Project Title: Processes affecting the productivity of capelin and pollock in the Gulf of Alaska

Project Period: From Date: August 1, 2005 to June 30, 2007

Name, Address, Telephone Number and Email Address of Applicant:
Elizabeth A. Legerwell
Alaska Fisheries Science Center, F/AKC2
P.O. Box 15700
Seasltle, WA 98115
206-526-4231, libby.legerwell@noaa.gov

Principal Investigator(s): (Include name, affiliation and email address)
Janet Duffy-Anderson, Alaska Fisheries Science Center, janet.duffy-anderson@noaa.gov
Matthew Wilson, Alaska Fisheries Science Center, matt.wilson@noaa.gov
Patricia Livingston, Alaska Fisheries Science Center, pat.livingston@noaa.gov

Component 1 – Specific Project Needs (Goal and need): _______________________________________

or

Component 2 – General Research Priorities (a-g): One Primary: 6 One Secondary: ______

Summary of Proposed Work (250 words or less):
Our work will investigate the potential for competition between juvenile pollock and capelin, which has implications for how ecosystem change can affect capelin and pollock productivity. Competition negatively impacts feeding opportunities which can in turn impact fish nutritional status, size and subsequent overwinter survival and recruitment. Funding from NPRB would enable an intensive study of the role of hydrography on zooplankton composition, and on the diets of capelin and juvenile walleye pollock in Barnabas Trough, Kodiak Island. In previous years (2000-2004) we have observed a hydrographic front in Barnabas Trough that appears to physically separate capelin and pollock schools, with capelin occurring offshore of the front and pollock occurring inshore. These observed differences in habitat utilization have implications for resource use and competition between pollock and capelin in that region. Work on competition between capelin and pollock is important because it has the potential to elucidate some of the mechanisms by which climate variability influences fish populations. For instance, climate-driven ecosystem variability could influence the physical oceanography off Kodiak Island such that the hydrographic front in Barnabas Trough breaks down, thereby increasing the degree of spatial overlap of the two species. As discussed in the Draft NPRB Science Plan, most assessments of the effect of ecosystem change on fish populations rely on correlations between climate indices and time series of variables such as fish recruitment. However, the processes (such as competition) linking ecosystem change and fish populations remain largely unknown.

Funding: Total NPRB Funding Requested: $70,017

Total Matching Funds Used: $168,084

Legally Binding Authorizing Signature and Affiliation:

[Signature]
Deputy Director, AFSC

(NOT TO EXCEED ONE PAGE)
A. Project Title
Processes affecting the productivity of capelin and pollock in the Gulf of Alaska
(short title: Productivity of capelin and pollock)

B. Proposal Summary
Our work will investigate the potential for competition between juvenile pollock and capelin.
Competition negatively impacts feeding opportunities which can in turn impact fish nutritional status and size. Because nutritional status and size affects overwinter survival, and thus recruitment, a better understanding of the role of competition should lead to a better understanding of capelin and pollock productivity. In addition, further understanding of the potential for competition between pollock and capelin is necessary to evaluate whether climate-driven ecosystem variability can affect pollock and/or capelin recruitment variability by increasing or decreasing interspecific competition. Funding from NPRB would enable an intensive study of the role of hydrography on the distribution and diets of capelin and juvenile walleye pollock, and on zooplankton composition in Barnabus Trough, Kodiak Island. In previous years (2000-2004) we have observed a hydrographic front in Barnabus Trough that appears to physically separate capelin and pollock schools, with capelin occurring offshore of the front and pollock occurring inshore (Hollowed, et al in revision). These observed differences in habitat utilization (inshore vs. offshore of the front) have implications for resource use and competition between pollock and capelin in that region. Work on competition between capelin and pollock is important because it has the potential to elucidate some of the mechanisms by which climate variability influences fish populations. For instance, climate-driven ecosystem variability could influence the physical oceanography off Kodiak Island such that the hydrographic front in Barnabus Trough breaks down, thereby increasing the degree of spatial overlap of the two species. As discussed in the Draft NPRB Science Plan, most assessments of the effect of ecosystem change on fish populations rely on correlations between climate indices and time series of variables such as fish recruitment. However, the processes (such as competition) linking ecosystem change and fish populations remain largely unknown. The NPRB Science Plan concludes that “research into these processes would deepen our understanding of ecosystem function”.

C. Project Responsiveness to NPRB Research Priorities
This research addresses Component 2: General Research Priorities, c. Groundfish, 6. Implications of ecosystem change on fishery management. As discussed in the Draft NPRB Science Plan, most assessments of the effect of ecosystem change on fish populations rely on correlations between climate indices and time series of variables such as fish recruitment. However, the mechanisms linking ecosystem change and fish populations remain largely unknown. Our work will address the potential for environmentally-mediated competition between juvenile pollock and capelin to contribute to recruitment variability. Funding from NPRB would allow for biological and physical oceanographic sampling focused in Barnabus Trough off east Kodiak Island where previous work indicates habitat partitioning by juvenile pollock and capelin (see section D). Differences in habitat utilization (inshore vs. offshore of a mid-trough hydrographic front) may have implications for resource use and competition between pollock and capelin in that region. Unlike in the Semidi Bank vicinity where juvenile pollock and capelin co-occur and may be significant competitors for prey (Wilson, et al. in review), spatial segregation of pollock and capelin in Barnabus Trough may preclude competition for food resources. As such, climate-driven increases in capelin or juvenile pollock abundance could intensify interspecific competition for prey resources in the Semidi Bank vicinity, potentially contributing to density-dependent mortality. On the other hand, because juvenile pollock and capelin are spatially separated in Barnabus Trough, competition between the two species may be lower there, reducing the potential for density-dependent population regulation. However, climate-driven ecosystem variability could influence physical structure off Kodiak Island such that the hydrographic front separating pollock and capelin shifts or weakens, resulting in increased overlap of the two species. Increased overlap and competition between pollock and capelin could be particularly significant during fall when zooplankton prey abundances are in decline. Further understanding of the potential for competition between pollock and capelin is necessary to evaluate...
whether climate-driven ecosystem variability can affect pollock and/or capelin recruitment variability by
increasing or decreasing interspecific competition in this region.

