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Plan for NPAFC Bering-Aleutian Salmon International Survey (BASIS) Phase II 2009 – 2013

BASIS Working Group

Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

Canada, Korea, Japan, Russia, and USA

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PROJECT SUMMARY

Research Questions

Climate change, and its impact on salmon carrying capacity in the Bering Sea was discussed at the November, 2008, NPAFC, BASIS Symposium, held in Seattle, WA. A current overarching hypothesis suggests that climate change will alter the current geographic distributions and behaviors of humans, marine mammals, seabirds, and fish by restructuring their habitats within the Bering Sea ecosystem (NPRB 2007). Oral presentations at the symposium highlighted evidence that increased levels of atmospheric carbon dioxide are linked to warming air and sea temperatures, reduced sea ice extent during winter, and melting of the polar cap in the Arctic region (Bond et al. 2008). However, the effect of climate change on the Bering Sea ecosystem is still debatable, with studies indicating no direct effect on the ecosystem (Shuntov and Temnykh in review) to studies that indicate the possibility of reduced ecosystem productivity with increasing sea surface temperatures (Coyle et al. 2008).

BASIS Phase II will address the following research questions:

1) How will climate change and climate cycles affect anadromous stocks, ecologically related species, and the Bering Sea ecosystems?

Within the broad, shallow shelf region of the eastern Bering Sea, there is evidence that increased warming will reduce sea ice extent during winter and spring, favoring pelagic productivity (Hunt et al. 2002). However, recent research suggests that climate change will reduce summer storm activity and increase water column stability. The greater water column stability is believed to reduce post-bloom production, altering the size and composition of zooplankton taxa and shifting trophic relationships among zooplankton and consumers, with the potential to impact fish, birds and mammals on the eastern Bering Sea shelf (Coyle et al. 2008). For example, juvenile pink salmon energy density was significantly lower during years with warm sea temperatures than during years with cold sea temperatures (Andrews et al. in review). Thus increased water column stability during summer due to climate change may reduce energy reserves of pelagic juvenile fish, increasing over-winter mortality.

2) What are the key climatic factors affecting cyclical changes in Bering Sea food production and pelagic fish communities?

In the deeper waters of the western Bering Sea, results suggest that climate change has not affected primary and secondary productivity or fish biomass (Shuntov and Temnykh in review). Instead, the evidence suggests that cyclic climate events restructure zooplankton and fish communities, but do not alter the overall biomass of these communities within the western Bering Sea ecosystem. However, predicting community structure in the wake of shifting climate regimes is difficult, due to the lack of thorough investigations on the structure and function of whole ecosystems.

3) How will climate change and climate cycles impact the available salmon habitat in the Bering Sea?

In the offshore waters of the Bering Sea, immature salmon abundance during summer is predicted to increase as climate change forces Pacific salmon further north in search of preferred sea temperatures. Recent bioenergetics models suggest that the carrying capacity of offshore Bering Sea ecosystem was sufficient for immature chum salmon growth during years with high abundance levels (Azumaya et al. 2008). However, if more immature salmon enter the Bering Sea during summer, inter and intra-specific competition could increase leading to density-dependent growth and mortality.

4) How will climate change and climate cycles affect Pacific salmon carrying capacity within the Bering Sea?

At the close of the BASIS Symposium, discussion turned to future Bering Sea pelagic ecosystem research. The general opinion was that BASIS research strengthened our knowledge of the effects of climate change and cylces on pelagic ecosystems of the Bering Sea. During the symposium we learned that cyclic patterns of warm and cold spring sea temperatures had positive and negative effects, respectively on salmon carrying capacity within the eastern Bering Sea shelf (Farley and Moss in review). Future salmon carrying capacity modeling efforts must account for cyclic patterns in climate, the potential of increased sea temperature warming, and density-dependent processes that effect salmon growth and survival.

The BASIS research fostered unprecedented cooperation among NPAFC Parties and is now considered a model for future collaborative international research efforts in the North Pacific Ocean. At the end of the BASIS Symposium, there was overwhelming opinion to continue BASIS research into Phase II, building on the knowledge gained during Phase I. This document discusses the research plan for BASIS phase II.

Survey Plan Elements

The BASIS Phase II plan calls for surveys of salmon and associated pelagic nekton within three regions that include the eastern Bering Sea shelf, the Russian EEZ, and the Bering Sea basin. Each region will have a set of survey stations where trawl fishing operations will occur. Sampling will consist of surface trawls to capture salmon and other fish, plankton tows, and sampling of ocean conditions (e.g., salinity, temperature, currents). Coordination of sampling by vessels of NPAFC member nations would be through the NPAFC.

As in BASIS phase I, in-depth biological and stock identification analyses will determine growth and life history characteristics of regional stock groups. BASIS data will be used in spatially-explicit models incorporating oceanographic data and salmon migration, growth, and mortality processes to advance our understanding of the causes of changes in productivity of salmon populations.

Survey Plan Benefits

- BASIS phase II continues much needed pelagic ecosystem research in the Bering Sea to determine the impact of climate cycles and climate change on ecosystem function and structure.
- BASIS phase II enables research to continue on all aspects of the effects of abiotic and hydrobiological factors on the marine period of life of Pacific salmon.
- BASIS phase II directly addresses the key elements of the 2006-2010 NPAFC Science Plan and is a component of one of NPAFC's scientific research themes
- BASIS phase II complements long-term climate, ocean, and ecosystem research and monitoring activities carried out within the framework of national and other international programs (PICES, NPRB, and GLOBEC).

