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GEM PROPOSAL SUMMARY PAGE

(To be filled in by proposer)

Project Title:	Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Project Period:	FY 04-FY 06
Proposer(s):	T. Mark Willette, Alaska Dept. of Fish and Game, 43961 Kalifornsky Beach Rd, Ste B, Soldotna, Alaska 99669-8367. (907)262-9368 ph, (907)262-4709 fax, mark_willette@fishgame.state.ak.us. W. Scott Pegau, Kachemak Bay Research Reserve, 2181 Homer, Alaska 99603. ph: 907-235-4799 ext. 6, fax 907-235-4794, email: spegau@coas.oregonstate.edu
Study Location:	Cook Inlet

Abstract: This project will use a vessel of opportunity to collect physical oceanographic and fisheries data along a transect across lower Cook Inlet from Anchor Point to the Red River delta. Logistical support for the field sampling will be provided in part by the Alaska Department of Fish and Game which has chartered a vessel annually to fish along this transect each day during July providing inseason projections of the size of salmon runs returning to the inlet. The work proposed here is for long-term monitoring of oceanographic conditions in Cook Inlet as part of these ongoing fisheries surveys. Investigators will also use physical oceanographic data collected by the project to improve management of Cook Inlet salmon through improved inseason salmon run projections. Several hypotheses regarding effects of changing oceanographic conditions on salmon migratory behavior will be tested. The oceanographic data collected by the project will also provide for valuable validation of remote sensing products, improved understanding of ocean dynamics in lower Cook Inlet, and a highly powerful statistical evaluation of the oil spill risk analysis models.

Funding:	EVOS Funding Requested:	FY 04	$ 89.8	
		FY 05	$ 68.0	
		FY 06	$ 27.9	TOTAL: $ 163.9
	Non-EVOS Funds to be Used:	FY 04	$ 106.9	
		FY 05	$ 106.9	
		FY 06	$ 106.9	TOTAL: $ 320.7

Date: 6/15/2003 Date proposal prepared

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GEM RESEARCH PLAN

I. NEED FOR THE PROJECT

A. Statement of Problem

Since 1979, the ADF&G has conducted an offshore test fishing (OTF) project near the southern boundary of the Upper Cook Inlet (UCI) salmon management area (Figure 1). The objective of this project has been to estimate the total run of sockeye salmon, *Oncorhynchus nerka*, returning to UCI before these fish reach commercial harvest areas. Sockeye salmon returning to UCI have been sampled by fishing geographically fixed stations along a transect between Anchor Point and Red River Delta (Figure 1). These data have been extremely important to ADF&G management biologists as they set and adjust commercial fishing times and areas to most effectively harvest sockeye salmon that are surplus to spawning needs. Test fishing results have been reported annually since 1979 (Waltemyer 1983a, 1983b, 1986a, 1986b, Hilsinger and Waltemyer 1987, Hilsinger 1988, Tarbox and Waltemyer 1989, Tarbox 1990, 1992, 1994, 1995, 1996, 1997, 1998a, 1998b, 1999).

In 1999, the Alaska Board of Fisheries adopted a sliding range of inriver escapement goals for late-run Kenai River sockeye salmon that were based upon preseason and inseason projections of the annual return of this salmon stock. The OTF project provides the primary source of information used to project the return of this stock inseason. Achievement of inriver escapement goals and allocation of salmon to commercial, personal use, and recreational user groups is thus largely dependent on the accuracy of these projections. The accuracy of the population estimates provided by the OTF project typically increases as the season progresses. Projections made on July 20 have ranged from -5.4% to +103% of the actual run. The program often fails to accurately predict runs that are earlier than normal. Failure to accurately predict very large runs can result in large escapements, loss of revenue to the commercial fishery, and reduced production in future years due to overgrazing of plankton stocks by large fry populations in rearing lakes. Failure to accurately predict weak runs can result in over harvest by the commercial fishery, loss of fishing opportunities in personal use and recreational fisheries, and reduced production in future years. Improving the accuracy of inseason sockeye salmon population estimates will enable ADF&G to better manage for inriver escapement goals and maximum sustained yield thus benefiting the economy of the UCI area.