It is also acknowledged in the NPRB Science Plan that forage fish, such as capelin, are important
components of North Pacific ecosystems, but that relatively little is known about the ecosystem effects of
changes in their abundance. Our work will examine the potential for spatial or temporal variability in
capelin biomass to impact juvenile pollock by way of interspecific competition.

D. Soundness of Project Design and Conceptual Approach

Problem addressed.
The ultimate goal of our proposed research is to understand some of the physical and biological processes
affecting the productivity of capelin and pollock in the Gulf of Alaska. Walleye pollock is a key species
in the Alaska groundfish complex and a target species for one of the world's largest fisheries. They are
important prey for other groundfish such as Pacific cod, arrowtooth flounder and Pacific halibut (Yang
2003), and for marine mammals (Sinclair & Zeppelin 2002). Capelin are an important forage fish in
Alaska, serving as prey for seabirds (Hatch & Sanger 1992), groundfish (Jewett 1978) and marine
mammals (Sinclair & Zeppelin 2002).

We will investigate the hydrographic processes that appear to drive juvenile pollock and capelin
distributions and thus whether they overlap spatially. We will also investigate the potential for
competition between capelin and juvenile pollock, which can
impact feeding opportunities. Variability in feeding opportunities
can in turn impact fish nutritional status and size. Because
nutritional status and size affects overwinter survival (Paul & Paul
1998; Sogard & Olla 2000; Sutton & Ney 2001), and thus
recruitment, a better understanding of forage requirements and the
role of competition should lead to a better understanding of
capelin and pollock productivity.

Our work will also contribute to a growing time series on the
physical and biological characteristics of capelin and pollock
habitat and the potential for competition between the two. These
data will eventually be applicable to understanding the influence
of ecosystem change on these populations. For example, the
climate regime shift of late 1970s saw a dramatic decline in
capelin abundance and an increase in pollock abundance in the
Gulf of Alaska (Anderson & Piatt 1999). This apparent
community reorganization was hypothesized to be a result of
changes in the timing of seasonal zooplankton production
augmented by predation by adult groundfish on capelin. It is also
possible that competition with juvenile pollock for shared
zooplankton prey adversely affected capelin (Wilson et al. in
review). Making the link between climate and interannual
variability in the physical and biological processes driving
recruitment may allow the formulation of models that help explain
past climate-related changes and others that predict future
changes.

Relation to previous work.
On-going investigations of forage fish productivity in the Shelikof
region by Wilson, Duffy-Anderson and others suggest that small

Figure 1. Geographic distribution of relative abundance (no. m\(^{-2}\)) of age-0 and age-1 walleye pollock, capelin, and eulachon collected 2-20 September 2000.
(ca. <150 mm SL) fishes (capelin and age-0 pollock) are more loosely affiliated with meso-scale bathymetric variation than are large (ca. > 150 mm SL) fishes (eulachon and age-1 pollock) (Fig. 1). In the Semidi Bank vicinity, which includes portions of the Shumagin and Shelikof sea valleys, forage fish biomass appears to be highest in the upper reaches of the sea valleys, especially along the upstream edge of Semidi Bank. Influxes of Alaska Coastal Current water likely enrich the prey in these areas and might explain why age-0 pollock along the upstream edge of Semidi Bank tended to be relatively large. Because these fishes co-occur and likely share prey resources in these areas, there is high potential for inter-specific competition and fine-scale resource partitioning to occur. There is also preliminary evidence that age-1 pollock and capelin overlap spatially and that they also share a degree of diet overlap (Yang 1993).

In contrast, juvenile pollock and capelin in another region of the Gulf of Alaska, the shelf off the east side of Kodiak Island, do not appear to overlap in distribution. In August 2000, scientists from the Alaska Fisheries Science Center (AFSC) initiated a multi-year investigation of the effects of fishing on Steller sea lion prey abundance and distribution in a commercial fishing ground located on the east side of Kodiak Island. In 2001, investigators from NOAA’s Pacific Marine Environmental Laboratory (PMEL) joined the project to provide enhanced biophysical sampling to characterize the marine habitat.

The east side of Kodiak Island features a wide shelf punctuated by two troughs, Barnabas and Chiniak troughs (Fig. 2). The sampling design for the effects of fishing experiment utilized control (unfished) and treatment (fished) areas. Barnabas and Chiniak troughs were selected as the study sites for the experiment because they share many biological and physical characteristics, such as orientation, depth and width. Barnabas Trough was open to fishing and Chiniak Trough was closed. All transects within a trough were surveyed twice before the start of the fishing season and at least once after fishing began. Surveys have been conducted in August-September 2000, 2001, 2002 and 2004 (no survey took place in 2003).

Results to date suggest that fronts define water masses of different temperature and of greater and lesser productivity and also determine the distribution of juvenile pollock and capelin. Sea surface temperature records from all years revealed the presence of a mid-trough front in Barnabas Trough (e.g., Fig. 3). Temperature profiles revealed that at distances less than 12 nmi from shore the water column (inshore of the front) was mixed, whereas a distinct mixed layer was detected in the region beyond 12 nmi (offshore of the front). In addition, chlorophyll-a concentrations observed with SeaWiFS satellite imagery during the...
2001 survey were restricted to the region inshore of the front. In 2000, 2001 and 2002, in Barnabas Trough, juvenile pollock (age-1 and age-2) were concentrated in the inshore area (e.g., Fig. 4). Further study of the relative nutrient, chlorophyll and zooplankton concentrations in the inshore and offshore areas is needed to evaluate the hypothesis that pollock are found nearshore because prey availability is greater.