PROJECT DESCRIPTION

NPAFC Bering-Aleutian Salmon International Survey (BASIS) Phase II 2009-2013

1. Cooperating International Organizations, Government Agencies, and Universities

This list includes organizations, government agencies, and universities that participated in the initial development and review of this proposal, as well as more recent participants.

International Organizations
North Pacific Anadromous Fish Commission (Vancouver, B.C.)

Government Agencies and Universities
Canada: Dept. of Fisheries and Oceans, Pacific Biological Station (Nanaimo, B.C.)

Japan: Fisheries Agency of Japan (Tokyo); Fisheries Research Agency, Hokkaido National Fisheries Research Institute (Kushiro); National Salmon Resources Center (Sapporo); Hokkaido University (Sapporo and Hakodate)

Republic of Korea: National Fisheries Research and Development Institute (Busan)

Russia: Federal Agency for Fisheries of Russia, Pacific Scientific Research Fisheries Centre (TINRO-Centre, Vladivostok), Russian Federal Research Institute of Fisheries & Oceanography (VNIRO, Moscow), Kamchatka Research Institute of Fisheries & Oceanography (KamchatNIRO, Petropavlovsk-Kamchatsky), , Magadan Branch of Pacific Scientific Research Fisheries Centre (Magadan)

U.S.A.: National Marine Fisheries Service, Alaska Fisheries Science Center (Seattle), Auke Bay Laboratory (Juneau); Alaska Department of Fish and Game (Juneau, Anchorage); University of Alaska Fairbanks (Juneau); University of Washington (Seattle)

2. Background

The North Pacific Anadromous Fish Commission (NPAFC) was established in 1992 by the Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean, which is the international treaty that banned high seas fishing for salmon in the North Pacific Ocean. Five nations are party to the treaty: U.S., Canada, Japan, Korea, and Russia. The primary purpose of the NPAFC is the promotion of conservation of anadromous species--most notably salmon—and "ecologically-related species." This is carried out through two major functions: scientific research and enforcement of the high seas fishing ban.

Cooperation on scientific research reached a new level of coordination and collaboration at the 2000 NPAFC Annual Meeting. For the first time, the NPAFC member nations agreed to go beyond coordinating their individual research plans by developing a joint set of research priorities. This is an unprecedented opportunity for all nations to gain regional cooperation on high seas salmon conservation and management issues. In March 2001 the NPAFC Research Planning and Coordinating Group agreed to develop a specific project-oriented plan, the Bering-Aleutian Salmon International Survey (BASIS), that would provide the basis for international cooperative research on Bering Sea salmon in NPAFC.

In October 2006, the NPAFC Parties agreed to continue the international effort to study salmon in the Bering Sea and requested a draft scientific plan for BASIS Phase II. BASIS phase II will continue the efforts of Phase I by proposing a set of surveys within three regions of the Bering Sea to establish when and where salmon stocks migrate and rear in the Bering Sea, and to clarify the mechanisms of biological response by salmon to the conditions affected by climate change. The NPAFC can play a vital role in providing continued focus on these issues by coordinating research in coastal and offshore waters, and by providing a forum for the dissemination of new scientific knowledge.

Prior to BASIS phase I, the issues regarding Pacific salmon stocks and their marine ecosystems were associated with declining salmon returns and size at age that occurred during the late 1990s (NPAFC Doc. 579 Rev 2). These declines were believed to be related to changing climate-ocean states that lead to reduced salmon carrying capacity in the Bering Sea. During BASIS Phase I research (2002 to 2006), salmon biomass in the Bering Sea increased and salmon returns to western Alaska climbed to all time highs despite the fact that brood year escapements for these returning salmon were low. BASIS research indicated the shift to higher abundance was related to increased carrying capacity for juvenile salmon in the eastern and western Bering Sea (Farley and Moss in review; Farley and Trudel in review; Gritsenko et al. in review). In addition, salmon carrying capacity in offshore regions of the Bering Sea remained sufficient for growth of immature salmon in the offshore regions, despite the significant increase in salmon abundance (Azumaya et al. 2008).

It is important that the research elements of BASIS Phase II build upon the achievements and content of BASIS Phase I. For instance, during BASIS Phase I, we learned that climate cycles can have profound effects on Bering Sea marine ecosystems. Shifts in the position the Far Eastern Low and Aleutian Low pressure systems can determine whether or not the Bering Sea experiences warming or cooling and also affect velocity of ocean currents (Figure 1). The position of these atmospheric low pressure systems (NE and W respectively) during 2002 to 2005 brought warmer air to the Bering Sea during winter and was related to decreased storm activity during summer. The position of these low pressure systems shifted again (SW and E respectively) during 2006; as a result, colder arctic air covered much of the Bering Sea during winter and summer storm activity increased. This climate cycle has persisted into 2008, with cold sea temperatures and record spring sea ice extent on the eastern Bering Sea shelf being recorded (http://www.arctic.noaa.gov/reportcard/seaice.html).

The impacts of these climate cycles (cool versus warm) on physical and biological parameters in the eastern Bering Sea were presented Danielson et al. (2008), Eisner et al. (2008), Andrews et al. (in review), Murphy et al. (in review), Coyle et al. (2008), Cieciel et al. (in review), and Farley and Moss (in review). These papers suggested pelagic productivity was highest during years with warm SSTs, as abundance levels of juvenile salmon and age 0 pollock were much higher than during years with cool SSTs. However, the zooplankton community shifted from large to small taxa during warm SSTs years (Coyle et al. 2008), altering energy transfer to pelagic fish and negatively impacting fish energy density prior to winter (Moss et al. in press; Andrews et al in review). This finding may explain why recruitment of some commercial fish species in the eastern Bering Sea was low during warm SST years, as fish with low energy reserves prior to winter would be expected to have higher mortality during winter.