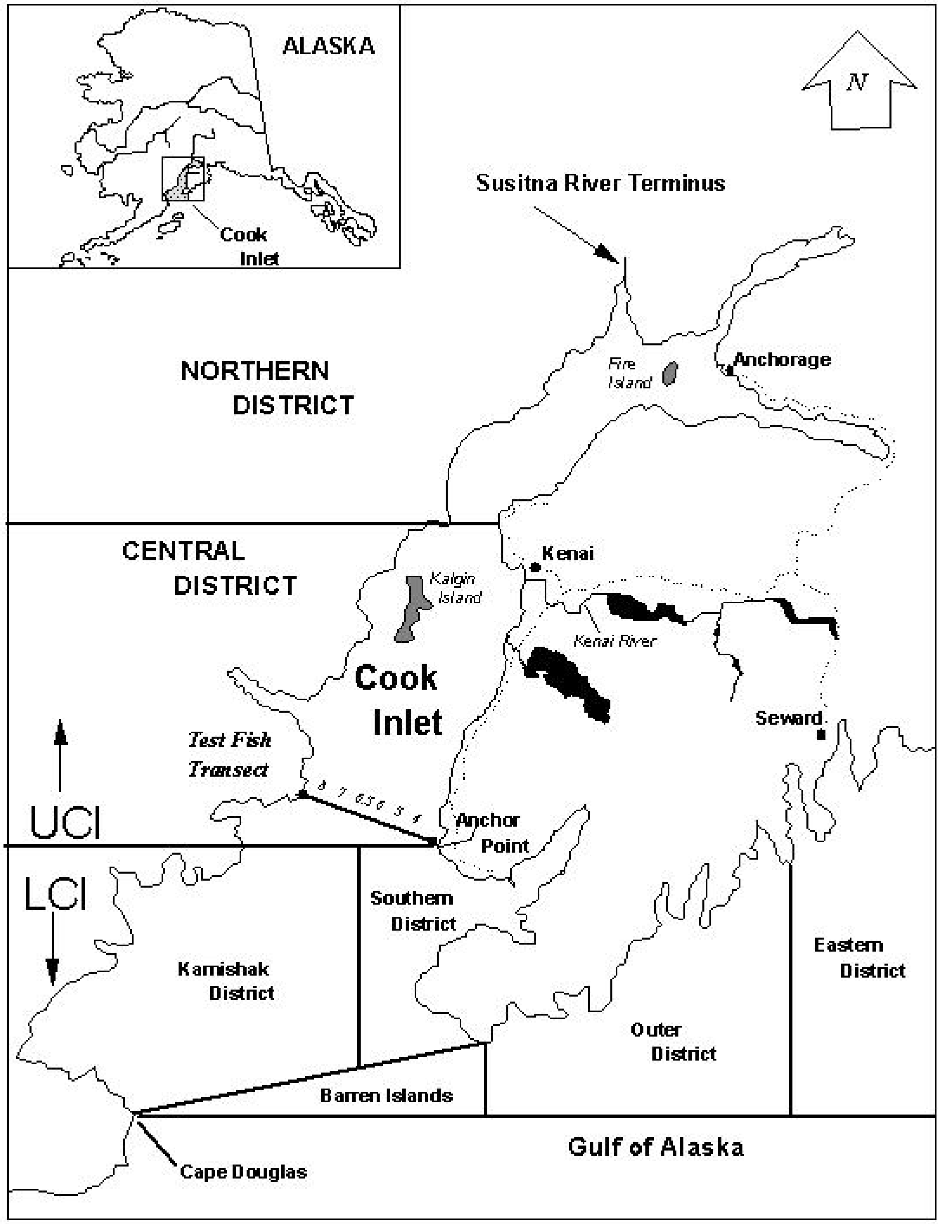

Figure 1. Location of fishing districts and offshore test fish transect in Cook Inlet, Alaska, 2001.

14

Errors in OTF program estimates of run size appear to be due to interannual changes in migratory timing and catchability. Migratory timing is defined as abundance as a function of time in a fixed geographic reference frame (Mundy 1982). The sockeye salmon run entering Cook Inlet normally peaks on July 15, but peak migratory timing has varied from July 6 to July 19. Variations in migratory timing are likely due to a range of biotic and physical factors that affect rates of maturation and migration. Ocean temperature (Burgner 1980), the strength of oceanic fronts (Mundy 1982), and tidal currents (Stasko et al. 1973a) are likely important physical factors affecting both the rate of maturation and migration. Catchability is defined as the fraction of the population captured by a unit of fishing gear. The OTF program estimates cumulative catchability to date from the ratio of cumulative catch per unit effort (CPUE) obtained from the test fishing vessel and estimates of total return to date. Cumulative catchability varies by a factor of 2 among years. Variations in catchability are likely due to biotic factors, e.g. fish size, as well as physical factors that affect the vertical and horizontal distribution (Huse and Holm 1993, Winters and Wheeler 1985) and migration rate of salmon (Hakoyama 1995).

The physical oceanography of Cook Inlet is characterized by a net inflow along the eastern boundary and a net outflow along the western boundary (Burbank 1977). Near the entrance of the inlet the inflowing water includes the ACC. The ACC then turns west and joins the outflowing water. The point at which the ACC turns west remains unresolved. Burbank (1977) shows a major portion of the ACC extending north past Anchor Point, while Muench et al. (1978) indicates that only a small portion of the ACC extends northward of Anchor Point. But, since these two studies were conducted in different years, it seems likely that the different current trajectories observed may simply indicate interannual variability. Driftcards released more recently off Point Adam as part of EVOS project 02671 were primarily recovered off Kenai indicating the surface flow of the ACC has a component that extends far northward of Anchor Point. This northward flowing component is then mixed within Cook Inlet and returns along the western boundary. A significant component of the water along the western boundary originates from Knik Arm and the Susitna River and is typically more turbid than the water further east due to the heavy glacial runoff from these drainages. However, the net flow is a minor component of the circulation, tidal currents largely determine current velocities. Tidal current velocities range from 1-2 kts at the entrance to 5-6 kts at the head of the inlet (Whitney 1999). Three distinct convergence zone, known at tide rips, have been identified in the inlet. The east rip is typically located 2-3 km offshore of the eastern boundary. The west and mid-channel rips are located just east of Kalgin Island. These two rips are associated with a 50-80 m deep channel running north to south along the inlet. During flooding and ebbing conditions, water flows faster through the channel due to lower bottom friction compared to the shallower areas east and west. The result is a surface convergence and strong turbulence along the rips.

The migration of salmon into the inlet is clearly influenced by the strength and location of tide rips. Fishermen working the inlet are very aware of tide rips and use the rips to locate and capture migrating salmon (Wilson and Tomlins 1999). Salmon have likely evolved behaviors that allow them to use tide rips and associated current structures to minimize the energy expended to reach their natal rivers (Scholz et al. 1972, Stasko et al. 1973b). Although tide rips clearly result from strong velocity gradients, they also represent boundaries between waters masses and may be associated with strong salinity gradients.

We propose to collect data to test the following hypotheses regarding effects of changing oceanographic conditions on the migratory behavior and catchability of salmon entering Cook Inlet.