In contrast to pollock, capelin were observed in the “offshore area” in Barnabas Trough in all three years, in association with subsurface intrusions of cool water advected from the slope (e.g., Fig. 5). Further study of the physical and biological characteristics of these areas is needed to understand how interactions between shelf and slope waters result in favorable pelagic habitat for capelin. Although the mid-shelf front in Barnabus Trough was observed in 2004, age-1 and age-2 pollock were virtually absent from the study area in that year. However, exceptionally high densities of age-0 pollock were observed, indicating that in 2005 age-1 pollock may once again be abundant in the study area.

Benefits resulting from proposed research.

Our work addresses several questions related to understanding the causes of change in fish productivity in the Gulf of Alaska: Is the hydrography of Barnabus Trough associated with differences in the community composition of zooplankton? Is it associated with a localized limitation in the geographic distribution of either fish species? How does the composition of fish diet correspond to the available prey field composition? Because habitat quality and interspecific competition are likely to influence forage and groundfish production, information gathered in pursuit of these questions can be used by NMFS to improve single-species assessment (e.g., for pollock) and ecosystem-based management in the Gulf of...
Alaska. The specific benefit of the proposed research is the diet data necessary to examine the biological significance of the habitat partitioning (driven by physical oceanographic processes) that we have observed during previous surveys off Kodiak Island. The proposed work thus will greatly increase the scientific value of our results to date by allowing us to predict whether climate-induced variability in frontal formation can modulate the degree of competition between juvenile pollock and capelin.

Hypotheses, experimental design and analytical approach.

**Hypothesis 1:** The distribution and abundance of juvenile pollock and capelin are controlled by different processes. Pollock distribution is determined by prey availability, whereas capelin distribution is determined by relative temperature.

Justification: Previous oceanographic studies (2000-2004) show that Barnabas Trough can be divided into two hydrographic regions: a well-mixed, chlorophyll-rich inner region, and a stratified, chlorophyll-poor outer region. Juvenile pollock were virtually restricted to the inner area. In contrast to pollock, capelin were most abundant offshore of the mid-trough front in association with cool slope water that had advected onto the shelf. Further study is needed to characterize the zooplankton prey field inshore and offshore of the hydrographic front, as well as to determine the diet composition of the two forage fish species.

Significance: Spatial partitioning between juvenile pollock and capelin may modulate the strength of competitive interactions between these two species (see Hypothesis 2) and potentially recruitment success. Further study is needed to evaluate the mechanisms resulting in localized geographic separation between pollock and capelin.

Experimental design: The data to test this hypothesis will be collected from the Barnabus Trough area which will be nested within the larger area to be sampled during the Ecosystem Fisheries Oceanographic Cooperative Investigations (Eco-FOCI) juvenile fish research cruise conducted in September 2005 by the Recruitment Processes Program (Alaska Fisheries Science Center, NMFS) on board the NOAA Research Vessel *Miller Freeman* (Fig. 6).

The distribution and abundance of capelin and pollock in Barnabus Trough will be assessed using acoustics and midwater net sampling. The abiotic characteristics of the habitat and the location of the front that has defined fish distribution in the past will be determined with a suite of surface and subsurface oceanographic measurements (including nutrients and chlorophyll). The species composition of pollock...
and capelin potential prey will be determined with zooplankton tows. Prey utilization will be assessed by collecting fish which will be preserved for subsequent diet determination.

**Water column profiles.** A conductivity-temperature-depth (CTD) probe or a net-mounted sensor (SeaCat) will be deployed at a minimum of seven stations in Barnabus Trough (Fig. 6). Niskin bottle samples will be collected during each CTD deployment for nutrient (NO$_3$, NO$_2$, PO$_4$, and SiO$_4$) and chlorophyll analyses. Nutrient samples will be collected at the surface and at depths of 10, 20, 30, 40, 50, 150, 200 m and 5 m off bottom (where water depths exceed 200 m). Chlorophyll samples will be collected at the surface and at depths of 10, 20, 30, 40, and 50 m (or a deeper depth if chlorophyll maximum is located deeper than 50 m). Chlorophyll samples will be collected from the CTD rosette Niskin bottles and the flow-through system (described below) in calibrated sample bottles. One salinity sample will be taken for each CTD to correct for drift of the conductivity cell. Sample depths will be chosen so that a range of salinities are sampled. The water samples to measure salinity are stored in labeled bottles and processed aboard the vessel. Nutrient samples will be collected from the CTD rosette Niskin bottles and from the flow-through system (described below).

**Continuous surface measurements.** A flow-through ship intake sampling system will make continuous measurements of sea surface temperature, conductivity, fluorescence and nutrients. Water samples will be taken from the flow-through system at 6 hour intervals to provide data to convert fluorescence to chlorophyll concentration and to calibrate the nutrient analyzer.

**Satellite-derived chlorophyll distribution.** SeaWiFS images will be used to describe the chlorophyll-a distribution in the study areas and thus supplement data from the CTDs and flow-through system. The images will be obtained from level 2A data files from the SeaWiFS web site. Images will be processed using the SeaDAS analysis package. Chlorophyll concentration will be calculated using the OC4 algorithm.

