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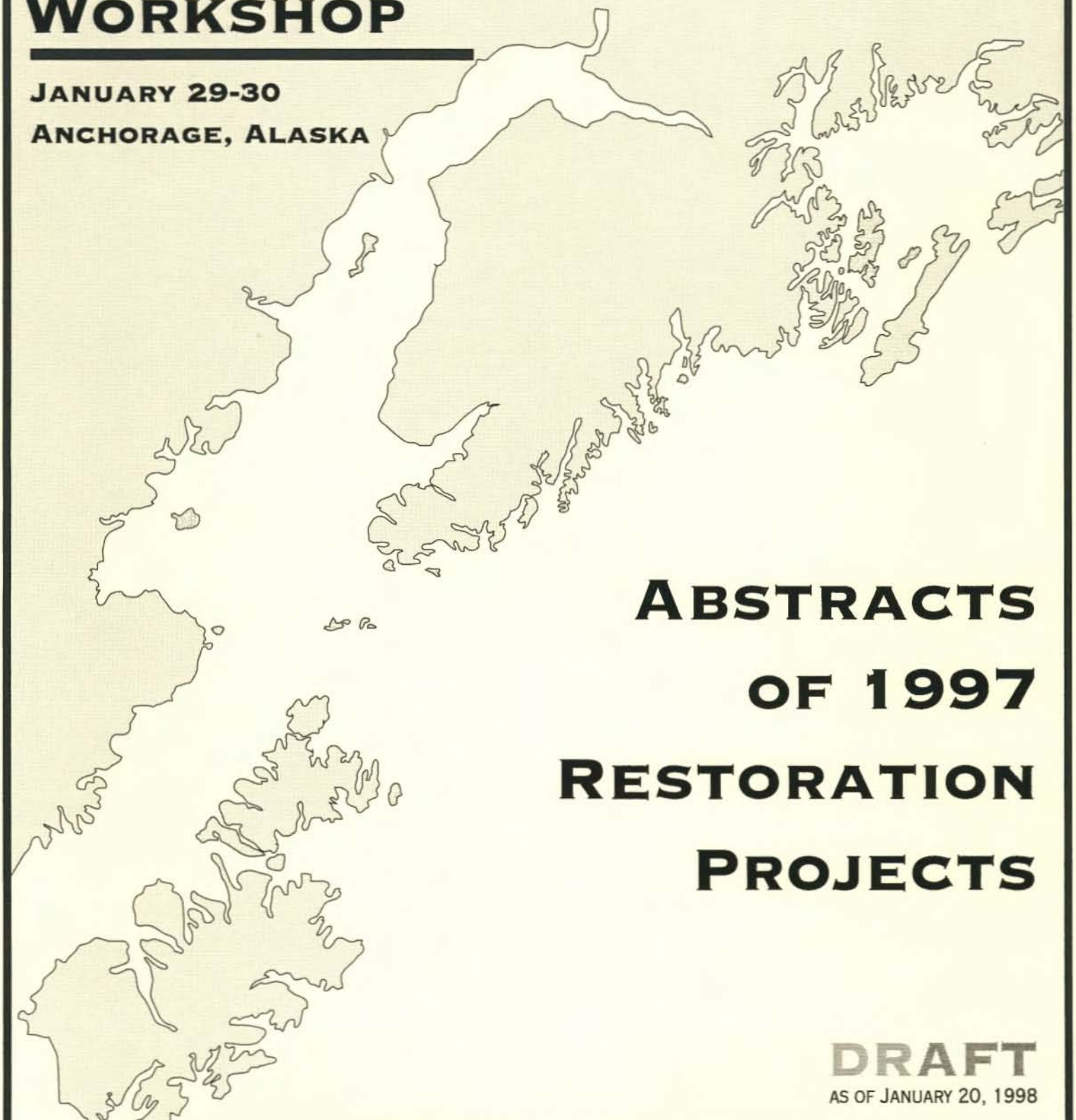
EXXON VALDEZ OIL SPILL TRUSTEE COUNCIL

1998 RESTORATION WORKSHOP

JANUARY 29-30

ANCHORAGE, ALASKA



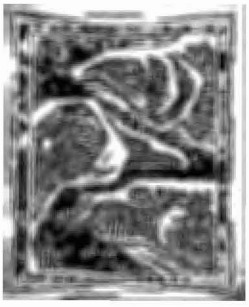
ABSTRACTS OF 1997 RESTORATION PROJECTS

DRAFT

AS OF JANUARY 20, 1998

Exxon Valdez Oil Spill Trustee Council

645 G Street, Suite 401, Anchorage, AK 99501-3451 907/278-8012 fax: 907/276-7178



January 20, 1998

Dear Workshop Participant:

These abstracts describe the results of most of the Research, Monitoring, and General Restoration projects carried out as part of the Fiscal Year 1997 Work Plan (plus a few others) and are compiled here for the benefit and information of participants in the 1998 Restoration Workshop and the public. Any abstracts submitted after January 20 will be available at the workshop, which is scheduled for January 29-30, 1998.

