , mesh=168 µm; diameter of mid-ring= 50 cm, length of opposite net cone= 120 cm, depressor weight=50 kg, net is equipped with non-filtered tumbler and lock	vertical	0-50 m and 50-200 m layers	4% formalin and onboard processing	?	organisms are separated into 3 size groups: <1.5 mm, 1.5-3.2 mm, and >3.2 mm

Table 12. Salmon fishing gear used to catch juvenile and adult salmon on Russian research vessels.

Agency	Fishing Gear	Mesh Size	Usual setting time	Set duration	Towing speed	Usual towing or setting depth	Number of stations	Measurements on salmon	Salmon samples collected	Handling of non-salmonid catch
Kamchat-NIRO	gillnets, troll, and jiggers	?	daytime and nighttime	1-12 hr, 4-12 hr	?	0-10 m	41-103 stations	sorted and counted by species; length, weight, sex	some salmon samples collected, scales, food habits, disease abnormalities, histology, parasites, tagging	marine mammals and sea birds are enumerated
TINRO-Centre	pelagic rope trawl;	12 mm minimum mesh size	daytime and nighttime	1 hr	4.5-5.2 kts towed for 350-400 m ; tow is 1 hour duration	0-50 m	one tow per trawl station	sorted and counted by species; length, weight, sex	biostatistic data, morphometric measurements, salmon feeding habits, scales, tissue samples for genetic analysis, and collection of parasites	trawl catches all types of nekton, including fish, squid, and jellyfish; used to estimate numbers and biomass of nekton, and collect biological samples; data recording system is a DOS database developed at TINRO-Centre

Table 13. Researchers conducting Russian ocean salmon research cruises.

Contact Person	Address	Phone/Fax	E-mail	Cruise Report
V. Shershneva ( <i>D/V Dezhnevo</i> )	KamchatNIRO 18 Naberezhnaya Street, Petropavlovsk- Kamchatshiy, 683602, Russia	415-22-25957/ 415-22-23705	mail@kamchatniro. kamchatka.su	Shershneva, V.I. 1995. Some abnormalities in salmon noted during their marine period of life. NPAFC Doc. 169
A. Dekstein ( <i>SRTM Nazarovsk</i> )	KamchatNIRO 18 Naberezhnaya Street, Petropavlovsk- Kamchatshiy, 683602, Russia	415-22-25957/ 415-22-23705	mail@kamchatniro. kamchatka.su	Dekstein, A.B., and M. Koval. 1995. Expeditional report on the programme of research scientific expeditional work on investigation of salmon stock localization in the Pacific Ocean in April-June 1995. NPAFC Doc. 171.
Zh. Zorbidi ( <i>SRTM-K Kamchatka Salmon</i> )	KamchatNIRO 18 Naberezhnaya Street, Petropavlovsk- Kamchatshiy, 683602, Russia	415-22-25954/ 415-22-23705	mail@kamchatniro. kamchatka.su	Zh. Zorbidi, cruise report
A. Dekstein ( <i>RMS Yupiter</i> )	KamchatNIRO 18 Naberezhnaya Street, Petropavlovsk- Kamchatshiy, 683602, Russia	415-22-25957/ 415-22-23705	mail@kamchatniro. kamchatka.su	A. Dekstein, M. Koval, cruise report
V.P. Shuntov	Pacific Research Fisheries Centre (TINRO-Centre) 4 Sevchenko Alley, Vladivostok, 690600, Russia	4232-25-9504/ 4232-25-7783	root@tinro.marine. su	Shuntov, V.P. et al., 1995. Cruise report. Vladivostok: TINRO-Centre Archive. No. 21994
K.M. Gorbatenko	Pacific Research Fisheries Centre (TINRO-Centre) 4 Sevchenko Alley, Vladivostok, 690600, Russia	4232-25-7451/ 4232-25-7783	root@tinro.marine. su	Gorbatenko, K.M. 1996. Cruise report. Vladivostok: TINRO-Centre Archive. No. 22004

Table 13. Continued.