Hypotheses

1. Salmon migration is delayed when fish encounter strong salinity gradients. Turbulence caused by strong tidal currents or winds breaks down salinity gradients increasing the rate of migration.
2. Interannual changes in freshwater outflow from UCI or the northward extent of the ACC affect salmon migratory timing. A stronger outflow or reduced northward flow of the ACC delays the migration, as salmon require more time to acclimate at frontal zones.
3. The variance of relative salmon density is a function of salmon abundance and the structure of tide rips along the OTF transect. When salmon abundance is low (high), relative salmon density is more contagiously (homogeneously) distributed. Strongly (weakly) developed tide rips cause salmon density to be more contagiously (homogeneously) distributed.
4. Salmon use tidal currents in UCI to facilitate their northward migration. On the flood tide, salmon density is highest between the west and mid rips where current speeds are maximum. On the ebb tide, salmon density is highest immediately east of the mid rip and west of the west rip where turbulence reduces the net southward flow.

In addition to our data collection we will work with any existing CODAR data and modeling results for the area to determine if those data sources are accurate enough and have sufficient resolution to address the fisheries questions at hand.

B. Relevance to GEM Program Goals and Scientific Priorities

This project will monitor the strength, structure, dynamics and mixing of the ACC as it intrudes into lower Cook Inlet (Burbank 1977). The location of the transect off Anchor Point and the high temporal sampling rate provided by the project will enable investigation of interactions between the ACC and processes such as tidal mixing, wind driven circulation, and frontal propagation, improving our understanding of linkages between the ACC and the nearshore estuarine habitat of the inlet.

The physical oceanographic data collected by the project will also be made available to other investigators studying how the dynamics of this current system affect the productivity of the biological resources in the region. The ADCP data in particular will be useful in determining the flow regimes that control larval, sediment, and contaminant dispersal within the inlet. The recent 20-year decline in seabird abundance at Chisik Island on the western end of the OTF transect and a concomitant increase in their abundance at Gull Island in Kachemak Bay (Piatt and Anderson 1996) provides an example of the kind of changes in resource productivity that might be explained by a long time series of physical oceanographic measurements in the region. Increases in turbid, nutrient-poor freshwater inflows into upper Cook Inlet, which flow southward along the west side of the inlet, may be linked to the decline of the Chisik Island seabirds. Studies of the Gull Island population may provide insights into processes sustaining seabird populations throughout the Gulf of Alaska, since this colony is the only one along the coast that has increased in recent years.

The proposed project could also contribute to our understanding of anthropogenic effects on resource productivity in the region by providing data for validation of the Oil Spill Risk Analysis (OSRA) model being developed by the Minerals Management Service for Cook Inlet and Shelikof Strait. The high temporal sampling rate proposed for this project will provide sufficiently numerous observations of temperature, salinity, and current velocity structures along the southern boundary of the inlet for a highly powerful statistical evaluation of the OSRA model.

II. PROJECT DESIGN

A. Objectives

1. Conduct an offshore test fishing (OTF) program to estimate the population size of sockeye salmon returning to Upper Cook Inlet.
2. Measure the horizontal distribution of relative salmon density along the OTF transect using side-looking acoustic equipment.
3. Measure environmental variables as well as the vertical distributions of temperature and salinity along the OTF transect and construct cross sections.
4. Measure the vertical distribution of current velocity along the OTF transect using an acoustic doppler current profiler and construct cross sections.
5. Analyze the possibility of using CODAR data and/or modeling results to supplement or replace the oceanographic data.
6. Conduct statistical analyses to test major hypotheses.

B. Procedural and Scientific Methods

Objective 1

Sockeye salmon returning to Upper Cook Inlet will be sampled by fishing six geographically fixed stations between Anchor Point and Red River Delta (Figure 1). Stations will be numbered consecutively from east to west, with station locations being determined using a differential global positioning system. A chartered test-fishing vessel will sample stations 4 - 8 daily, traveling east to west on odd-numbered days and west to east on even-numbered days.

Sampling will start on 1 July and continue through 30 July. The chartered vessel will fish a 366 m x 10 m drift gill net with 13 cm multi-filament web at each station. Once deployed at a station, gillnets will be fished 30 min before retrieval is started.

All captured salmon will be identified to species and sex. Fork length (mid-eye to fork-of-tail) will be measured to the nearest millimeter. The number of fish caught at each station will be expressed as a catch per unit of effort (CPUE) statistic for each species:

$$CPUE_S = \frac{100\, fm \;\; x \;\; 60 \min \;\; x \;\; number\ of\ fish}{fm\ of\ gear \;\; x \;\; MFT} \qquad (1)$$

where $CPUE_s$ = CPUE for station s, and
MFT = mean fishing time.

Mean fishing time will be calculated as:

$$MFT = (C - B) + \frac{(\mathrm{B} - \mathrm{A}) + (\mathrm{D} - \mathrm{C})}{2} \qquad (2)$$

where A = time net deployment started,
B = time net fully deployed,
C = time net retrieval started, and
D = time net fully retrieved.

Daily CPUE ($CPUE_d$) will be calculated as:

$$CPUE_d = \sum_{s=1}^{n} CPUE_s\ . \qquad (3)$$

Daily CPUE statistics will be used to estimate the size of the migrating salmon population as described by Mundy (1979).

Objective 2

A Biosonics model DT6000 scientific 200 kHz echosounder will be used to measure relative salmon densities along the OTF transect. A 6.6^o circular split-beam transducer will be mounted in a side-looking orientation on a 2.0-m long aluminum sled. Fish will be acoustically sampled at 3-5 pings sec^{-1}, at ranges from 0-100 m, using a pulse width of 0.2 ms, and a –47 dB threshold. Data will be stored on a laptop computer and geo-referenced using a differential global positioning system (DGPS). Later in the laboratory, fish targets will be counted by 20 m range bins using autotracking software.

Acoustic equipment will be operated along transects between the 6 stations fished with the drift gill net each day. Transects will be traversed at 3-6 m sec^{-1} depending on sea state. The area swept by the sonar along each transect will be calculated by multiplying each 20 m range strata by the length of the transect. Relative salmon densities (no. m^{-2}) will be estimated for 500 m by

20 m report areas. The data from each range strata will be used to evaluate the detection characteristics as a function of range. Tarbox and Thorne (1996) have established the feasibility of using side-looking sonar to estimate densities of migrating adult salmon in Cook Inlet.