These abstracts describe works in progress and their contents are the responsibilities of the authors. **The abstracts have not received scientific peer review and are not intended for citation in scientific publications.** If you have questions about a particular project, please contact that project's principal investigator or project leader.

Thank you.

Sincerely,

Molly McCammon
Executive Director

MM/ty

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[1]These projects are from 1991 during the Natural Resources Damage Assessment. With support from the Trustee Council, the authors are now preparing manuscripts for publication.

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Project Number and Title: 96048 - Historical Analysis of Sockeye Salmon Growth Among Populations Affected by Overescapement in 1989

Principal Investigators: Gregory T. Ruggerone, Natural Resources Consultants, Inc., 4055 21st Avenue West, Seattle, WA 98199, (206) 285-3480, E-mail: GRuggerone@aol.com; Dr. Donald E. Rogers, Box 357980, Fisheries Research Institute, University of Washington, Seattle, WA

Abstract: A number of sockeye salmon systems received exceptionally large spawning escapements as a result of the 1989 *Exxon Valdez* oil spill, potentially leading to reduced growth of future offspring, reduced survival, and lower production of adult salmon. Systems affected by large escapements include the Kenai River, Red Lake, Akalura Lake, and Chignik Lake. Although comprehensive field studies were initiated as a result of the 1989 spill, few data had been previously collected in these systems.

We measured growth patterns recorded on returning adult sockeye salmon scales, which are routinely collected by ADFG, to develop an historical index of sockeye growth during each life stage (freshwater and marine). We used these data to examine the effect of escapement on growth and to examine growth during years following 1989.

We measured scales from nine sockeye stocks during each year of return, 1970 to 1997. For each stock and each year, we measured 100 scales from the dominant age group (age 1.3 for most stocks), when scales were available. In addition to the stocks listed above, we measured scales from Kasilof River, Black Lake, Bear Lake, and Nushagak Bay, since these stocks were affected less by the oil spill. Selected sockeye scales were measured on the Optical Pattern Recognition System (OPRS), which consists of a video monitor connected to a microscope to view scales and computer program to enable scale measurements. All available scales through 1996 have been measured and 1997 scales will be measured by late December. A few preliminary results related to Kenai River sockeye are presented below.

Freshwater growth of Kenai sockeye salmon was relatively great during brood years 1967 to 1986 (i.e., year when parents spawned) before declining in 1987, the first year of a large escapement resulting from the Glacier Bay oil spill. Exceptionally large escapements continued in 1988 and 1989 and sockeye growth remained low during these years and during 1990, the first year of moderately low escapement following the large escapements. After two consecutive years of relatively low escapement (1990 and 1991), growth increased during the 1991 brood year, but it was still below the average prior to the first large escapement in 1987. Scale growth in freshwater was inversely related to average spawning escapement of parents and previous two broods, suggesting that large escapements up to two years prior to the parent year may influence growth of juvenile sockeye salmon. These results suggest that the effect of successively large escapements leads to lower sockeye growth rates and that reduced growth may continue for at least one or two years after spawning escapements have declined.

Scale growth data may provide information on factors influencing large runs. The first large run of sockeye to the Kenai (1987) was associated with exceptionally great growth during freshwater and the third year at sea.

Project Number and Title: 97001 - Recovery of harbor seals from EVOS: Condition and health status

Principal Investigators: Drs. Michael Castellini and Brian Fadely, Institute of Marine Science, University of Alaska Fairbanks. Fairbanks, AK 99775; (907) 474-6825; mikec@ims.alaska.edu

Abstract: This project is the final year of a four year program that focused on quantifying the health and body condition of harbor seals both inside and outside of Prince William Sound (PWS). The central hypothesis of the program has been that given the declining population status of harbor seals in the impacted area, do these animals show signs of health, nutritional or body condition deterioration that could be contributing to their poor recovery?