**Acoustic data.** Capelin and age-1 and age-2 pollock distributions will be assessed using echo integration trawl (EIT) survey techniques. The acoustic data will be collected with a calibrated Simrad ER 60 echosounder and three split-beam transducers at 38 kHz, 120 kHz and 200 kHz. The survey will consist of 20 nautical mile (nmi) transects spaced 8 nmi apart to be conducted during transit between stations (Fig 6). An anchovy trawl with a 3-mm mesh liner will be used to collect data on species composition and size distribution of acoustic sign. Fish collected in these tows will be used to supplement other samples collected to identify fish diet (described in detail below).

**Zooplankton samples.** Zooplankton sampling will occur at stations inshore and offshore of the hydrographic front (Fig 6). The location of the front will be assessed in near “real time” with water column profiles and continuous surface data (described above). At each station, a plankton sample and a midwater fish sample will be collected. Plankton samples will be collected with a 20-cm Bongo equipped with 150-micron mesh nets, and a 60-cm Bongo net equipped with 505- and 333-micron mesh (one on each side). A Sea-Bird 19 SeaCat profiler will be attached to the wire to provide real-time depth information and temperature and salinity profiles. Ship speed will be adjusted to maintain a 45-deg wire angle. Samples will be preserved in 10% formalin buffered with sodium borate, and sent to the Polish Plankton and Identification Center, Szezcin, Poland for taxonomic identification and enumeration. Zooplankton samples have been effectively collected using these methods by the Recruitment Processes Program at AFSC for over 20 years.

**Fish samples.** All fishes will be collected with an anchovy trawl equipped with a 3-mm mesh liner to accommodate smaller-sized capelin and juvenile pollock. In addition to conducting trawls to verify species composition of the acoustic sign (described above), trawls will be conducted at the same stations occupied for zooplankton sampling (Fig. 6). All fishes will be sorted to the lowest taxonomic level
possible, and then each group weighed and the individuals enumerated. Up to 50 individuals of each select group (target species/cohorts: capelin, age-0 pollock, age-1 pollock, and age-2 pollock) will be randomly selected and measured for length. Age-classes will be identified on the basis of size. Previously, age-0 individuals (<130 mm standard length) comprised a clear and distinct portion of the overall pollock size composition. Pollock between 130-240 mm standard length comprise the next larger modal size range and are considered to be age-1 individuals. Pollock between 240 mm and 400 mm are age-2, and pollock larger than 400 mm are age-3+. Although the anchovy trawl does not quantitatively sample age-2+ pollock, we will nonetheless be able to provide information on the relative abundances of these individuals on either side of the hydrographic front. Random subsamples of each select group of fishes will be frozen or preserved in formalin (up to 50 per tow) for subsequent gut content examination. Fishes will be weighed in the laboratory, and diet data will be obtained by excising the stomach of preserved individuals and examining the gut contents following established protocols (Wilson et al., in press). Gut contents will be sorted to broad taxonomic groups and the prey items in each group graded into four levels of quality (i.e. digestion). For each taxonomic and quality group, individual organisms will be counted and weighed, along with any fragments, to the nearest 0.01 mg.

Hypothesis 2: Spatial separation is necessary to prevent competition for food between juvenile pollock and capelin.

Justification: Unlike in the Semidi Bank vicinity where juvenile pollock and capelin co-occur and have similar diets, spatial segregation of pollock and capelin along East Kodiak may preclude competition for food resources. Two questions arise: do juvenile pollock and capelin diets overlap in Barnabus Trough, and if so, is spatial separation the only process that is preventing competition between pollock and capelin in this area? If the answer to both questions is “yes”, then a breakdown of the mechanisms separating the two species could result in competition. Although the Barnabus Trough front has been observed during each of the past surveys (2000-2002, 2004), in one year (2002), the front weakened between survey pass 1 (August 16) and pass 2 (September 2). There was an expansion of juvenile pollock distribution offshore and a decrease in capelin abundance following the spreading of the weakened mid-trough front. This apparent disruption of the front could have been caused by the mesoscale eddy that passed through the region during the survey (Fig. 7). Large (~ 200 km) eddy features have been observed on numerous occasions in the northern central Gulf of Alaska during the spring and summer (Thompson & Gower 1998; Stabeno, et al. 2004). These eddies are thought to increase on/off shelf exchange along the outer portions of the shelf (Stabeno, et al. 2004). It appears that they also influence the frontal systems in the troughs on the shelf. In order for competition to occur in a scenario of a weakened mid-trough front and increased spatial overlap, pollock and capelin must have similar diets. Detailed study of pollock and capelin diets is required to evaluate the hypothesis that spatial separation is necessary to prevent competition between juvenile pollock and capelin in Barnabus Trough.

Significance: There are several mechanisms by which climate-driven ecosystem variability could influence physical structure in the troughs off Kodiak Island. The strength of the subarctic gyre has been...
hypothesized to be related to the phase of the PDO. The resulting variability in the position and strength of the Alaska Stream may affect the flow into the troughs. Interannual variability in weather patterns determines the timing and strength of storms which affects vertical mixing. Finally, ENSO variability is expected to be important in determining the physical structure on the shelf via atmospheric teleconnections, but the mechanisms are not currently understood (see Stabeno, et al. 2004 for a review). Further understanding of the potential for competition between pollock and capelin off East Kodiak is necessary to evaluate whether climate-driven ecosystem variability can drive pollock and capelin recruitment variability by way of increasing or decreasing interspecific competition.

Experimental design: Diet overlap will be examined with data from gut content analysis, as described above.

Literature Cited


Hollowed, A.B., Wilson, C.D., Stabeno, P. and Salo, S. in revision. Effect of ocean conditions on the cross-shelf distribution of walleye pollock (Theragra chalcogramma) and capelin (Mallotus villosus) Fisheries Oceanography.


Wilson, M., C. Deliyanides, and J. Duffy-Anderson. in review. Capelin (Mallotus villosus) and age-0 walleye pollock (Theragra chalcogramma) in the Western Gulf of Alaska: Potential competitive interaction?