Within the western Bering Sea, climate cycles of warm and cool also resulted in shifting food webs and abundance of pelagic consumers. Naydenko (in review) showed that juvenile walleye pollock consumed a large portion of the forage resource during 2002 and 2003 and Pacific salmon, squids, Atka mackerel , herring, and capelin were the dominate consumers of the available forage during 2004 to 2006. Volkov and Naydenko (2008) noted that copepods dominated the zooplankton biomass in the western Bering Sea during 2006, whereas euphausiids and hyperiids dominated the zooplankton biomass during 2003 and 2005. Koval (in review) connected 11 year cyclic solar activity to shifts in biomass of dominant pelagic fish species in the western Bering Sea (between salmon and Atka mackerel to walleye Pollock).

Models of salmon migration were also updated during BASIS Phase I. We now know that western Alaska sockeye salmon have extensive offshore migratory routes as juveniles during years with warm sea temperatures (Farley et al. 2007). Western Alaska immature sockeye salmon were also found in the northwestern regions of the Bering Sea during summer (Bugaev and Myers in review). This information updates the migration and distribution models for western Alaska sockeye salmon and suggests that climate cycles and climate change may impact the migratory pathways as well as winter and summer distribution. Several genetic and scale identification studies indicated Asian stocks of chum salmon are dominant in the western and central Bering Sea during summer/fall feeding period (Urawa et al. 2004, 2005a,b; Bugaev et al. in review; Sato et al. in review). A migration model of Japanese chum salmon suggests that they migrate between the Bering Sea and North Pacific Ocean depending on seasonal sea temperature changes (Urawa et al. 2005b). Extensions of BASIS research into Chukchi Sea during 2007 also revealed that large numbers of juvenile chum salmon were located within the Bering Strait and Chukchi Sea and that genetic analyses of these salmon suggested they were from the Anadyr-

Kanchalan region, Kamchatcka Peninsula and northwestern Alaska (Kondzela et al. in review). Knowledge of these range extensions, shifts in migratory pathways, and distributional patterns for Pacific salmon are important components to understand as they suggest salmon may be distributing themselves further north or colonizing northern regions as the sea and air temperatures become warmer.

During BASIS phase II, the NPAFC has an unprecedented chance to continue the time series of biological and oceanographic data to focus on how climate change and cycles affect the Bering Sea ecosystem. Our primary methodological approach is to conduct an international survey of salmon, associated pelagic nekton, and their ecosystem in the Bering Sea, deploying survey vessels at key times and regions to provide, among other things, a picture of the migration and ecology of salmon inhabiting the Bering Sea. BASIS phase II is intended to be a 5-year (2009-2013) program of field, laboratory, and computer modeling research would enable us to combine previous field efforts to track at least two cohorts of the longer-lived salmon species (sockeye, chum, and Chinook salmon) through a complete Bering Sea production cycle. Through this research plan, we hope that a clear understanding of salmon carrying capacity in the Bering Sea will result: from their first entry into the marine environment, to their departure from coastal to offshore waters where they develop and migrate extensively, and then their return back to home streams.

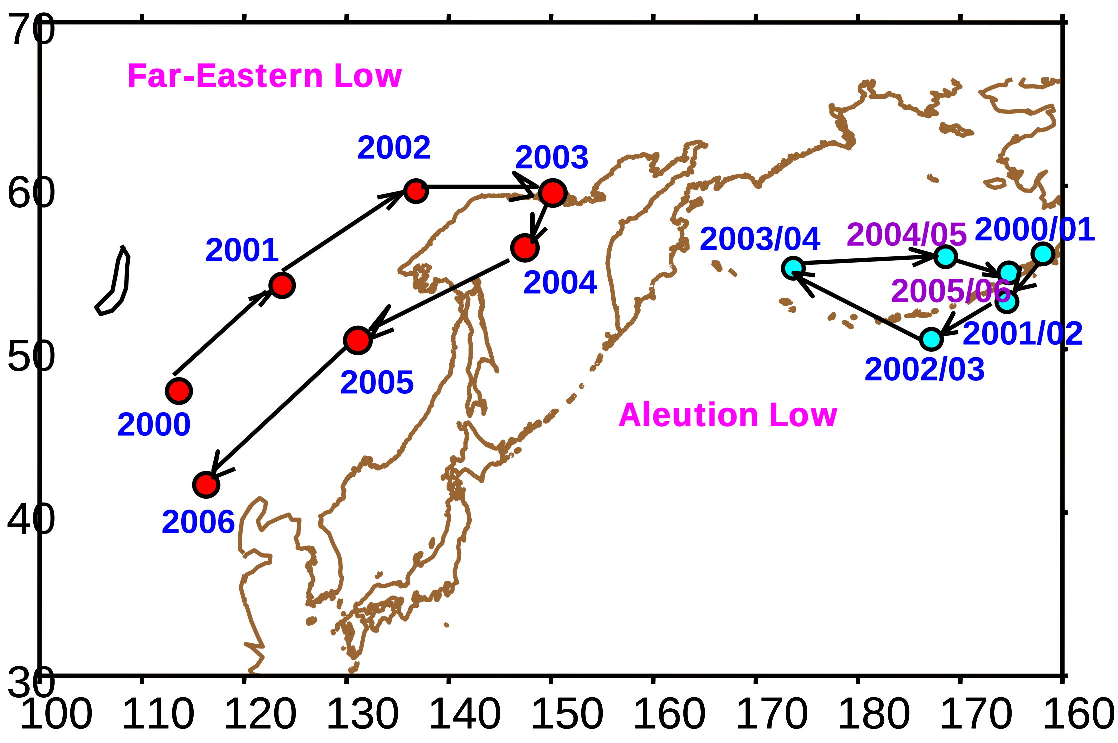

Figure 1. Center locations during winters 2000 to 2006 for the Far-eastern Low and Aleutian Low pressure systems.