This program was completed with significant logistical and scientific collaboration from project /064 which dealt with monitoring population levels, habitat use and trophic interactions of harbor seals. Project /064 provided access to the animals and a broad-based ecological view relevant to harbor seals in this geographic area. The goals of the combined collaborative projects were to investigate ecosystem-wide questions addressing the recovery of harbor seals. These issues included the direct impact of oil spills, human interactions, food, competition, climatic factors, disease and habitat loss. We also initiated a collaborative study with the Alaska Native Harbor Seal Commission (ANHSC) to obtain harbor seal blubber samples from Native hunters through projects /052A, /210 and /244. This biosampling program has been extremely successful.

Three aspects of health status were examined: blood chemistries, blubber distribution and quantity, and blubber quality. Clinical ranges of plasma chemistries and blood values were established for free-ranging seals in the Gulf of Alaska. Significant handling, individual, and seasonal effects were found on many blood parameters that could bias interannual and interregional comparisons. Based on statistical modeling, some of the seals sampled showed more clinically aberrant values than expected by chance, but these were not clustered among regions or years. Differences existed in interannual blood chemistry and hematology patterns between juveniles and adults, and there were regional differences in blood chemistries of unknown significance.

Morphometric indices were poor indicators of condition defined as size-at-age or blubber content. This was related to patterns of blubber distribution and variability, which differed between males and females. Blubber quality, measured as lipid content, did not substantially vary seasonally or between geographic regions, but blubber from Prince William Sound was less hydrated than blubber from non-declining areas. There were no detectable differences in body condition of seals from the Gulf of Alaska sampled during 1963/64 (pre-decline), 1976-78 (during decline) and 1995-96. However, sample sizes were small and patchily distributed throughout locations and years. Body condition was not substantially different among seals from Prince William Sound, Kodiak Island and southeast Alaska measured during 1993-996. However, interannual blood chemistry and body condition patterns were evident among Prince William Sound seals that may have been associated with environmental conditions.

Project Number and Title: 97007 - Archaeological Index Site Monitoring.

Principal Investigators: Douglas R. Reger, Office of History and Archaeology, Alaska Department of Natural Resources, 3601 C Street, Suite 1278, Anchorage, AK, 99503-5921, (907) 269-8725
Charles E. Diters, Alaska Regional Office, U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK, 99503, (907) 786-3386
Ted Birkedal, Alaska Region, National Park Service, 2525 Gambell Street, Anchorage, AK 99503, (907) 257-2668
Linda Finn Yarborough, Chugach National Forest, 3301 C Street, Suite 300, Anchorage, AK, 99503-3998, (907) 271-2511

Abstract: Sites monitored during 1997 were those identified and monitored in previous project years. All are located in the Kodiak Island area, on the Kenai Peninsula coast or in Prince William Sound.

Kodiak Island area sites visited by the U.S. Fish and Wildlife Service were located on or off-shore of Afognak Island. Sites AFG-026, AFG-027, AFG-028, and AFG-143 were all subjected to vandal digging during the EVOS cleanup phase. Extensive tunneling and surface disturbance of the sites were well documented at the time. Exposures noted during 1989 are re-vegetating naturally. No new vandal activity was detected since 1989 documenting visits. Weather conditions prevented a scheduled visit to the Chief Cove Site, KOD-171, so that site was not visited during 1997. Because of the weather and schedule conflicts a visit to AFG-129 was substituted. Last monitored during 1996, the site remained unchanged from the prior year.

The Alaska Department of Natural Resources monitored sites on Shuyak Island during 1997. AFG-081 and AFG-098 were examined. No new vandalism has occured at AFG-098 but erosion of the intertidal beach sediments containing cultural remains continues at a slow but steady rate. Additional artifacts and fire cracked rocks have been exposed. The damage noted at AFG-081 during 1996 was re-checked for continued damage. None was noted and the 1996 damaged is naturally re-vegatating. Availability of boat transportation allowed return to AFG-046 although it was not scheduled for monitoring. The site continues to erode from winter storm waves and fresh exposures revealed more human remains. AFG-097 was also revisited to further document the site which was damaged by vandals during 1996.