E. Project Management

Qualifications of Principal Investigators.

E. Logerwell is Leader of the Fishery Interaction Team at Alaska Fisheries Science Center (AFSC). She has extensive experience investigating the physical and biological characteristics of fish and seabird habitat and she will have primary responsibility for overseeing the project to completion. She has participated in three of the four previous Barnabus Trough surveys. She will be responsible for acoustic data collection and interpretation. She will be responsible for coordination with collaborators and integration of project components. She will also have overall responsibility for the preparation of reports and manuscripts.

M. Wilson (Recruitment Processes Program, AFSC) has over ten years of experience working with juvenile and forage fishes in the North Pacific. He has expertise in forage fish ecology including the analysis of patterns of distribution and trophic dynamics. He will serve as the Chief Scientist on the cruise, assist in field collections and project coordination, and assist in the integration and accomplishment of the various components. His obligations also will be to assist in the interpretation of results and the preparation of manuscripts.

J. Duffy-Anderson (Recruitment Processes Program, AFSC) has an extensive background in juvenile fish habitat use, and has considerable experience investigating the effects of habitat on fish growth and survival. In addition, she has expertise in the biology and ecology of forage fishes in the Gulf of Alaska. She will assist in coordinating the food habits portion of the field work. She will also oversee and advise work on stomach content dissections of age-0 pollock and capelin in the laboratory. Her obligations also will be to assist in the interpretation of results and the preparation of manuscripts.

P. Livingston is Program Leader of the Resource Ecology and Ecosystem Modeling program at AFSC. She has extensive experience with the collection and analysis of data relating to trophic interactions in the North Pacific and incorporation of these data into environmental assessments and single-species and multispecies models. She will oversee stomach content dissections of age-1 and age-2 pollock in the laboratory. She will also assist in the interpretation of results and the preparation of manuscripts.

Coordination with other projects.

We will collaborate closely with Phyllis Stabeno with regard to oceanographic data collection and analysis. P. Stabeno is the Director of the Ecosystems Fisheries Oceanographic Coordinated Investigations (Eco-FOCI) at Pacific Marine Environmental Laboratory (PMEL) and has over 15 years of experience studying the oceanography of Alaska. She will take the lead on analyzing and interpreting the physical oceanographic data.

We will also collaborate extensively with Chris Wilson, Program Leader of the Midwater Assessment and Conservation Engineering (MACE) program at AFSC. He has numerous years of experience conducting Echo-Integration Trawl (EIT) surveys in Alaska. He will provide guidance in the collection and interpretation of acoustic data.
We will collaborate with Dr. Robert Foy of the University of Alaska, School of Fisheries and Ocean Sciences, on the distribution, abundance, and trophodynamics of juvenile gadids and forage fishes. Dr. Foy is an expert in fisheries oceanography, particularly in the fields of pelagic fish assessment, feeding dynamics, and juvenile fish ecology, and we will confer with him in the interpretation of our data and results.

Leverage from other sources.

The Recruitment Processes Program will stage the Eco-FOCI Fall Survey in the Kodiak Archipelago in 2005 that will provide the platform for the proposed research. Our order of magnitude estimate of the matching funds associated with the Barnabus Trough sampling is $25,000. In addition, NOAA will contribute salary, benefits and indirect costs for the four Principal Investigators each year (Logerwell, Duffy-Anderson, Wilson, 2 mos. each per year; and Livingston, 0.5 mos. per year) for a total value of approx. $148,000.

Schedule and milestones

Year 1, FY 05, 4th quarter (July 1, 2005 – September 30, 2005)
August: Survey preparation
September: Eco-FOCI Fall Survey

Year 1, FY 06, 1st quarter (October 1, 2005 – December 31, 2005)
October: Data quality checking and preliminary analyses

Year 1, FY 06, 2nd quarter (January 1, 2006 – March 31, 2006)
January: Present preliminary results at annual science symposium

Year 1, FY 06, 3rd quarter (April 1, 2006 – June 30, 2006)
March: Finish acoustic and oceanographic data analyses
Zooplankton data available from sorting laboratory

Year 2, FY 06, 4th quarter (July 1, 2006 – September 30, 2006)
July: Finish fish diet and zooplankton data analyses

Year 2, FY 07, 2nd quarter (January 1, 2007 – March 31, 2007)
January: Present preliminary results at annual science symposium

Year 2, FY 07, 3rd quarter (April 1, 2007 – June 30, 2007)
June: Submit final report to NPRB
Submit manuscripts to peer-reviewed journals

Products and presentations.


American Society of Limnology and Oceanography, Ocean Sciences Meeting, 2006, Honolulu; J.-Duffy Anderson will make an oral presentation on preliminary results of the proposed research.
F. Project costs

Salaries

We request funds to cover the salaries of an AFSC Recruitment Processes Technician and a Food Habits Technician to assist with cruise preparation, and conduct fish stomach sample processing and data analysis during Year 1. The Food Habits Technician will be employed via a JISAO cooperative agreement:

Recruitment Processes Tech., 100% time, GS7, 2 mos @ $3,233/mo. and 3 mos. @ $3,362/mo.; $16,552
Food Habits Tech., 3 months, 100% time, $3,000 per month; $9,000

Matching Year 1 $51,052
Year 2 $41,418

NOAA will contribute salary for the four Principal Investigators (Logerwell, Duffy-Anderson, Wilson, 2 mos. per year; and Livingston, 0.5 mos. per year; includes at-sea overtime in Year 1).