Objective 3

A conductivity-temperature-depth profiler (CTD) equipped with a fluorometer and transmissometer will be used to measure the vertical distribution of temperature, salinity, fluorescence and turbidity from the surface to the bottom at each fixed station. Additional CTD casts will be made on each side of obvious frontal zones. The data will be used to construct a cross section of the distribution of these variables along the OTF transect each day. A continuously-recording CTD equipped with a transmissometer will also be towed along the entire transect each day. The data from this instrument will enable investigators to better define the location of frontal structures.

Air temperature, wind velocity, tide stage, water depth, and water clarity will also be measured at each station using methods employed over the past 20 years of the OTF program. Wind speed will be measured in knots and direction recorded as 0 (no wind), 1 (north), 2 (northeast), 3 (east), 4 (southeast), 5 (south), 6 (southwest), 7 (west), or 8 (northwest). Tide stage will be classed as flood, ebb or slack by observing the movement of the vessel while drifting with the gill net. Water depth will be measured in fathoms using a Simrad echo sounder, and water clarity will be measured using a 17.5 cm secchi disk.

Objective 4

A 300 kHz acoustic doppler current profiler (ADCP) will be used to measure the vertical distribution of current velocity along the OTF transect. The ADCP will be mounted in a down-looking orientation on a 2-m long aluminum sled. A 2-m cell depth size will be used providing a velocity measure with a standard deviation of 66 mm sec^{-1}. A bottom-tracking algorithm will be used to measure the survey vessel's velocity over the bottom. Absolute current velocity will be calculated in real time by subtracting the vessel's velocity from the relative current velocities measured by the ADCP. Data will be stored on a laptop computer and geo-referenced using a DGPS. Acoustic equipment will be operated along transects between the 6 stations fished with the drift gill net each day. Transects will be traversed at 3-6 m sec^{-1} depending on sea state.

Objective 5

In addition to the oceanographic variables being measured, we will examine the possibility of using CODAR data and modeling results. We will use any CODAR data that overlaps our study in time and space to determine if the resolution and accuracy is sufficient to replace the shipboard measurements. At this point it is unclear if CODAR data will be available in the region. The University of Alaska systems are scheduled to be moved away before our study begins, but a group from NOAA may install systems that overlook our study region. We will also collaborate with the SALMON project and the MMS funded work of Mark Johnson to evaluate the accuracy and resolution of oceanographic modeling results. The optimal data set is likely to be a mixture of high resolution shipboard measurements and the non-ship intensive studies of CODAR and modeling.

C. Data Analysis and Statistical Methods

Hypothesis 1:

Salmon migration is delayed when fish encounter strong salinity gradients. Turbulence caused by strong tidal currents or winds breaks down salinity gradients increasing the rate of migration.

The gradient of salinity (?o/oo m^{-1}) across tide rips will be calculated using CTD data collected on each side of the rip zones. The gradient of salinity across the tide rips will then be plotted against wind speed and tidal current velocities measured using the ADCP. Linear and non-linear regression analyses will be conducted to determine the model that best fits the data and test the hypothesis that strong tidal currents or winds are associated with weaker salinity gradients. We will also examine the feasibility of using our split-beam acoustic system to measure salmon swimming speeds. If practical, this will provide the data needed to directly test whether migration rate is related to salinity gradients. It is unlikely that sufficient data will be available the first year to test this hypothesis. However, the next hypothesis addresses this same issue although many years of data will be required to test it.

Hypothesis 2:

Interannual changes in freshwater outflow from UCI affect salmon migratory timing. A stronger (weaker) outflow delays (accelerates) the migration.

Salmon migratory timing will be estimated using CPUE data from the OTF drift gill net vessel. Cumulative daily $CPUE_t$ will be calculated as:

$$CPUE_t = \sum_{d=1}^{n} CPUE_d \qquad (4)$$

Daily estimates of $CPUE_t$ and $CPUE_d$ will be used to estimate cumulative proportions of $CPUE_t$, and the data will be fit to a non-linear model (Mundy 1979):

$$y_d = 1 \big/ (1 + e^{-(a+bd)}) \qquad (5)$$

where: y_d = cumulative proportion of $CPUE_t$ on day d,
a and b = coefficients of model,
d = day of observation.

The mean date of the salmon migration (M) is then estimated as (Tarbox 1999):

$$M = a/b \quad (6)$$

Average salinity measured west of the west rip will be calculated using all data collected during July each year. The mean date of migration (M) will then be plotted against average salinity. Linear, non-linear, and multiple regression analyses will be conducted to determine the model that best fits the data and test the hypothesis. Covariates in multiple regressions will include salinity in Cook Inlet, and sea surface temperature in the Gulf of Alaska (Burgner 1980). Multiple years of data will be required to test this hypothesis.

Hypothesis 3:

The variance of relative salmon density is a function of salmon abundance and the structure of tide rips along the OTF transect. When salmon abundance is low (high), relative salmon density is more contagiously (homogeneously) distributed. Strongly (weakly) developed tide rips cause salmon density to be more contagiously (homogeneously) distributed.

The mean and variance of relative salmon density along the OTF transect will be calculated for each day and plotted against one another. If the abundance hypothesis is correct, a plot of the variance against the mean density should indicate an asymptote at high salmon densities. Various transformations of the data will be explored to satisfy assumptions for regression analysis (Zar 1984). Linear, non-linear and multiple regression analyses will be conducted to determine the model that best fits the data and test the hypothesis. Covariates in multiple regressions will include the relative salmon density, and the gradients of salinity (?o/oo m^{-1}) and velocity (?m/sec m^{-1}) across tide rips (as a measures of the strength of the rips). Sufficient data may be available the first year for a preliminary test of this hypothesis.