Contact Person	Address	Phone/Fax	E-mail	Cruise Report
V.I. Radchenko	Pacific Research Fisheries Centre (TINRO-Centre) 4 Sevchenko Alley, Vladivostok, 690600, Russia	4232-25-7921/ 4232-25-7783	root@tinro.marine. su	Radchenko, V.I. 1996. Cruise report. Vladivostok: TINRO-Centre Archive. No. 22124
A. Ya. Efimkin	Pacific Research Fisheries Centre (TINRO-Centre) 4 Sevchenko Alley, Vladivostok, 690600, Russia	4232-25-7451/ 4232-25-7783	root@tinro.marine. su	Efimkin, A. Ya. 1996. Cruise report. Vladivostok: TINRO-Centre Archive. No. 22140

Table 14. Description of the U.S. salmon research vessels, sampling seasons, geographical areas of operation, and research objectives, 1995-1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Ship name	<i>F/V Great Pacific</i>	NOAA Ship <i>John N. Cobb</i>
Gross tonnage	199	185
Ship type	Bering Sea stern trawler	Multi-gear research vessel
Ship size	38-m length overall, 3-m draft, 1450 hp main engine, built 1979	29-m length overall, 3-m draft, 325 hp main engine, built 1950
Ship owner	Wards Cove Trawler Group, Inc., Seattle	National Oceanic and Atmospheric Administration (NOAA), U.S. Dept. Commerce
Time period	1996: Seattle-Kodiak-Dutch Harbor 7/15-8/25 1997: Kodiak-Dutch Hbr 7/21-8/19	1995: Jun 20-30, Jul 29-Aug 7 1996: Jun 19-30 and Jul 30-Aug 7 1997: monthly sampling May to October (41 days total): 7 in May, 7 in June, 11 in July, 7 in Aug, 2 in Sept, and 7 in October
Geographical area	1996: southeast Alaska, extending around the Gulf of Alaska, west to Amchitka Pass, including parts of the Bering Sea and Bristol Bay 1997: central Alaska, extending around the Gulf of Alaska, west to Aleutian Isl. and parts of the Bering Sea	1995 & 1996: southeast Alaska: northern region (Icy St.-Cross Sd.) and southern region (Clarence St.-Dixon Entrance) 1997: southeast Alaska: northern region (Auke Bay, Chatham St., Cross Sd., and coastal ocean)
Number of research stations	1996: 30 transects over nearshore, shelf, slope (200-m contour), and oceanic waters 1997: 18 transects, 75 tows	1996: 20-30 stations 1997: 20 stations
Research objectives	ocean distribution and migration routes of salmon; relative abundance and co-occurrence of salmon; stock identity; salmon size and ocean growth; salmon feeding; co-occurrence of other fishes, predators or competitors; and prevalent oceanographic conditions	1995-1996: size and species composition of juvenile salmon and ecologically related species; catch composition and size distribution of salmon between rope and paired trawls during night- and day-time tows 1997: stock-specific migration and growth information on thermally-marked juvenile chum salmon and assessment of wild and hatchery stock interactions
Additional comments	plan to continue the charter in 1998: April, July-Aug 1999: May-June, July-Aug 2000: July-Aug, Nov	-