Fringe Benefits

Request Year 1 $6,518
Recruitement Processes Tech., @26%; $4,304
Food Habits Tech., @24.6%; $2,214

Matching Year 1 $13,274
Year 2 $10,769

NOAA will contribute benefits for the four Principal Investigators (Logerwell, Duffy-Anderson, Wilson, 2 mos. per year; and Livingston, 0.5 mos. per year).

Travel

Request Year 1 $4,500
Year 2 $1,100

Year 1 Eco-FOCI Fall Survey, Kodiak, E. Logerwell, airfare ($800), per diem (3 days @$100); $1,100
Year 1 Science Symposium, Anchorage, E. Logerwell, airfare ($800), per diem (3 days @$100); $1,100
Year 1 Ocean Sciences Meeting, Honolulu, J. Duffy-Anderson, airfare ($900), per diem (7 days @$200); $2,300
Year 2 Science Symposium, Anchorage, E. Logerwell, airfare ($800), per diem (3 days @$100); $1,100

Supplies

Request Year 1 $7,700

Bottles, preservatives, labels, filters, etc. to collect and process zooplankton and fish samples; $1,000
Chemicals and other supplies to prepare the flow-through nutrient analyzer for deployment; $6,000
Chemicals, filters and other supplies for collecting and analyzing chlorophyll samples; $700

Contractual

Request Year 1 $8,500

Shipping equipment to Kodiak for Eco-FOCI Fall Survey; $1,500
Processing zooplankton samples at Polish Plankton Sorting and Identification Center; $6,500
Nutrient sample analysis; $500

The Polish Plankton Sorting and Identification Center in Szczecin, Poland does excellent work and returns both the sample sort and a digital record of the results. NOAA/NMFS has been using this Center for 30 years.
Requested Year 2 $4,000
Publication costs (journal color plate charges, page charges, reprint charges, etc.); $2,000
Outreach; $2,000

Indirect Costs
Requested Year 1 $12,147
AFSC Management Fund, @12.5% of salaries
NOAA, NMFS Management Funds and GSA Rent, @43.27% of salaries
JISAO Indirect Costs, @26% of salary and benefits

Matching Year 1 $28,472
Year 2 $23,099
NOAA will contribute indirect costs for the four Principal Investigators (Logerwell, Duffy-Anderson, Wilson, 2 mos. per year; and Livingston, 0.5 mos. per year).

Ship time
The Recruitment Processes Program will stage the Eco-FOCI Fall Survey in the Kodiak Archipelago in 2005 that will provide the platform for the proposed research. Thus, no additional funds are requested from NPRB for ship time. Our order of magnitude estimate of the matching funds associated with sampling proposed here is in excess of $25,000. This includes vessel operation within the Barnabus Trough study area and sample collection and processing associated with the overall juvenile survey.

Agency Justification
The Recruitment Processes Program (NOAA/AFSC) has not received increases to base support in over 10 years. As it’s first priority, this Program uses those limited resources to support continuation of time series investigations, in particular, support for field work associated with spring ichthyoplankton surveys (20+ years of data), spring investigations of zooplankton abundance and distribution in the Gulf of Alaska (15+ years), and juvenile fish research (10+ years). The importance of continuation of these activities pre-empts new projects, and lack of funding severely limits our ability to conduct new and much-needed applied fisheries-oceanography research and process-oriented work on older pollock (age-1 and age-2+ individuals and other species (capelin) in the Gulf of Alaska.

NOAA Fisheries has supported this research in the past (during 2000, 2001, 2002 and 2004) with funds from the Steller sea lion research initiative awarded to the SSMA program (NOAA/REFM). However, budget cuts were implemented in fiscal year 2003 and are expected to continue through the near future. Because the proposed work is not central to the issue of sea lion declines, support was withdrawn. As its first priority SSMA uses limited resources to fund research of critical immediate application to stock assessment. The importance of these activities often precludes new projects designed to explore new management applications, such as the one proposed here.
ELIZABETH A. LOGERWELL  
Resource Ecology and Fishery Management  
Alaska Fisheries Science Center, F/AKC2  
P.O. Box 15700  
Seattle, WA  98115-0070  
(206) 526-4231  Libby.Logerwell@noaa.gov

CURRICULUM VITAE

EDUCATION
9/83-6/88  B.S. in Biological Sciences with Honors, Stanford University, CA.

9/91-6/97  PhD. in Biology, Department of Ecology and Evolutionary Biology, University of California Irvine, CA.

POSITIONS HELD
5/97-9/97 Post-graduate researcher, Scripps Institution of Oceanography, CA

9/97-12/99 National Research Council Post-doctoral fellow, Southwest Fisheries Science Center, CA

1/00-2/01 Post-doctoral researcher, Pacific Northwest Coastal Ecosystem Regional Study, University of Washington, WA

2/01-8/03 Research Fishery Biologist, Alaska Fisheries Science Center, WA

8/03-present Supervisory Research Fishery Biologist, Alaska Fisheries Science Center, WA

SELECTED PUBLICATIONS
E.A. Logerwell, N.B. Hargreaves, 1996. The distribution of seabirds relative to their fish prey off Vancouver Island: opposing results at large and small spatial scales. *Fisheries Oceanography* 5: 163-175


RECENT COLLABORATORS (2001-2004)
K. Aydin, Alaska Fisheries Science Center
S. Barbeaux, Alaska Fisheries Science Center
E. Brown, Alaska Fisheries Science Center
M.E. Conners, Alaska Fisheries Science Center
R. Francis, University of Washington
A. Hollowed, Alaska Fisheries Science Center
B. Lavaniegos, Centro de Investigacion Cientifica y Educacion Superior de Ensenada
P. Lawson, Northwest Fisheries Science Center
S. Lowe, Alaska Fisheries Science Center
N. Mantua, Joint Institutes for the Study of the Atmosphere and Ocean
S. McDermott, Alaska Fisheries Science Center
J. Orr, Alaska Fisheries Science Center
I. Ortiz, University of Washington
R. Reuter, Alaska Fisheries Science Center
L. Schaufler, Alaska Fisheries Science Center, Auke Bay Laboratory
P. Smith, Southwest Fisheries Science Center
P. Spencer, Alaska Fisheries Science Center
P. Stabeno, Pacific Marine Environmental Laboratory
C. Wilson, Alaska Fisheries Science Center