Hypothesis 4:

Salmon use the tidal currents in UCI to facilitate their northward migration. On the flood tide, salmon density is highest between the west and mid rips where current speeds are maximum. On the ebb tide, salmon density is highest immediately east of the mid rip and west of the west rip where turbulence reduces the net southward flow.

The gradients of salinity, current velocity, and visual observations will be used to determine the location of the west and mid rips each day. The ratio of the mean relative salmon density between and outside of the two rips will be calculated for each day. An analysis of variance will be conducted to test whether the ratio of the two densities is significantly different during the flood versus the ebb tide. Various transformations of the data will be explored to satisfy assumptions for analysis of variance (Zar 1984). Sufficient data may be available the first year for a preliminary test of this hypothesis.

D. Description of Study Area

This project will be conducted in lower Cook Inlet along a transect running from Anchor Point on the east to the Red River delta on the west. The vessel will operated out of Homer and will return to Homer every other day. The sampling region for this project lies north of latitude 59.675, west of longitude 152.833, south of latitude 60.000 and east of longitude 153.666.

E. Coordination and Collaboration with Other Efforts

The physical oceanographic data collected by this project will be made available to others studying the dynamics of the ACC. The data collected by this project will complement the dataset of physical conditions at station GAK 1 near the mouth of Resurrection Bay. The proposed project could also provide data for validation of the Oil Spill Risk Analysis (OSRA) model being developed by the Minerals Management Service for Cook Inlet and Shelikof Strait, as well as the modeling efforts being conducted by Mark Johnson and SALMON projects. The high temporal sampling rate provided by the proposed project increases the likelihood of encountering clear weather conditions for validation of remote sensing products and will provide sufficiently numerous observations of temperature, salinity, and current velocity structures along the southern boundary of the inlet for a highly powerful statistical evaluation of the OSRA model. We hope that the NOAA CODAR units currently installed will remain during this study so that we can compare in-water measurements against the surface measurements of CODAR. We are working with the NOAA group that is deploying bottom mounted ADCPs to ensure that are programs are complimentary. We will coordinate our measurements with vessel-of-opportunity efforts that will be making similar surface property measurements in Lower Cook Inlet and the Gulf of Alaska.

III. SCHEDULE

A. Project Milestones

Objective 1. Conduct an offshore test fishing (OTF) program to estimate the population size of sockeye salmon returning to Upper Cook Inlet.
To be met annually by August 2004-2005.

Objective 2. Measure the horizontal distribution of relative salmon density along the OTF transect using side-looking acoustic equipment.
. To be met annually by December 2004-2005.

Objective 3. Measure environmental variables as well as the vertical distributions of temperature and salinity along the OTF transect and construct cross sections.
To be met annually by December 2004-2005.

Objective 4. Measure the vertical distribution of current velocity along the OTF transect using an acoustic doppler current profiler and construct cross sections.

To be met annually by December 2004-2005.

Objective 5. Analysis of model and CODAR accuracy and resolution.
To be met annually by April 2005-2006.

Objective 6. Conduct statistical analyses to test major hypotheses.
To be met annually by April 2005-2006.

B. Measurable Project Tasks

FY 04, 2nd quarter (January 1, 2004-March 31, 2004)
(dates not yet known) Annual GEM Workshop

FY 04, 3rd quarter (April 1, 2004-June 30, 2004)
June 1: Award contract for vessel charter

FY 04, 4th quarter (July 1, 2004-September 30, 2004)
August 1: Complete field sampling

FY 05, 1st quarter (October 1, 2004-December 31, 2004)
December 31: Complete analyses of fisheries acoustic and ADCP data

FY 05, 2nd quarter (January 1, 2005-March 31, 2005)
(dates not yet known) Annual GEM workshop
March 31: Complete preliminary tests of major hypotheses if possible.

FY 05, 3rd quarter (April 1, 2005-June 30, 2005)
June 30: Submit annual report to Trustee Council Office.

FY 05, 4th quarter (July 1, 2005-September 30, 2005)
August 1: Complete field sampling

FY 06, 1st quarter (October 1, 2005-December 31, 2005)
December 31: Complete analyses of fisheries acoustic and ADCP data

FY 06, 2nd quarter (January 1, 2006-March 31, 2006)
(dates not yet known) Annual GEM workshop

FY 06, 3rd quarter (April 1, 2006-June 30, 2006)
August 1: Complete tests of major hypotheses, if possible.

FY 06, 4th quarter (July 1, 2006-September 30, 2006)
September 30: Submit final report (which will consist of draft manuscript for publication) to Trustee Council Office.

IV. RESPONSIVENESS TO KEY TRUSTEE COUNCIL STRATEGIES

A. Community Involvement and Traditional Ecological Knowledge (TEK)

This project will utilize the traditional knowledge of local fishers who have observed the migratory behavior of salmon entering the inlet for many years. This knowledge will help the investigators interpret the quantitative data collected during the course of the project. A local hire preference will be employed for all contracts and technicians recruited during the course of the project. The Kachemak Bay Research Reserve will design a program of public education to disseminate knowledge obtained from the project to the community.

B. Resource Management Applications

This project will conduct research needed to improve the accuracy of inseason projections of migratory salmon populations entering Cook Inlet. The tools developed by the project will help ADF&G better manage for inriver escapement goals and maximum sustained yield of the salmon resource in the inlet. The physical oceanographic data collected by the project will also be used by resource managers to better understand the dynamics of the ACC system and how physical conditions affect the productivity of the biological resources in the region.

V. PUBLICATIONS AND REPORTS

A manuscript describing the "Effects of oceanographic conditions on the migratory behavior of salmon entering Cook Inlet" will be submitted to the Fisheries Oceanography during fall of 2006.