3. BASIS Objectives

The goal of BASIS phase II is to understand how climate change will affect productivity of Bering Sea salmon and ecologically related species.

Key Scientific Questions

1. How will climate change affect anadromous stocks, ecologically related species, and the Bering Sea ecosystems?
2. What are the key climatic and oceanographic factors affecting long-term changes in Bering Sea food production and salmon growth rates?
3. How will climate change impact the available salmon habitat in the Bering Sea?
4. How will climate change affect Pacific salmon carrying capacity within the Being Sea?

Long-Term Objectives

1. Monitor and evaluate climate-oceanographic and biological factors related to foraging conditions, distribution, abundance and production of salmon and ecologically related species.
2. Determine and understand the role of salmon in nektonic communities and their association to Bering Sea ecosystem status.
3. Understand influence of climate-oceanographic conditions upon structure, status, population structure, migration, biological parameters and production processes of Pacific salmon stocks.
4. Understand foraging dynamics, food competition and its influence on growth and survival of salmon.
5. Understand the processes that affect salmon production.
6. Study the linkage between marine survival of salmon, and climate and ocean changes.
7. Predict the potential impacts of global climate change on marine salmon habitats.

Expected Contributions

1. Improve the ability to forecast abundance trends for international and domestic resource management;
2. Improve understanding and forecasts of future salmon productivity; and
3. Improve our understanding of salmon carrying capacity in the epipelagic ecosystem of the Bering Sea;
4. Co-operate with and participate in international salmon conservation efforts.

4. Approach

Our approach to BASIS Phase II will be to develop sampling plans to survey the entire Bering Sea. It would be desirable that the survey area consist more than 300 sampling stations spaced at regular intervals across the Bering Sea. The stations should cover coastal (<50 m deep), middle shelf (50-100 m deep), outer shelf (100-200 m deep), shelf break (along the 200-m contour), and oceanic (> 200 m deep) habitats. Sampling will consist of surface trawls to capture salmon of all ages, plankton tows, and sampling of ocean conditions (e.g., salinity, temperature, currents). Coordination of sampling will be through the NPAFC. Participants of BASIS Phase II will work actively in developing and standardizing a common database format for BASIS-related data. Exchange of scientists and methods are encouraged during BASIS Phase II.

4.1 Field Methods

The Bering Sea will be broken up into three distinct survey regions including the eastern Bering Sea, western Bering Sea, and the Bering Sea basin (Figure 2). The stations within each region will be evenly spaced to provide broad scale coverage over a number of habitats (i.e. coastal (<50 m deep), middle shelf (50-100 m deep), outer shelf (100-200 m deep), shelf break (along the 200-m contour), and oceanic (> 200 m deep) habitats). Each Party can develop relevant survey designs for regions they are interested and have funding to survey. Sampling will consist of surface trawls to capture salmon of all ages, plankton tows, and sampling of ocean conditions (e.g., salinity, temperature, currents). Coordination of sampling would be through the NPAFC.

Figure 2. Regions for the Bering-Aleutian Salmon International Survey (BASIS) Phase II. Regions include the eastern Bering Sea defined as being within the US zone along the eastern Bering Sea shelf from the western Alaska coast to the slope, western Bering Sea defined as the area within the Russian EEZ, and Bering Sea basin defined as the deep basin waters beyond the slope to the US/Russian boarder (dark black line).

4.1.1 U.S. Plan

The proposed annual U.S. BASIS survey will be conducted at stations located over the eastern Bering Sea shelf (Figure 3). The cruises will be conducted aboard a chartered fishing vessel or NOAA research vessel. Fish samples will be collected using a midwater rope trawl, model 400/580, made by Cantrawl Pacific Limited of Richmond, B.C., Canada. The net is approximately 198 m long, has hexagonal mesh in wings and body, and a 1.2-cm mesh liner in the codend. The 400/580 has a typical spread of 50 m horizontally and 18 m vertically. At each station, the net will be towed at or near the surface for 30 minutes at speeds up to 5 kts.

Salmon and other fishes will be sorted by species and counted. Standard biological measurements including fork length, body weight, and sex as well as scale samples from the preferred area (for growth analyses) will be taken from subsamples of all salmon species. All other fish species will be counted and standard biological measurements including length and weight will be taken from subsamples of each species. Diets of subsamples of salmon as well as other marine fish will be examined onboard. Tissues from subsamples of juvenile, immature, and maturing salmon will be collected and frozen for genetic stock identification.