Table 15. Description of hydrographic sampling aboard U.S. salmon research vessels, 1995-1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Instrument type	CTD meter: SEACAT SBE 19-01; Sea-Bird Electronics Inc., Seattle, with DO sensor (SBE 23Ba, Beckman-type polarographic element) and fluorometer, manufactured in 1988; hand-held salinity temperature probe: YSI 30, Yellow Springs, Ohio used for bucket-collected surface water measurements	CTD meter; SeaBird Seacat SBE 19; Sea-Bird Electronics Inc., manufactured in 1993, 1996  Seabird SBE 21 Thermosalinograph with a 2-m intake depth; this instrument is an on-board system that logs temperature and salinity at 1-min intervals
Vertical range of observations	1996: 0-100 m, or to sea bottom, if shallower 1997: 0-300 m, or to approx. 5 m above the bottom at shallower depths	1996: 0-100 m 1997: 0-200 m, or within 10 m of the sea bottom
Depth increment for observations	1 m	0.5 m
Variables measured	temperature ( $^{\circ}\text{C}$ ), salinity (ppt), pressure, and DO (ml/l), chlorophyll ( $\mu\text{g/l}$ )	depth, temperature ( $^{\circ}\text{C}$ ), salinity (ppt)
Variable and resolution	CTD: temperature $\pm 0.001$ ( $^{\circ}\text{C}$ ) YSI probe: temperature $\pm 0.01$ $^{\circ}\text{C}$	CTD: temperature ( $^{\circ}\text{C}$ ), $\pm 0.001$
Variable and resolution	CTD: salinity (ppt); conductivity converted to salinity $\pm 0.001$ ppt YSI probe: salinity $\pm 0.05$ psu	CTD: salinity (ppt); conductivity converted to salinity ppt, $\pm 0.001$ ppt
Variable and resolution	dissolved $\text{O}_2 \pm 0.1$ ml/l	-
Data recording system	to hard drive of a Compac computer, then to diskette in hexadecimal converted to ASCII	to hard drive of a Compac computer, then to diskette in hexadecimal converted to ASCII
Sensor calibration	CTD: by manufacturer, July 1995 and March 1996	CTD: by manufacturer, July 1995, March 1996
Number of stations	1996: start and end of transects (40-60 stations) 1997: 4 transects, approx. 80-120 nm apart, and at the start and end of fishing stations along other selected transects, approx. 48 stations; surface water collection: end of each fishing station, approx. 75 stations	1996: 30 stations 1997: 20 stations

Table 15. Continued.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Additional comments	CTD raw data is stored and transmitted to computer in binary form, conversions to engineering units made with Vers. 4.219 SEASOFT software	-

Table 16. Description of phytoplankton sampling aboard U.S. salmon research vessels, 1995-1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Collection method	1997: bucket	-
Vertical depth range	surface only	-
Filtration method	500 ml of sieved seawater passed through a 47 mm GF/F glass fiber filter, pore size approx. 0.7 $\mu$ m	-
Method for sample preservation	filters folded in half, sealed in aluminum foil, and frozen for laboratory analysis	-
Number of stations	1997: 21 stations	-

Table 17. Description of zooplankton sampling aboard U.S. salmon research vessels, 1995-1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Net type	1996: Norpac net 1997: WP-2 net (UNESCO, 1968), Bongo net	1995-1996: Norpac net 1997: Norpac net, WP-2 net, and Bongo net
Net specifications	Norpac: 0.50-m diameter; 243- $\mu$ m mesh, approx. 2 m length WP-2: 0.50-m diameter; 200- $\mu$ m mesh Bongo: 0.60-m diameter, 253- and 505- $\mu$ m mesh	Norpac: 0.50-m diameter, 243- $\mu$ m mesh WP-2: 0.57-m diameter, 202- $\mu$ m mesh; Bongo: 0.60-m diameter, 333- $\mu$ m and 505- $\mu$ m mesh;
Towing method	Norpac: vertical WP-2: vertical Bongo: oblique	Norpac vertical WP-2: vertical Bongo: oblique
Vertical depth range	Norpac: 0-20 m WP-2: 0-200 m Bongo: 0-200 m	Norpac: 0-20 m WP-2: 0-200 m Bongo: 0-200 m
Towing speed	1996: Norpac hand-pulled; no rate of speed 1997: WP-2: lowered at $\geq 2$ m/sec Bongo: lowered at 1 m/sec and vessel speed 2 kts, retrieved at 1 m/3 sec and vessel speed 1-1.5 kts	Norpac: 1 m/sec WP-2: 1 m/sec; Bongo: 0.5 m/sec
Method for determination of volume filtered	Norpac: not determined, no flow meter WP-2: flow meter used Bongo: flow meter used in opening of each net	Norpac: not determined, no flow meter; WP-2: flow meter used Bongo: flow meter used
Method for sample preservation	Norpac: 10% formalin WP-2: 5% formalin Bongo: 253- $\mu$ m mesh sample sieved into 3 size groups and frozen; 505- $\mu$ m mesh sample preserved in 5-10% formalin	5-10% formaldehyde or alcohol
Number of stations	1996: start and end of transects (40-60 stations) 1997: 1997: (WP-2 and Bongo): 21 stations, approx. 2.5 nm apart along each of 4 standard oceanographic transects	1995-1996: 13 triplicate plankton tows 1997: 20 stations