Sites on the outer coast of the Kenai Peninsula were visited by ADNR and the National Park Service. SEL-178 was visited to monitor conditions at the housepit site. No further damage has occurred however, foot traffic on the trail across the site, coupled with heavy rains continue to erode areas of the site margin. No vandal activity was snoted at SEL-215 but tidal erosion has removed additional intertidal peat. A newly exposed area of wood chips and fire cracked rocks was found adjacent to the 1991 trench. The National Park Service returned to SEL-188 to check for persistent oil and check for vandalism. No results are yet available.

Archaeologists from the U.S. Forest Service monitored SEW-440 on Eleanor Island and SEW-469 on Knight Island. Surface examinations of each site were made and scaled map of the cave at SEW-469 was recorded. Neither site showed signs of human disturbance.

Project Number and Title: 97012A - Comprehensive Killer Whale Investigation in Prince William Sound/Kenai Fjords, Alaska

Principal Investigators: Craig O Matkin, NGOS, P.O. Box 15244, Homer, AK 99603 (907) 235-6590 and Dr. David Sheel, PWSSC, P.O. Box 705, Cordova, AK 99574 (907) 424-5800

Abstract: Goals of this project include: 1) determination of recovery status of the damaged killer whale population(s) that regularly use Prince William Sound/Kenai Fjords, 2) examination of relevant aspects of killer whale behavior and ecology, and 3) determination of the potential separation of killer whale populations.

Annual monitoring of killer whales (*Orcinus orca*), a species currently considered injured following the *Exxon Valdez* oil spill, continued in 1997. The AB pod was still traveling as two groups; one of those groups was again traveling with AJ pod. One mortality occured in the pod (AB3, a male whose dorsal fin collapsed at the time of EVOS). Two females (AB33, AB27) produced calves (AB52, AB53, respectively). There were 24 hales in ABpod in 1997, a net increase of 2 whales since 1995. Recovery to the prespill number of 36 whales has not occurred.

There were only 5 encounters with the AT1 transient group and only 6 of the original 22 whales in that group were photographed. Ten of those whales have not been observed for 8 years and are believed dead. This group is genetically distinct from the resident pods and from other transient groups sampled. Their long-term survival remains in doubt.

The genetic work had three components in FY97. First, DNA was extracted from the 29 new samples collected. The complete mitochondrial D-loop region of each was sequenced and compared to previous samples. Comparisons supported the genetic divergence of resident- and transient-type killer whales and clarified the observation that two genetically-distinct groups of residents inhabit Prince William Sound/Kenai Fjords waters. One of these resident groups shares a common lineage with residents from southern British Columbia and northern Washington waters, and the other with residents from northern British Columbia and southeast Alaska. Second, a polymerase chain reaction-based method was used to genetically determine the sex of sampled killer whale calves and juveniles. Third, nuclear microsatellite loci were screened for use in paternity analysis and in more detailed population analyses. Seven variable loci were identified, and microsatellite typing of all sampled Prince William Sound killer whales at these loci is currently underway.

Acoustic repertoires of 6 major resident pods AB, AD, AE, AI, AK, AN were analyzed from recordings made from 1984 to 1994. A total of 8456 calls was digitized and spectro- graphically compared. Pods were found to have distinct repertoires which are termed pod- specific dialects. Twenty-eight call types have been identified Preliminary results indicate the six pods fall into two acoustic clusters. The first cluster contains AB, AI, and AN pod; the second cluster contains AD, AE, and AK pod. Each pod in cluster one uses an average of 12.33 calls (range: 9-15), while each pod in cluster two uses an average of 8.66 calls (range 8-9). Recordings during January and February 1996 from a remote hydrophone located in southwest Prince William Sound revealed the presence of at least three pods: AB,AK, and AD.

Thirteen years of encounter data (1984-96), were entered into a GIS database and used to examine killer whale distribution within the Sound Four patterns of area use were identified: two among resident pods and two among transient groups. Area use was similar in resident pods AB, AE, AI, and AN, which all tended to use Knight Island passage and Knight passage more than other areas of the Sound. This pattern was different from that of resident pods AJ and AK, which used all areas of the Sound more evenly. The transient groups made relatively common use of the southwest bays and passages. The AT1 group was also biased towards the use of mid- and eastern-Sound waters more than any other group, while GOA transients were more frequently found in Montague Strait or just outside the Sound. The dichotomy between residents in Montague Strait and Knight Island Passage, and transients in the narrow bays and passages reflects dietary preferences.