Oceanographic data will be collected at each trawl station. Depth profiles of salinity, temperature, density, chlorophyll a fluorescence (indicates phytoplankton biomass), beam transmission (indicates particle load), irradiance (light) and dissolved oxygen will be taken from surface to near bottom depths at each trawl station using a CTD (conductivity, temperature, and depth meter, SBE-25 or SBE-911, Sea-Bird Electronics, Inc, Bellevue, WA). Water samples for nutrients, phytoplankton species and chlorophyll a (size fractionated and total) will be collected at 5 m and below the thermocline. Continuous measurements of surface temperature and salinity will be collected with a thermosalinograph (SBE-45, Sea-Bird Electronics, Inc[1]). Zooplankton samples will be collected at each trawl station using double oblique bongo tows taken to near bottom depths using a 60-cm diameter frame with 505 and 333 micron mesh nets and vertical tows using a Juday net (163 micron mesh) and /or pairvet nets (163 micron mesh) from near bottom to surface.

All biological and oceanographic data will be recorded in an ACCESS database.

BASIS research by the US Party during other time periods or expansion of the research to be conducted on the eastern Bering Sea shelf and into the Bering Sea basin will be dependent on future funding and ship time.

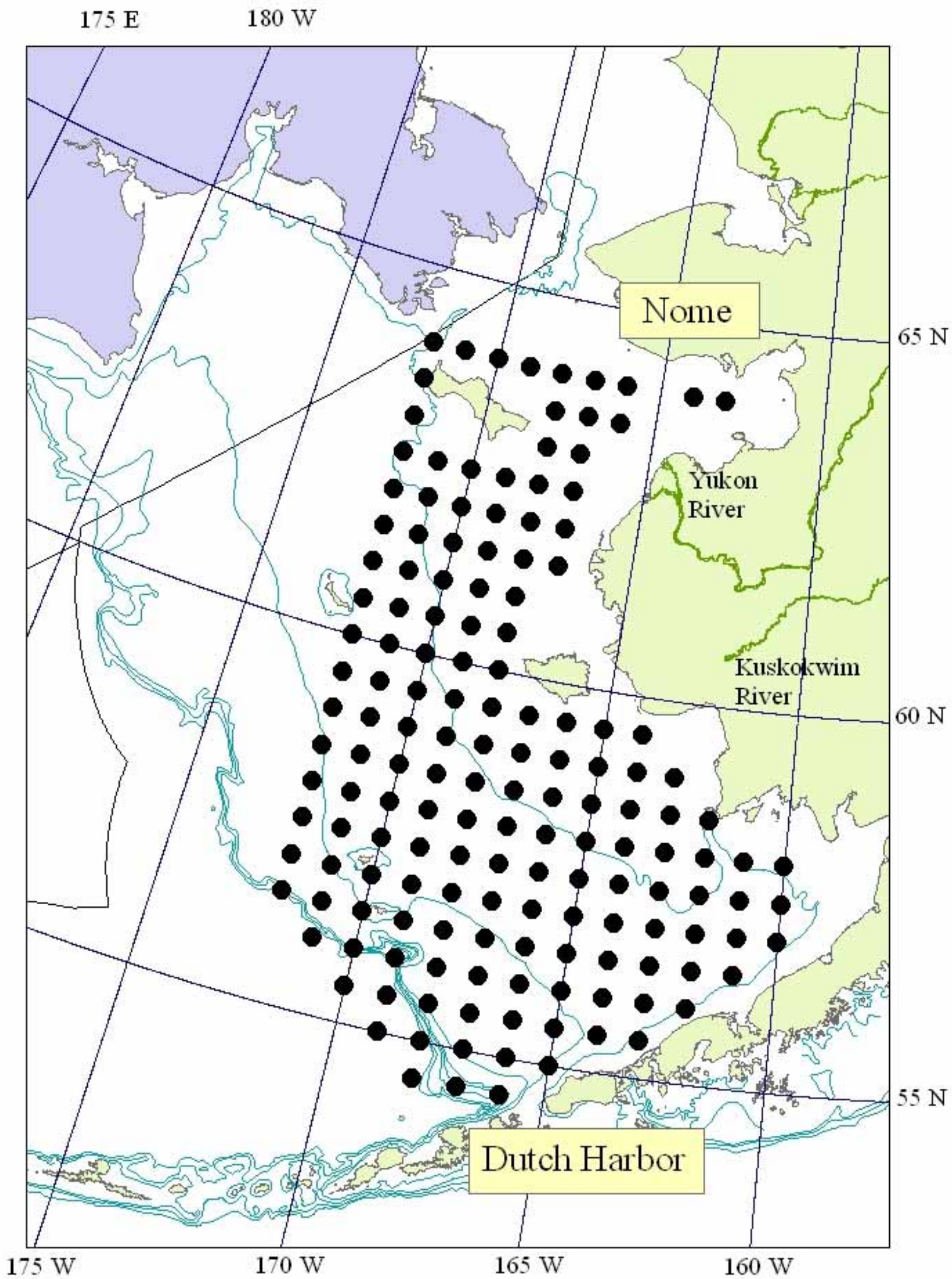

Figure 3. Proposed trawl stations for U.S. BASIS research. Number of stations sampled and area surveyed per year is dependent on funding.

4.1.2 Russia Plan

Russia proposes one survey per year for each research Center on the east coast, and placing its specialists aboard other vessels (as it was done during BASIS Phase I). Russia plans to conduct its surveys in the way similar to BASIS Phase I in the western Bering Sea within Russian EEZ and off eastern Kamchatka (Temnykh et al. 2003; Glebov et al. 2005a,b; Glebov et al. 2006).