SOCIETY MEMBERSHIPS
American Fisheries Society
American Geophysical Union
American Society of Limnology and Oceanography
PICES – North Pacific Marine Science Organization (Fisheries Science committee member)

GRANTS AND AWARDS
6/92 Chapman Memorial Fund of the American Museum of Natural History, $600
6/93 Chapman Memorial Fund of the American Museum of Natural History, $500
6/95 Holcomb Scholarship, University of California Irvine, $500
6/96 Lerner-Gray Fund for Marine Research, $860
9/97 National Research Council Post-doctoral Fellowship, $34,000
Janet T. Duffy-Anderson

NOAA/NMFS Phone: (206) 526-6465
Alaska Fisheries Science Center E-mail: Janet.Duffy-Anderson@noaa.gov
7600 Sand Point Way, NE
Seattle, WA 98115-0070

EDUCATION:
Ph.D., March 1996, Marine Studies. University of Delaware, Graduate College of Marine Studies, Lewes, DE.
B.S., June 1990, Biology. Lafayette College, Easton, PA.

PROFESSIONAL EXPERIENCE:
2003-present: Affiliate Faculty, University of Washington, Seattle, WA
2001-present: Research Fisheries Biologist, NOAA/Alaska Fisheries Science Center, Seattle, WA.
1999-2001: Postdoctoral Researcher, University of Washington/JISAO; NOAA/NMFS Alaska Fisheries Science Center, Seattle, WA.
1996-1999: Postdoctoral Associate, Rutgers University, Tuckerton, NJ
1991-1996: Graduate Research Assistant, University of Delaware, Lewes, DE.

RELATED PUBLICATIONS:


OTHER PUBLICATIONS:


**RECENT COLLABORATORS (past 4 years):**

**CRUISES:**
2005: (Anticipated) Juvenile Fish Ecology, East Kodiak Island, Gulf of Alaska
2003: (Completed) Chief Scientist, Ichthyoplankton Survey, Unimak Island/Pass, Bering Sea
2002: (Completed) Chief Scientist, Ichthyoplankton Survey, East Kodiak Island, Gulf of Alaska
2002: (Completed) Ichthyoplankton Survey, Unimak Island/Pass, Bering Sea
2000: (Completed) Juvenile Fish Habitat Survey, Kodiak - Shumigan Islands, Gulf of Alaska
2000: (Completed) Juvenile pollock vertical distribution survey, Pribilof Islands, Bering Sea

**STUDENTS ADVISED & POSTDOCTORAL ASSOCIATES SPONSORED:**
L. Weis (UW)
M. Cooksey (UW)
W. Boeing (UW/JISAO)
RESUME of
PATRICIA A. LIVINGSTON
Alaska Fisheries Science Center, NMFS/NOAA
7600 Sandpoint Way NE
Seattle, WA  98115, U.S.A.
Work Phone: (206) 526-4242
Email: Pat.Livingston@noaa.gov

Education
1973-1976  Michigan State University: B.S., Fishery Biology (Honor)
1976-1980  University of Washington: M.S., Quantitative Fishery Management

Scientific Experience:
1977-1983  Fishery research biologist, Northwest and Alaska Fisheries Center, Seattle, WA. Member of Ecosystem modeling group which developed models of North Pacific ecosystems.
1984-1996  Supervisory fishery research biologist, Alaska Fisheries Science Center, Seattle, WA. Head of the Trophic Interaction Group/Resource Ecology and Ecosystem Modelling Task in the Resource Ecology and Fishery Management Division which involves planning and conducting research on marine fish feeding interactions and applying and parameterizing single-species, multispecies and ecosystem models.
1989- now  Affiliate faculty member, University of Washington School of Fisheries

Committees and Societies:
1983-1986  Member, officer, and regional correspondent Marine Fisheries Section, American Fisheries Society
1984-1986  Member, Sea Use Council Scientific and Technical Advisory Board
1989–now  Member, American Institute of Fishery Research Biologists
1990-1991  Committee member, American Fisheries Society, Professionalism committee
1991-1992  Member and membership chair of the International Fisheries Section, American Fisheries Society
1991-1992  Membership committee, American Fisheries Society
1995-2001  Member, MODEL Task Team of PICES CCCC GLOBEC Program
1995-1996  Member, PICES WG5 on Bering Sea
1995-1997  Co-lead, MMPA Bering Sea Ecosystem Study Plan
1996-1997  Associate Director, NW Washington Chapter of American Institute of Fishery Research
1996-1998  National representative, PICES CCCC GLOBEC Implementation Panel
1996-1998  Co-chair, PICES-GLOBEC Climate Change and Carrying Capacity Program
1999-2001  Chairman, PICES Science Board
2001-now  Member, Arctic Climate Impact Assessment, Marine Drafting Group
2001-now  Member, North Pacific Fishery Management Council Ecosystem Committee
2002  Member, EVOS STAC Nominating Committee
2002  Member, PICES Organizational Review Committee
2004  Member, PICES Ecosystem-based Management Study Group
**Invited participant and organizer of regional, national, and international workshops and reviews**

Some examples include:

- Invited speaker at AFS theme session on Ecosystem Advice (1989)
- Invited keynote speaker at ICES Multispecies theme session at 1994 ICES Annual Meeting
- Invited speaker to review status of models for predicting the effects of climate change on upper trophic level species (PICES MODEL workshop, 1996)
- Invited plenary session keynote speaker at Center for Marine Conservation Biology workshop on Ecosystem Management in the Bering Sea (October 1997)
- Member of organizing group, workshop report editor, and workshop group leader for interagency workshops on developing a research plan for the Bering Sea Ecosystem (1997-1998)(two workshops, two workshop reports, one research plan)
- Member of organizing committee and session co-chair for the Lowell Wakefield symposium on Ecosystem approaches for Fisheries Management (Fall 1998)
- Invited participant in two focus groups at the ICES/SCOR international symposium on Ecosystem effects of Fishing (multispecies modeling and boreal ecosystems)(March 1999)
- Invited Keynote speaker at EVOS Restoration Workshop (Winter 2000)
- Invited speaker and participant in Canadian national workshop on Objectives and Indicators for Ecosystem-based Management. (Feb 2001)
- Invited panel member, Ecosystem-based Management Hearing, Subcommittee on Fisheries Conservation, June 14, 2001

**SELECTED PUBLICATIONS**


CURRICULUM VITAE
Matthew Thomas Wilson

Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, WA 98115
tel: (206) 526-6522; fax: (206) 526-6723; e-mail: matt.wilson@noaa.gov

Education
M.S.  Fishery Biology  Oregon State University, Corvallis, OR  1990
B.S.  Fishery Biology  University of Washington, Seattle, WA  1983

Employment History
Research Fishery Biologist (1991-present), Alaska Fisheries Science Center, Seattle, WA
Fishery Biologist (1988-90), National Marine Fisheries Service, Seattle, WA
Research Assistant (1986-88), College of Oceanography, Oregon State Univ., Corvallis, OR

Research Interest
My primary interest is the study of geographic differences among organisms in relation to their environment. My previous work on geographic differences among juvenile marine fish (e.g., juvenile pollock density, condition, growth, diet) in different bathymetric and hydrographic settings (e.g., eastern Bering Sea, western Gulf of Alaska) raised an exciting question: how are coastal pelagic fishes influenced by bathymetry? My current interests include the relevance of bathymetry and hydrography to the production of potential Steller sea lion prey (e.g., pollock, capelin, eulachon). In the future, I would like to include ontogenetic and ecosystem-level perspectives on fish distribution ecology, and thereby make some contribution toward a mechanistic understanding of such things as habitat suitability and the effects of climate change.

Relevant Publications


Collaborators
David A. Beauchamp, Associate Professor, Assistant Unit Leader-Fisheries, WA Coop. Fish & Wildlife
Community Service
Education outreach presentations on fish and NOAA research at local K-12 public schools

Grants
Co-principal investigator
NPRB Grant R0308. $320,000. 2004-05. Variation in forage fish productivity.
NOAA/SSLRI Grant 02FF-04. $330,400. 2002-03. Production of pelagic prey of sea lions
NOAA/SSLRI Grant 2001-121. $53,000. 2001. Production of pelagic prey of Steller sea lions
NOAA Coastal Ocean Program. $41,000. 1996-98. Juvenile pollock habitat, Bering Sea

Collaboration

Shipboard Experience
Research Vessels: >12 months, chief scientist on seven multi-week ocean cruises (1990-present)
# NPRB BUDGET SUMMARY FORM

**PROJECT TITLE:** Processes affecting the productivity of capelin and pollock in the Gulf of Alaska  
**PRINCIPAL INVESTIGATOR:** Logerwell, Duffy-Anderson and Wilson and Livingston

<table>
<thead>
<tr>
<th>FUNDING SOURCE</th>
<th>YEAR 1</th>
<th>YEAR 2</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPRB Funding</td>
<td>64,917</td>
<td>5,100</td>
<td>70,017</td>
</tr>
<tr>
<td>Match/In Kind</td>
<td></td>
<td></td>
<td>168,084</td>
</tr>
<tr>
<td>TOTAL</td>
<td>64,917</td>
<td>5,100</td>
<td>238,101</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Categories</th>
<th>NPRB Year 1</th>
<th>NPRB Year 2</th>
<th>NPRB TOTAL</th>
<th>Match/In kind TOTAL (all years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Personnel Salaries</td>
<td>25,552</td>
<td>25,552</td>
<td>92,470</td>
<td></td>
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<tr>
<td>2. Personnel Fringe Benefits</td>
<td>6,518</td>
<td>6,518</td>
<td>24,043</td>
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</tr>
<tr>
<td>3. Travel (include 1 trip to review meeting in Anchorage)</td>
<td>4,500</td>
<td>1,100</td>
<td>5,600</td>
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<tr>
<td>4. Equipment</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5. Supplies</td>
<td>7,700</td>
<td></td>
<td>7,700</td>
<td></td>
</tr>
<tr>
<td>6. Contractual/Consultants</td>
<td>8,500</td>
<td></td>
<td>8,500</td>
<td></td>
</tr>
<tr>
<td>7. Other (Include $2000 for education and outreach)</td>
<td></td>
<td>4,000</td>
<td>4,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total Direct Costs</strong></td>
<td>52,770</td>
<td>5,100</td>
<td>57,870</td>
<td>116,513</td>
</tr>
<tr>
<td><strong>Indirect Costs</strong></td>
<td>12,147</td>
<td>12,147</td>
<td>51,571</td>
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</tr>
<tr>
<td><strong>TOTAL PROJECT COSTS</strong></td>
<td>64,917</td>
<td>5,100</td>
<td>70,017</td>
<td>168,084</td>
</tr>
</tbody>
</table>

Annual cost category breakdowns will be requested for matching funds only if the project is funded.