Table 18. Description of the salmon sampling methods on board U.S. salmon research vessels, 1995-1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
Gear type	Midwater rope trawl: model 400/580, catches juvenile, immature, and adult salmon	1995-1996: Kodiak pair trawl 1996-1997: nordic rope trawl model 264
Gear manufacturer	CanTrawl Pacific Fishing Services, Ltd., Richmond, BC; identical to the rope trawl used on the <i>R/V WE Ricker</i> (PBS, Nanaimo)	Kodiak FRI pair trawl: Research Nets, Inc.; nordic rope trawl: NorEastern Trawl Systems, Inc.
Gear description	198 m long, hexagonal mesh in wings and body; trawl fished with three 60-m, 1.9-cm bridles attached at a single point to 5.5-m <sup>2</sup> steel alloy trawl doors, each weighing 463 kg; floats on the headrope and 260-m warp line on each door; typically fished with approx 13-m vertical and 44-m horizontal net opening; designed for higher-than-average towing speeds; towed at or near the surface	Kodiak pair trawl: 6 m (width) X 3 m (height) X 15 m (length), fished using a seine skiff; headrope has a series of floats that skim the surface and bridles that funnel fish into the trawl at the surface; nordic rope trawl: 30 m (width) X 16 m (height) X 130 m (length), fished with 3-m <sup>2</sup> lite doors, headrope has floats on the wingtips and in the center that enable it to fish near the top of the trawl doors, which are towed just below the surface
Codend mesh size	1.2 cm mesh liner	pair trawl: 0.8 cm nordic rope trawl: 0.64 cm
Usual setting time	1996: day 1997: day and night	1996: day and night 1997: day
Usual set duration	1996: 1.0 h 1997: 0.5 or 1.0 h	1996: 10 min 1997: 20 min
Towing speed	5.0 kts	pair trawl: 2 kts nordic rope trawl: 3 kts
Usual towing or setting depth	0-13 m	pair trawl: 0-3 m nordic rope trawl: 0-20 m
Number of stations	1996: 105 tows, each tow 5-nm long 1997: 75 tows	1995-1996: 11 stations 1997: 19 stations

Table 19. Scientific contacts for U.S. ocean salmon research cruises, March 1995-August 1997.