VI. PROFESSIONAL CONFERENCES

A manuscript entitled "Effects of oceanographic conditions on the migratory behavior of salmon entering Cook Inlet" will be presented at the annual meeting of the American Fisheries Society, Alaska Chapter in 2006. The location of the meeting is not known at this time.

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Waltemyer, D.L. 1983a. Migratory timing and abundance estimation of the 1982 sockeye salmon return to Upper Cook Inlet based on a test fishing program. Alaska Department of Fish and Game, Division of Commercial Fisheries, Upper Cook Inlet Data Report 83-1, Soldotna.

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Whitney, J. 1999. What the actual movement of oil in Cook Inlet tells us about the circulation in Cook Inlet. Pages 25-47. In *Proceedings of the Cook Inlet oceanography workshop*. M.A. Johnson and S.R. Okkonen (eds.), University of Alaska, Fairbanks, Alaska.

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Winters, G.H. and J.P. Wheeler. 1985. Interaction between stock area, stock abundance, and catchability coefficient. *Can. J. Fish. Aquat. Sci*. **42**: 989-998.

Zar, J.H. 1984. Biostatistical Analysis. Prentice Hall, Inc, Englewood Cliffs, N.J.

CURRICULUM VITAE

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Commercial Fisheries Division
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Educational Background:

Bachelor of Science, Fisheries Science, 1983, University of Alaska Fairbanks.
Master of Science, Fisheries Oceanography, 1985, University of Alaska Fairbanks.

Appointments:

Research Project Leader, AK Dept. Fish & Game, Soldotna, AK	2000-present
Research Project Leader, AK Dept. Fish & Game, Cordova, AK	1999-2000
Research Biologist, AK Dept. Fish & Game, Cordova, AK	1991-2000
Assistant Research Professor, University of Alaska, Fairbanks, AK	1990-1991
Instructor of Fisheries, University of Alaska, Fairbanks, AK	1986-1990
Graduate Research Assistant, University of Alaska, Fairbanks, AK	1983-1986

Current Duties:

Design and implement research projects to assess the abundance, size and age composition of salmon returning to Upper Cook Inlet and develop preseason and inseason forecasts of abundance. These projects include sonar enumeration of sockeye salmon in the Kenai, Kasilof, Crescent, and Yentna rivers, sampling of commercial catches and escapements to estimate size and age composition, preseason forecasts of abundance from assessment of juvenile salmon populations in rearing lakes, inseason forecasts of abundance from test fishery statistics, and evaluation of biological escapement goals.

Selected Publications:

Willette, T.M., R. DeCino, N. Gove. 2003. Mark-recapture population estimates of coho, pink, and chum salmon runs to upper Cook Inlet in 2002. Alaska Dept. of Fish and Game, Regional Information Report no. 2A03-20, 65 p.

Tobias, T., and T.M. Willette. 2003. An estimate of the return of sockeye salmon to upper Cook Inlet, Alaska 1976-2002. Alaska Dept. of Fish and Game, Regional Information Report no. 2A03-11, 425 p.

Willette, T.M., R.T. Cooney, V. Patrick, D.M. Mason, G.L. Thomas, and D. Scheel. 2001. Ecological processes influencing mortality of juvenile pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound, Alaska. *Fish. Oceanogr*. **10** (suppl. 1): 14-41.

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R.T. Cooney, T.M. Willette, S. Sharr, D. Sharp, J. Olsen. 1995. The effect of climate on Pacific salmon production in the northern Gulf of Alaska: examining the details of a natural experiment. In *Proceedings of the International Symposium on Climate Change and Northern Fish Populations, Can. Spec. Publ. Fish. Aquat. Sci.* **121**: 475-482.

Willette, T.M. and R.T. Cooney. 1991. An empirical orthogonal functions analysis of sea surface temperature anomalies in the North Pacific Ocean and cross-correlations with pink salmon (*Oncorhynchus gorbuscha*) returns to southern Alaska. In *Proceedings of the 1991 Pink and Chum Salmon Workshop*, Parksville, British Columbia.

CURRICULUM VITAE

W. Scott Pegau
Kachemak Bay Research Reserve
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email scott_pegau@fishgame.state.ak.us

Professional Preparation:

University of Alaska, Fairbanks	Physics	B.S./1990
Oregon State University	Oceanography	Ph.D./1996
Oregon State University	Oceanography	Post doc./1996-1997

Appointments:

Senior Scientist, Kachemak Bay Research Reserve (KBRR)	2002-present
Assistant Professor (tenure track), Oregon State University	1999-present
Faculty Research Associate, Oregon State University	1997-1999
Faculty Research Associate (Post Doc), Oregon State University	1996-1997
Graduate Research Assistant, Oregon State University	1990-1996
Research Assistant, University of Alaska, Fairbanks	1987-1990

Current duties:

Current duties at KBRR include maintaining and expanding the in-situ monitoring program, and developing new research programs examining the circulation and primary production in Kachemak Bay and Lower Cook Inlet. I am maintaining a quarter time position at OSU while completing grants from the Navy and NASA to investigate uses of hyperspectral remote sensing data, developing an autonomous underwater vehicle program, and discrimination of phytoplankton taxa using ocean color remote sensing.

Expertise:

My primary area of expertise is the interpretation of in-situ and remote optical measurements to determine types of materials in the water column, determination of vertical distributions from space, water masses, and circulation patterns. I have extensive experience in the conceptual design and deployment of sensors on a number of platforms ranging from traditional cages, ferry vessels, and autonomous vehicles. I also have experience determining heat fluxes using meteorological and oceanographic measurements.

5 related publications:

Pegau, W. Scott, Inherent optical properties of the central Arctic surface waters, *J. Geophys Res*, **107**, doi. 10.1029/2000JC000382, 2002.

Pegau, W. S., E. Boss, and A. Martinez, Ocean color observations of eddies during the summer in the Gulf of California, *Geophys. Res. Lett.*, **29**, 10.1029/2001GL014076, 2002.