Project Number and Title: 97025 - Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Summary Abstract*

Principle Investigators: Leslie Holland-Bartels[1], Brenda Ballachey[1], James Bodkin[1], Terry Bowyer[2], Tom Dean[3], Larry Duffy[4], Dan Esler[1], Stephen Jewett[2], Lyman McDonald[5], David McGuire[6], Chuck O'Clair[7], Alan Rebar[8], Paul Snyder[8], Glenn VanBlaricom[9]

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[4] Department of Chemistry and Biochemistry, Box 756160, University of Alaska, Fairbanks, 907-474-7525
[5] Western Ecosystems Technology, Inc., 2003 Central Ave., Cheyenne, WY 82001 307-634-1756
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[7] Nat. Marine Fisheries Service, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801, 907-789-6016
[8] Veterinary Pathobiology, Purdue Univ., Veterinary Pathology Bldg, West Lafayette, IN 47907, 317-494-9676
[9] USGS, Washington Coop Fish and Wildlife Res. Unit, Univ. of Washington, Seattle, WA 98195 206-685-7471

Abstract: The nearshore ecosystem served as a repository for much of the oil spilled by the T/V *Exxon Valdez* (EVOS). The Nearshore Vertebrate Predator Study (NVP) focuses on the status of system recovery using a suite of injured apex predators--the invertebrate feeders sea otter *Enhydra lutris* and harlequin duck *Histrionicus histrionicus*, and fish feeders pigeon guillemot *Cepphus columa* and river otter *Lutra canadensis*. The project takes a multispecies approach to assess potential mechanisms constraining recovery by asking "Are vertebrate populations recovering?" If so, "Are they recovering as quickly as expected given demographic constraints?" Population density and demographic factors are measured at previously oiled (Naked and Knight Islands) and nonoiled sites (Montague Island and Jack Pot Bay) to examine possible reasons for lack of recovery, and to assess progress toward recovery. We also ask " is it oil?" or "is it food?" that potentially limits recovery by evaluating health, biomarkers of oil exposure, and availability of prey for each of the study predators. We have purposely focused on specific study areas and not a random selection of oiled and unoiled areas and our results must be examined with that limitation in mind. While we loose a statistical ability to infer more broadly to previously "oiled" and "nonoiled" areas throughout the Sound, we gain an ability to more critical assess complex functional relationships that may exist between food, demography, health and any continued oil exposure. The full NVP design was implemented in 1996. Below is a summary to date.

Overview: Our species provide unique views into the issue of nearshore recovery. Our integrated approach develops insight into both status of and factors constraining recovery that was difficult to obtain previously. We find that none of our species can be classified as recovered based on program recovery criteria. In our study areas, we see that female harlequin ducks in previously oiled areas have lower survival and that sea otter and pigeon guillemot numbers remain depressed. Recovery criteria for river otters are based on biochemical indices of hydrocarbon exposure or stress. The 1996 data suggest a lack of recovery; the 1997 picture is not as clear. We also find evidence of elevated P450 expression (a hydrocarbon exposure indicator) in our oiled study areas. We have learned a great deal in the last two years, but interpretation of our findings to assess whether it " is oil, food, or demography?" that potentially limits recovery of our four species is not straightforward. Please refer to the eight companion abstracts for additional insight into what each of the elements of this study tell us to date.

Project Number and Title: 97025A - NVP: Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Sea Otter Recovery*

Principal Investigators: J.L. Bodkin, B.E. Ballachey, D.H. Monson, G.G. Esslinger and J.D. DeGroot, 1011 E. Tudor Rd., Anchorage , Alaska, 99503 (907-786-3550) and P.W. Snyder, Purdue University, 1243 Veterinary Pathology Building, West Lafayette, Indiana 47907 (765-494-9676), NVP collaborators[1]

Abstract: Studies designed to evaluate the status of sea otter *Enhydra lutris* recovery contrast findings between northern Knight Island, which was heavily oiled, and northwest Montague Island, which was not oiled. Post-spill aerial surveys of sea otter abundance at northern Knight and Naked Islands showed no increasing trend and ranged from 103 to 187. These numbers remain below two pre-spill estimates of 258 and 216 in 1973 and 1984, respectively. Survey results from western Prince William Sound range from 2,054 in 1993 to 2,379 in 1997 and illustrate a slight, although insignificant increase.