TINRO Centre

Station locations to be sampled by the standard comprehensive survey of the upper epipelagic layer of the western Bering Sea are shown in Figure 4. The provisional survey period will be during summer-fall. Pelagic fish will be sampled using a standard midwater trawl, model RT/TM 80/376 m fished with four 120 m bridles. Heavy orbicular midwater trawl doors, each one of 6 sq.m, will be used. Depending on towing speed, the vertical spread of the trawl is 32-42 m and horizontal spread is 30-34 m. At each station the net will be towed for 1 hour at about 4.5-5.0 kts with the headrope located at the surface (fixed layer - 0 m). The warp length for the trawl is typically 250-310 m.

Standard biological measurements including length (nearest 1.0 mm) and weight (nearest 1.0 g) will be taken from fish samples collected from the trawl. Salmon samples collected at each station will be examined for the presence and type of parasites and injuries and these data are recorded for future analyses. Genetic samples are also taken from salmon to determine stock origin. Salmon are tagged with disk tags and released whenever possible. Samples are also collected for Pacific salmon bioenergetic studies. Samples for fish and squid diet studies are taken from the catch of every trawling and these samples undergo on-board processing.

During the second stage of BASIS these studies will be significantly strengthened by extensive collection of caloric content samples for different species (including salmon food items), as well as isotope research on different species trophic status. The details TINRO-center traditional ecosystem survey techniques are present in published sources (Temnykh et al. 2003; Glebov et al. 2005a,b; Glebov et al. 2006).

Zooplankton samples will be collected at each station using a Juday net with 143 micrometer mesh. The zooplankton samples are processed using “express method of analysis”, developed by TINRO-center. Oceanographic characteristics including temperature, salinity at depth are collected at each station by means of hydrological probe (sounds painful) Neil-Brown or by ICTD. The data are recorded for the fixed layer 0-1000 meters and for the areas with the depth less than 1000 meters – down to the bottom.

If additional external funding emerges, Russia will be able to expand its surveys into central Bering Sea beyond Russian EEZ. There is a possibility of expansion of surveys into the Chukchi Sea.

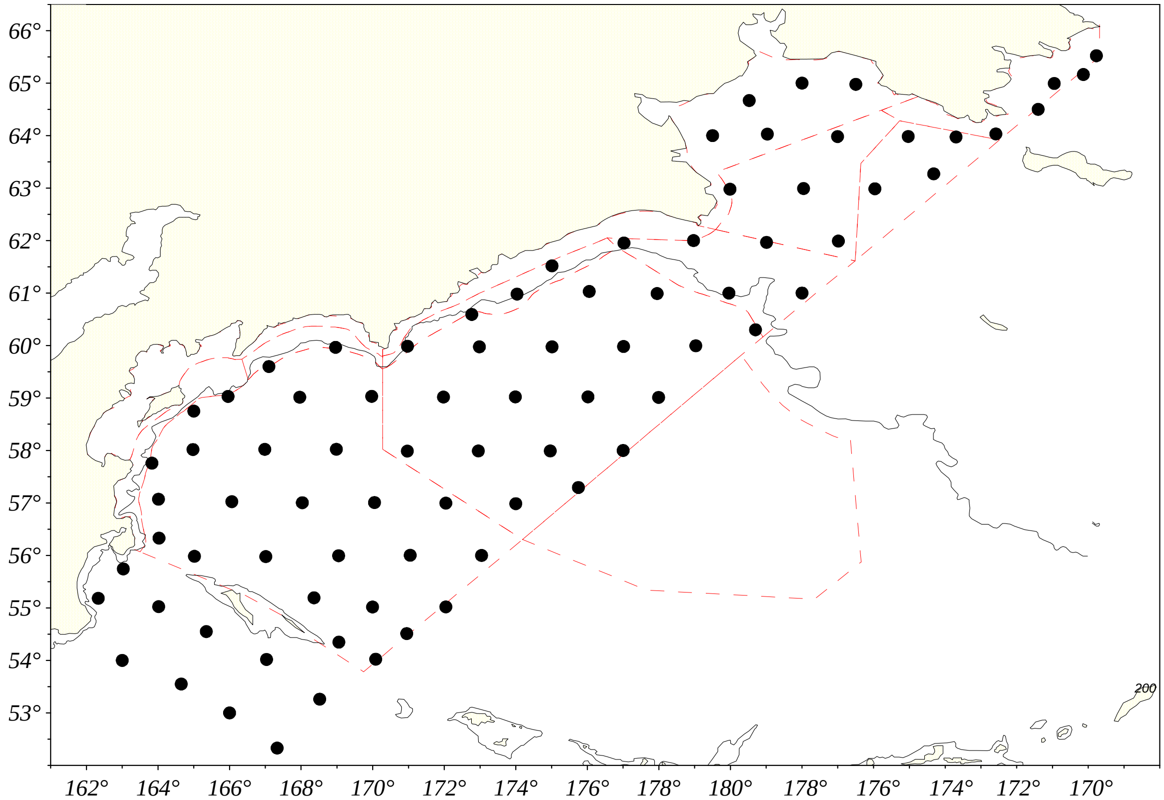

Figure 4. Proposed BASIS station locations to be sampled by scientists at the TINRO Center during summer-fall within the western Bering Sea and adjacent Pacific waters.

KamchatNIRO

BASIS research will be conducted in the southwest Bering Sea and adjacent waters of the North West Pacific during September – October at standard stations (Figure 5). The cruises will be conducted aboard a chartered fishing vessels.

Trawl operations will be will be conducted during day time with a 54.4/192 m trawl, consisting of 12 mm mesh equipped with a hydro dashboard. The trawl will be towed with the head rope near surface, for one hour, at a speed of 3.6–5.4 knots. The trawl will be armed by spherical trawling desks (the area of 3.3 m^2) and the hydrodynamic device. The typical spread for the trawl is 23–30 m vertical and 40–50 m horizontal.