Chang G. C., T. D. Dickey, O. M. Schofield, A. D. Weidemann, E. Boss, W. S. Pegau, M. A. Moline, and S. M. Glenn, Nearshore physical forcing of bio-optical properties in the New York Bight. *J. Geophys. Res*., **107**, 10.1029/2001JC001018, 2002.

Twardowski, M. S., E. Boss, J. B. MacDonald, W. S. Pegau, A. H. Barnard, J. R. V. Zaneveld, A model for estimating bulk refractive index from the optical backscattering ratio and the implications for understanding particle composition in case I and case II waters, *J. Geophys. Res.*, **106**, 14129-14142, 2001.

Boss, E., W. S. Pegau, J. R. V. Zaneveld, and A. H. Barnard, Spatial and temporal variability of absorption by dissolved material at a continental shelf, *J. Geophys. Res.* **106**, 9499-9508, 2001.

5 other publications

Bartlett, J. S., M. R. Abbott, R. M. Letelier, and W. S. Pegau, Analysis of a method to estimate chlorophyll-a concentration from irradiance measurements at varying depths, *J. Atmos. Ocean. Tech.*, **18**, 2063-2073, 2001.

Weideman, A. D., D. J. Johnson, R. J. Holyer, W. S. Pegau, L. A. Jugan, and J. C. Sandidge, Remote imaging of internal solitons in the coastal ocean, *Remote Sensing of Environment*, **76**, 260-267, 2001.

Boss, E., and W. S. Pegau, The relationship of light scattering at an angle in the backward direction to the backscattering coefficient, *Appl. Opt*., **40**, 5503-5507, 2001.

Pegau, W. S., J. R. V. Zaneveld, A. H. Barnard, H. Maske, S. Avarez-Borrego, R. Lara-Lara, and R. Cervantes, Inherent optical properties of the Gulf of California, *Ciencias Marinas*, **25,** 469-485,1999.

Pegau, W. S., D. Gray, and J. R. V. Zaneveld, Absorption of visible and near-infrared light in water: the dependence on temperature and salinity, *Applied Optics*, **36**, 6035-6046, 1997.

Collaborators E. L. Andreas (CRREL), S. Alvarez-Borrego (CICESE), D. G. Barber, A. H. Barnard (Bigelow), J. C. Blakey, E. Boss (OSU), G. C. Chang (UCSB), G. F. Cota (ODU), J. A. Curry, T. D. Dickey (UCSB), H. Eiken (UAF), C. W. Fairall, W. D. Gardner (TAMU), S. Glenn (Rutgers), D. Gray (TAMU), M. Gregg (UW), T. C. Grenfell (UW), A. J. Gow, R. E. Green (WHOI), P. S. Guest, J. Intrieri, D. R. Johnson (NRL), D. Kadko(U. Miami), R. W. Lindsay(UW), M. Landry, R. Lara-Lara (CICESE), J. Longacre, J. MacKinnon (UW), H. Maske (CICESE), M. G. McPhee, C. D. Mobley (Sequoia Scientific), M. Moline, J. Morison (UW), R. E. Moritz (UW), J. L. Mueller (SDSU), R. G. Onstott, C. A. Paulson (OSU), D. K. Perovich (CRREL), P.O.G. Persson, A. A. Petrenko, R. Pinkel (SIO), R. A. Maffione (Hobilabs), M. J. Richarson, J. A. Richter-Menge (CRREL), C. S. Roesler (Bigelow), O. Schofield (Rutgers), E. Skyllingstad (OSU), H. M. Sosik (WHOI), T. Stanton, H. Stern, M. Sturm (CRREL), W. B. Tucker III (CRREL), T. Uttal, M. Twardowski (WETLabs), E. Valdez-Holguin, I. D. Walsh (OSU), A. Weidemann (NRL), A. J. Williams III (WHOI), J. R. V. Zaneveld (OSU/Wetlabs)

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Budget Category:	Proposed FY 04	Proposed FY 05	Proposed FY 06		TOTAL PROPOSED	
Personnel	$22.9	$22.9	$23.6		$69.4	
Travel	$1.0	$1.0	$1.0		$3.0	
Contractual	$37.5	$37.5	$1.0		$76.0	
Commodities	$1.0	$1.0	$0.0		$2.0	
Equipment	$20.0	$0.0	$0.0		$20.0	
Subtotal	$82.4	$62.4	$25.6		$170.4	
General Administration (9% of Subtotal)	$7.4	$5.6	$2.3		$15.3	
Project Total	$89.8	$68.0	$27.9		$185.7	

Cost-share Funds (annual):

Item	Purpose	Source	Amount
Vessel charter	data collection	ADFG	37.5
Personnel	data analysis	ADFG	17.4
CTD & Fisheries Sonar	data collection	ADFG	52.0

FY 04-06

Date Prepared:

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3A TRUSTEE AGENCY SUMMARY

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Description	Step	Budgeted	Costs	Overtime	Sum
Mark Willette	Fishery Biologist III	18K	1.0	6.7		6.7
Scott Pegau	Senior Scientist	18C	2.0	5.5		11.0
Robert Decino	Fishery Biologist II	16C	1.0	5.2		5.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.0	17.4	0.0	
					Personnel Total	$22.9

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
Attend annual EVOS workshop	0.1	2	8	0.1	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY 04

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 04 - FY 06

Contractual Costs:	Contract
Description	Sum
Vessel charter for 34 days (1/2 of total cost requested)	37.5
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$37.5

Commodities Costs:	Commodity
Description	Sum
Field and laboratory supplies (rigging for two body, diskettes, rite-in-rain paper)	1.0
Commodities Total	$1.0