Item	Inshore/Offshore Cruises (OCC)	Southeast Alaska Monitoring Cruises
name	Richard Carlson	Joseph Orsi
address	Auke Bay Laboratory 11305 Glacier Hwy. Juneau, AK 99801-8626	Auke Bay Laboratory 11305 Glacier Hwy. Juneau, AK 99801-8626
phone	(907) 789-6050	(907) 789-6034
fax	(907) 789-6094	(907) 789-6094
e-mail address	dick.carlson@noaa.gov	joe.orsi@noaa.gov
Cruise Reports	<p>Carlson, H.R., K.W. Myers, E.V. Farley, H.W. Jaenicke, R.E. Haight, and C.M. Guthrie III. 1996. Cruise report of the <i>F/V Great Pacific</i> survey of young salmon in the North Pacific--Dixon Entrance to western Aleutian Islands--July-August 1996. (NPAFC Doc. 222) Auke Bay Laboratory, Juneau. 50 pp.</p> <p>Carlson, H.R., E.V. Farley, R.E. Haight, K.W. Myers, and D.W. Welch. 1997. Survey of salmon in the North Pacific and southern Bering Sea--Cape St. Elias to Attu Island July-August 1997. (NPAFC Doc. 254) Auke Bay Laboratory, Juneau.</p>	<p>Orsi, J.A. 1996. Unpublished Cruise Report Number JC-96-05. Auke Bay Laboratory, Juneau.</p> <p>Orsi, J.A. 1996. Unpublished Cruise Report Number JC-96-08. Auke Bay Laboratory, Juneau.</p> <p>Orsi, J.A. 1997. Unpublished May Cruise Report Number JC-97-06. Auke Bay Laboratory, Juneau. 6 p.</p> <p>Orsi, J.A. 1997. Unpublished June Cruise Report Number JC-97-09. Auke Bay Laboratory, Juneau. 8 p.</p> <p>Orsi, J.A. 1997. Unpublished July Cruise Report Number JC-97-11. Auke Bay Laboratory, Juneau. 8 p.</p> <p>Orsi, J.A., and J.M. Murphy. 1997. Unpublished August Cruise Report Number JC-97-14. Auke Bay Laboratory, Juneau. 8 p.</p> <p>Orsi, J.A., J.M. Murphy, and A.L.J. Brase. 1997. Survey of juvenile salmon in the marine waters of southeastern Alaska, May-August 1997. (NPAFC Doc. 277) Auke Bay Laboratory, Juneau. 27 p.</p> <p>Murphy, J.M., A.L.J. Brase, L.B. Hulbert, E.C. Martenson, and J.A. Orsi. (In prep.) Unpublished October Cruise Report Number JC-97-17.</p>

Table 20. Example of the basic sampling information that could be included for each NPAFC-related salmon research cruise compiled annually by the MSWG.

1. Description of the research cruise and vessel
  - (1) Ship name
  - (2) Gross tonnage
  - (3) Ship type
  - (4) Ship owner or sponsoring institution
  - (5) Cruise objectives
  - (6) Research time period
  - (7) Geographical area of research
  - (8) Number of stations
  
2. Methods for hydrographic sampling
  - (1) Gear or instrument model name and manufacturer
  - (2) Vertical range of observations
  
3. Methods for zooplankton sampling
  - (1) Net type and specifications
  - (2) Vertical range of observations
  
4. Sampling gear for salmon
  - (1) Gear Type
  - (2) Targeted salmon life history stage
  - (3) Gear size, specifications
  - (4) Usual setting or towing time
  - (5) Towing speed
  - (6) Usual towing or setting depth

## Appendix 1. Sample NPAFC methods questionnaire, as sent to Canadian scientists.

## 1. Research Vessel

Ship name:	
Gross tonnage:	
Ship type (e.g. stern trawler):	

## 2.. Information on Hydrographic/Physical Oceanographic observations

Gear or instrument type (include manufacturer and year, e.g. 1996 Seabird CTD):	
Vertical range of observation:	
Primary and additional variables measured: (e.g. pressure, temperature, and salinity)	
Resolution of temperature:	
Resolution of salinity:	
Data recording/archival system: (e.g. ASCII computer files of 1 m-averaged data)	
Procedures for evaluation or check of data quality:	

## 3. Information on zooplankton sampling

Net type (e.g. bongo, NORPAC, SCOR-WP2):	
Method of towing (vertical or horizontal):	
Vertical range: (for example, 0-150m)	
Method of preservation (formalin or others):	
Method of determination of volume filtered:	