Standard biological measurements including length (nearest 1.0 mm) and weight (nearest 1.0 g) will be taken from fish samples collected from the trawl. Salmon sampled will be analyzed by sex, AC and AD lengths, the total weight of fish and the weight without viscera, otoliths and scales and also stomachs will be fixed in 10% solution of formaldehyde for laboratory processing. Samples for studying chemical composition of fish body and for histological analysis will also be collected.

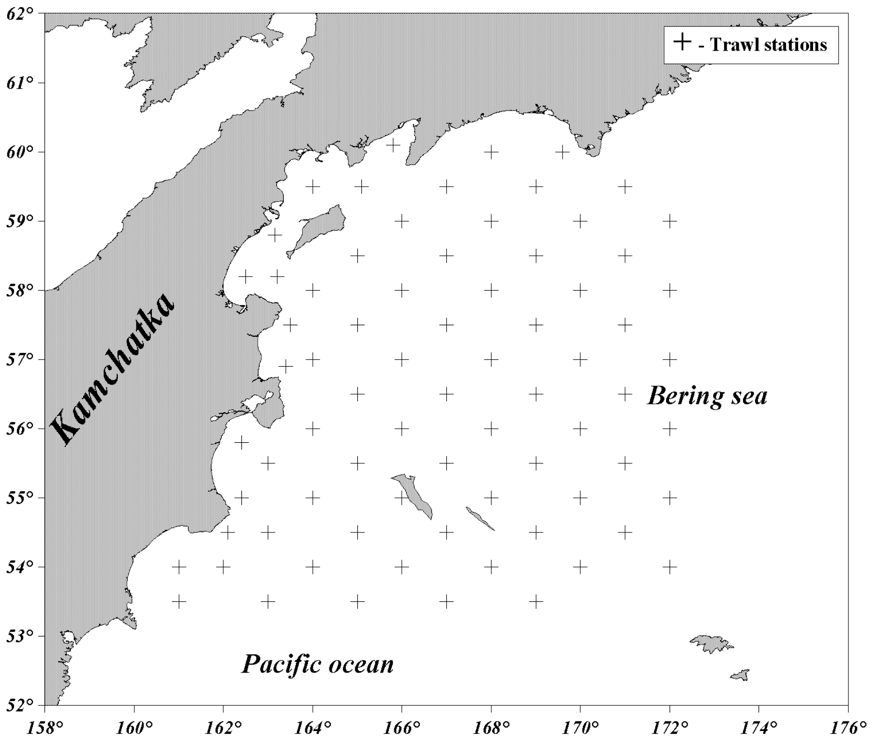

Figure 5. Proposed trawl stations by KamchatNIRO BASIS

Zooplankton samples will be collected at each station using a IKS–80 net with a mouth area 0.5 m^2 (ring diameter – 80 cm) and equipped with capron sieve № 15 in Russian standard (mesh size – 0.550 mm). The net will be deployed vertically with collections taken from near bottom (max 100 m) to surface depths. Zooplankton samples will be fixed in a solution of 4 % formaldehyde and transported to the KamchatNIRO laboratory for processing. Fixed plankton samples will be processed by the standard laboratory method for Russian plankton studies. Biomass of separate components in the sample will be calculated by multiplying the number of animals by their average weight. The average weight of each zooplankton species will be determined experimentally or taken from tables of standard weights. All large zooplankton, mainly euphausiids, hyperiids, large molluscs, polyhaets etc. will be weighed on a torsion or electronic balance to within 1 mg.

Oceanographic observations will be conducted at each trawl station using an SBE–19 plus or SBE–25 recorder (conductivity, temperature, and depth meter, SeaBird Electronics, Inc.). The data will be processed using standard Seabird data processing software.

4.1.3 Japan Plan

Japan plans to continue a traditional salmon monitoring program in the Bering Sea basin and its adjacent waters (Fukuwaka et al. 2009), but Japanese BASIS research plan is not fixed.

4.2 Laboratory Methods

Laboratory analyses will be performed by scientists at participating agencies and universities according to their areas of scientific expertise. Each component (scale analyses for age and growth, stomach content analyses, zooplankton analysis, calorimetry, genetic stock identification, scale pattern analysis, otolith marks, coded-wire tags, archival and disk tags, and parasite tags) should be regarded as a study independent but related with other components in the project.

4.3 BASIS Modeling

- The participating agencies and universities will use BASIS data to develop spatially-explicit models incorporating oceanographic data and salmon migration, growth, and mortality processes to advance our understanding of the causes of changes in productivity of salmon populations.

- Bioenergetic modeling will be used to evaluate the seasonal productivity and salmon carrying capacity (defined by salmon growth potential) in different habitats (coastal, middle shelf, outer shelf, shelf break, and oceanic) in the eastern and western Bering Sea and to estimate prey consumption for all species of salmon. Growth potential will be estimated by modeling consumption with an encounter rate model and a bioenergetics model to calculate daily weight-specific growth (growth potential; see Perry et al. 1996) with inputs of: 1) prey consumption rates based on predator/prey encounter rates, 2) the temporal pattern in diet composition over the period of interest; 3) the average daily temperatures that the salmon experienced over the period of interest, and 4) the energy density of salmon and their prey.