FY 04

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Contractual
&
Commoditie

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
Biosonics DTX upgrade w/ attitude sensor			20.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$20.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
300 kHz portable acoustic doppler current profiler	1	ADFG
200 kHz DT 6000 echosounder with split-beam transducer	1	ADFG
Conductivity-temperature-depth (CTD) profiler w/ fluorometer & transmissometer	1	ADFG
Vessel charter for 34 days (1/2 of total cost)	1	ADFG

FY 04

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Equipment
DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Description	Step	Budgeted	Costs	Overtime	Sum
Mark Willette	Fishery Biologist III	18K	1.0	6.7		6.7
Scott Pegau	Senior Scientist	18C	2.0	5.5		11.0
Robert Decino	Fishery Biologist II	16C	1.0	5.2		5.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.0	17.4	0.0	
					Personnel Total	$22.9

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
Attend annual EVOS workshop	0.1	2	8	0.1	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
			Travel Total		$1.0

FY 05

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

Contractual Costs: Description	Contract Sum
Vessel charter for 34 days (1/2 of total cost requested)	37.5
If a component of the project will be performed under contract, the 4A and 4B forms are required. **Contractual Total**	$37.5

Commodities Costs: Description	Commodity Sum
Field and laboratory supplies (rigging for two body, diskettes, rite-in-rain paper)	1.0
Commodities Total	$1.0

FY 05

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Contractual
&
Commoditie

EXXON VALDEZ **OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
300 kHz portable acoustic doppler current profiler	1	ADFG
200 kHz DT 6000 echosounder with split-beam transducer	1	ADFG
Conductivity-temperature-depth (CTD) profiler w/ fluorometer & transmissometer	1	ADFG
Vessel charter for 34 days (1/2 of total cost)	1	ADFG

FY 05

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Equipment
DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Personnel Costs:		GS/Range/	Months	Monthly		Personnel
Name	Description	Step	Budgeted	Costs	Overtime	Sum
						0.0
Mark Willette	Fishery Biologist III	18K	1.5	6.7		10.1
Scott Pegau	Senior Scientist	18C	1.5	5.5		8.3
Robert Decino	Fishery Biologist II	16C	1.0	5.2		5.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		4.0	17.4	0.0	
					Personnel Total	$23.6

Travel Costs:	Ticket	Round	Total	Daily	Travel
Description	Price	Trips	Days	Per Diem	Sum
					0.0
Attend annual EVOS workshop	0.1	2	8	0.1	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

FY 06

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Personnel
& Travel
DETAIL

***EXXON VALDEZ* OIL SPILL TRUSTEE COUNCIL**
DETAILED BUDGET FORM FY 04 - FY 06

Contractual Costs:	Contract
Description	Sum
Publication costs	1.0
Contractual Total	$1.0

Commodities Costs:	Commodity
Description	Sum
Commodities Total	$0.0

FY 06

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Contractual
&
Commoditie

EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL
DETAILED BUDGET FORM FY 04 - FY 06

New Equipment Purchases: Description	Number of Units	Unit Price	Equipment Sum
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
		New Equipment Total	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY 06

Project Number: G-030670
Project Title: Monitoring dynamics of the Alaska coastal current and development of applications for management of Cook Inlet salmon
Agency: ADFG

FORM 3B
Equipment
DETAIL

Budget Justification:

FY04 & 05:

Personnel Requested funds: $22.9
In-kind funds: $17.4

Funds requested for S. Pegau (1 mm) and R. Decino (1 mm) are needed to support these staff during the 1 month of field sampling required for this project (objectives 1-4). An additional 1 mm of funding for S. Pegau and 1 mm for M. Willette are needed for data analysis and report writing (objectives 2-6). In-kinds funds support an additional 1 mm for each investigator for data management, data analysis, and report writing (objectives 2-6).

Travel Requested funds: $1.0
In-kind funds: $0.0

Funds requested for S. Pegau and M. Willette to travel to annual GEM workshop.

Contractual Requested funds: $37.5
In-kind funds: $37.5

Funds requested for one half of the total vessel charter needed for field sampling (objectives 1-4). In-kind funds support the other half of total charter cost. We request that the EVOS TC fund one half of the total charter cost, because the oceanographic data collected by the project will provide for valuable validation of remote sensing products, improved understanding of ocean dynamics in lower Cook Inlet, and a highly powerful statistical evaluation of ocean circulation models. In the past, the ADFG has funded this fisheries survey from sale of fish captured by the test fishing vessel, but this is not longer possible due to the lower ex-vessel price for salmon in recent years.

Commodities Requested funds: $1.0
In-kind funds: $0.0

Funds requested for hardware needed to rig acoustic tow body on board charter vessel, as well as, miscellaneous supplies needed for data management (objectives 1-4).

Equipment Requested funds:$20.0 (FY04 only)
In-kind funds: $52.0

Funds requested for upgrade of DT6000 echosounder to stabilize ping rate and install attitude sensor in transducer. This upgrade will improve estimates of salmon swimming speed and depth distribution. In-kind funds support purchase of a conductivity-temperature-depth profiler, a 200 kHz DT 6000 split-beam sonar system, and Echoview acoustic processing software (objectives 1-4).

FY06:

Personnel Requested funds: $23.6
In-kind funds: $17.4

Funds requested for R. Decino (1 mm) are needed for data management and analysis (objectives 2-6). An additional 1.5 mm of funding for S. Pegau and 1.5 mm for M. Willette are needed for data analysis, report and manuscript preparation (objectives 2-6). In-kinds funds support an additional 1 mm for each investigator for data management, data analysis, report and manuscript preparation (objectives 2-6).

Travel Requested funds: $1.0
In-kind funds: $0.0

Funds requested for S. Pegau and M. Willette to travel to annual GEM workshop.

Contractual Requested funds: $1.0
In-kind funds: $0.0

Funds requested for publication of 1 manuscript.

Commodities Requested funds: $0.0
In-kind funds: $0.0

No funds requested.

Equipment Requested funds: $0.0
In-kind funds: $0.0

No funds requested.