## 4. Information on sampling methods for juvenile salmon

Gear type (including the maker):	
Size of the gear (vertical and horizontal length):	
Usual setting or towing time (day and night/ term): (for example, daytime, one tow requires 60 minutes)	
Mesh size: (for example, cod end: 17 mm)	
Numbers of unit used:	
Towing speed:	
Usual towing or setting depth: (for example, 0-30 m deep)	
Number of the operational stations:	
Principle measurement variables (for example, fork length (mm), body weight (g), sex, gonad weight (g))	
Principle sampling items: (for example, stomach, scale, and otolith)	

## Appendix 1. Continued.

## 5. Information on sampling methods for adult salmon

Gear type (including the maker):	
Size of the gear (vertical and horizontal length):	
Usual setting or towing time (day and night/ term): (for example, daytime, one tow requires 60 minutes)	
Mesh size: (for example, cod end: 17 mm)	
Numbers of unit used:	
Towing speed:	
Usual towing or setting depth: (for example, 0-30 m deep)	
Number of the operational stations:	
Principle measurement variables (for example, fork length (mm), body weight (g), sex, gonad weight (g))	
Principle sampling items: (for example, stomach, scale, and otolith)	

## 6. Methods for additional measurements (for example primary production, microzooplankton, micronekton)

Appendix 2: Guideline for collecting oceanographic observations on Japanese salmon research vessels.

I. Basic information

- (1) Office code
- (2) Area code
- (3) Vessel code
- (4) Station name
- (5) Date
- (6) Location (latitude and longitude)
- (7) Attribute of research

II. Records of geography, weather, and others

- (1) Depth of sea bottom (m)
- (2) Color of sea (Forel's scale of color)
- (3) Transparency (m)
- (4) Wave (direction and degree)
- (5) Swell (direction and degree)
- (6) Air temperature
- (7) Weather
- (8) Cloud (type and amount)
- (9) Wind (direction and degree)
- (10) Atmospheric pressure (mb)

III. Oceanographic observation

- (1) Instruments for oceanographic observation
- (2) Temperature and salinity at fixed layers
- (3) Fixed layers:  
0 m/10/20/30/50/75/100/125/150/175/200/250/300/400/500/  
600/700/800/900/1000/1200/1500/2000

Appendix 3. General categories to which zooplankton samples collected on Japanese salmon research vessels are routinely sorted and identified.

No.	Abbreviation	General Category
1	EU	euphausiids
2	CO	copepods
3	AM	amphipods
4	PT	pteropods
5	AP	appendicularians
6	CH	chaetognaths
7	OS	ostracods
8	JE	jellyfishes (medusae, ctenophores)
9	SA	salps
10	FI	fishes
11	SQ	squids
12	OT	others

Appendix 4. Data recorded during Japanese salmon research vessel fishing operations.

1. Date of sampling operation
2. Location (latitude and longitude)
3. Time at the beginning of the operation
4. Sea surface temperature
5. Wind velocity
6. Name of sampling gear
7. Mesh sizes of sampling gear
8. Number of units of the sampling gear (by mesh)
9. Number of fish collected by species (by mesh)
10. Time of completion of the operation

## Appendix 5. Comparison of the relative advantages of sampling with trawls and gillnets.

### A. Trawl

#### 1. Advantages

- a. Possible to directly estimate absolute abundance of the standing stock
- b. Operation is satisfactory in stormy weather
- c. Biological measurements collected from one subsample represent whole operation
- d. Sample a range of depths
- e. Possible to conduct several trawling operations in one day

#### 2. Disadvantages

- a. Most salmon scales come off and are lost
- b. Requires a strongly powered stern trawler for operation
- c. Consumes a large quantity of fuel for operation

### B. Gillnet

#### 1. Advantages

- a. Most salmon scales remain on the fish and can be sampled
- b. Do not need a specifically-equipped research vessel
- c. Can save on fuel for operation

#### 2. Disadvantages

- a. Not possible to directly estimate absolute abundance of standing stock
- b. Operation is poor in stormy weather
- c. Time consuming because biological measurements must be collected from each mesh size
- d. Vertical range of sampling depth is limited to the surface (0-8 m)
- e. Operation conducted only once per night