- Models that capture the effect of climate change on salmon carrying capacity could be built if appropriate climate driven, nutrient, phytoplankton, and zooplankton (NPZ) models were constructed. For example, NEMURO (Kishi et al. 2007) could be utilized with parameters developed for the Bering Sea to provide a platform NPZ model. This model can be linked to salmon bioenergetics models to provide details on how lower trophic levels effect growth rate potential (carrying capacity) of salmon in the Bering Sea.

4.4 Final Synthesis and Review

The scientific results of the entire 5-year cooperative research effort will be synthesized, reviewed, and published in the NPAFC Bulletin series as a joint comprehensive report on salmon in the Bering Sea (see section 4.7.3).

4.5 Relationship between BASIS and Current Bering Sea Salmon Research

BASIS expands current research conducted by the US and Russia on juvenile salmon in the coastal zones to include other life history stages in offshore zones. BASIS also increases temporal and spatial coverage of the Japanese research being conducted along the 180° line in the Bering Sea by the *Wakatake maru* (gillnetter).

4.6 Project Relevance and Benefits

- BASIS provides the first ever synoptic seasonal information on distribution, abundance, and stock origins of all species, age, and maturity groups of salmon in the Bering Sea.

- BASIS directly addresses the key elements of the 2006-2010 NPAFC Science Plan.

- BASIS complements long-term climate, ocean, and ecosystem research and monitoring activities by other international organizations such as the North Pacific Marine Science Organization (PICES), and Global Ocean Ecosystem Dynamics (GLOBEC), and the North Pacific Research Board (NPRB), Bering Sea Integrated Ecosystem Research Program (BSIERP).

4.7 Project Management

The NPAFC BASIS Working Group (BWG), composed of members from each of the Parties, will coordinate individual national plans, draft an annual implementation plan for joint BASIS research, and draft an annual report to summarize BASIS results. Annual cruise plans, cruise reports, data reports, and documents showing preliminary results of laboratory analyses and computer modeling will be submitted to NPAFC for review and evaluation. We believe it is important for individual researchers to publish the results of each aspect of the research (e.g., salmon, zooplankton, and oceanographic data). Principal investigators, project participants, and modelers will cooperate in constructing a dynamic model of salmon in the Bering Sea. BWG will prepare a final synthesis and review of all aspects of the research for publication in the NPAFC Bulletin series.

4.7.1 National Research Plans

Each country will propose an annual national research plan for BASIS. Submitted plans will be coordinated and compiled as the joint project of five nations by the BASIS Working Group.

4.7.2 NPAFC Research Planning and Coordination

The CSRS research planning and coordinating activities will include: 1) annual review and coordination of the collection and exchange of scientific data and collection of specimens; 2) coordination and assessment of stock identification research; 3) coordination of scientific exchanges, seminars, workshops, field research, and data analyses; 4) review of proposed research plan; and 5) review and approval of reports submitted for publication and recommendations regarding other reports to be published. In addition, the CSRS will make recommendations on cooperation, as appropriate, with PICES and other relevant organizations involved in Bering Sea research.

Scientists will meet annually at NPAFC Research Planning and Coordinating Meetings in March/April to plan and coordinate research activities, and at NPAFC Annual Meetings in October/November to review results and prepare an annual report to the Commission.

4.7.3 Workshop, Symposium and Publications

For BASIS Phase I (2002-2006), a NPAFC Symposium was held in Seattle, WA in 2008 to review BASIS research results as well as a BASIS Workshop held in Sapporo, Japan in the fall of 2004. Papers from the Symposium (NPAFC Bulletin No. 5) and Workshop (NPAFC Technical Report No. 6) are referenced throughout the BASIS Phase II plan.

For BASIS Phase II (2009-2013), a Workshop on Bering Sea salmon would be held in 2011 (halfway through the research program) with the objective of summarizing work done to date and laying out options for BASIS models (see section 4.3). To synthesize and review a series of BASIS projects, it would be ideal to hold BASIS Symposium-II in 2014 or 2015 and to publish results and reviews in the NPAFC Bulletin series (see section 4.4).

2011: BASIS Workshop-II
2014 or 2015: BASIS Symposium-II
2016: Publication of BASIS results in the NPAFC Bulletin series

4.8 BASIS Data Policy and Principles

The purpose of BASIS data policy is to facilitate full and open access to the highest quality of data. BASIS principal investigators and project participants must support this data policy.

I. No-cost, open, voluntary and ethical exchange of data or other BASIS-related information.

Publication of results immediately and directly from field and laboratory data is the privilege and responsibility of the investigators who collect the data. Any scientist making substantial use of a data set should anticipate that the data collectors would be co-authors of published results.

II. Methods and equipment used to take measurements and collect samples must be of sufficient accuracy and precision to yield data with quality adequate to meet the objectives of the BASIS field projects, associated modeling efforts, and larger-scale synthesis.

Final responsibility for selection of methods, equipment, and calibration procedures is assigned to the investigators making measurements. However, the procedures that will be used to collect and process samples and data will be considered in the review process.

III. A data archive system will be established for each project component within six (6) months of the project start date for temporary repository of the data prior to their submittal to a permanent archive.

The data archive system must facilitate the exchange of data and insure the long-term existence of the data set. Each investigator will be responsible for quality control of his or her data. The data will include the actual measurements and supporting descriptive information sufficient to permit its effective use by researchers not familiar with the original project or the particular instrument making the measurements (e.g., location, time, units, accuracy, precision, method of measurements or sampling, method and rate of sensor calibration and calibration data, investigator, reference to publications describing the data set, and data processing methods). Raw genotype scores for individual fish for both mixture and baseline samples will be archived for genetic data.

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