Most results to date strongly suggest food resources are not limiting the abundance of sea otters at Knight Island. Sea otters at Knight Island gather significantly more and larger prey per dive than sea otters at Montague Island resulting in a greater caloric intake per dive at Knight Island (17 kcal/dive vs. 11 kcal/dive). A sea otter energetic model suggests animals at Knight Island require less time than animals at Montague Island to obtain an estimated requirement of 4700 kcal/day (11.0 hrs vs. 15.0 hrs). Sizes of live clams, mussels, and urchins are larger at Knight Island, indicating predation pressure is greater at the Montague Island study site.

Condition indices, measured as weight/length, are similar between areas for independent females (0.174 kg/cm in both areas) and males (0.247 kg/cm and 0.234 kg/cm for Knight Island and Montague Island respectively). Levels of P4501A in blood lymphocytes, a biomarker of hydrocarbon exposure, were significantly higher in sea otters captured at Knight Island than at Montague Island in 1996 (mean, sd = 221±224 copies of P450 per cell at Knight vs. 49±81 copies of P450 per cell at Montague), indicating continued exposure to residual oil or other environmental contaminants. Analyses of P450 in 1997 samples are underway. In 1996, blood serum enzymes (GGT, ALT, AP) indicative of liver function were slightly elevated in sea otters from oiled areas, but these differences were not seen in 1997.

Available data support the conclusion that sea otters are currently less numerous at northern Knight Island than prior to the oil spill. Further, we feel relatively confident in concluding that recovery of sea otters is not constrained by prey availability. However, this conclusion must be tempered with caution because some results, such as lack of differences in body condition, are inconsistent with our finding of greater prey availability at our oiled site. The weight of evidence suggests either demography and/or exposure as limiting recovery and these issues should be the focus of efforts in 1998.

[1]*Please see the NVP 97025 summary abstract for primary scientists in the overall study*

Project Number and Title: 97025B - NVP: Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Harlequin Duck Recovery*

Principal Investigators: Dan Esler, Alaska Biological Science Center, USGS-Biological Resources Division, 1011 E. Tudor Road, Anchorage, Alaska, 99503 (907 786-3485) and NVP collaborators[1]

Abstract: Harlequin ducks *Histrionicus histrionicus* are a major seaduck species in Prince William Sound from late summer through winter. We have studied their ecology during this nonbreeding part of their annual cycle (wing molt and winter) since 1995 to assess status of their recovery from the *Exxon Valdez* oil spill and to examine potential demographic, health, and trophic constraints to recovery.

Some 1287 capture events (1031 unique individuals and 105 within-year and 151 between-year recaptures) have occurred since 1995. Molt site philopatry was high; 96.7% of ducks recaptured between years were found at the same or adjacent sites as their previous capture. Similarly, 92% of radioed adult females moved <20 km during wing molt and winter. With such high levels of site fidelity, the ability of local populations to recover from the oil spill can be depressed because of their reliance solely on recruitment for population growth (i.e., absence of immigration) and because of potential cumulative effects on birds in oiled areas, if deleterious effects exist.

Numbers and densities of harlequin ducks during winter were approximately 7 times higher on the unoiled study site (800 ducks; 10.8/km shoreline) than on the oiled site (113 ducks; 1.5/km). Analysis are ongoing to determine if oiling history or habitat and prey differences between study sites best explains this difference.

Based on birds with radio transmitters, adult female survival during winter (1995-1996, 1996-1997) was 81.9% in the unoiled area and 74.4% in the oiled area. Because adult female survival particularly influences population dynamics, this difference in winter survival could critically affect population recovery. Survival information from birds fitted with transmitters this summer will be available late winter 1998 and provide a total of three years of survival data to assess recovery issues.

Variation in health of birds is being assessed annually through a number of tools. Body mass of molting females was related (1995, 1996 data) to area (oiling history) and stage of molt (wing feather length). However, body mass was significantly lower in oiled areas only in 1995. Improvements in our assessment of body condition will include lipid and lean mass estimates from condition indices, as well as body mass. Blood chemistry data from molting females have been similar between areas. However, since blood was collected during late summer, only just after birds' first arrival at the sites, we will assess blood chemistries further by collecting during mid and late winter 1998, after birds have been on the study sites several months and during a period of heightened stress. P450 induction in harlequin ducks, as a measure of hydrocarbon exposure, is discussed under a companion abstract for 97025.

[1]*Please see the NVP 97025 summary abstract for primary scientists in the overall study*

Project Number and Title: 97025C - NVP: Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *River Otter Recovery*

Principal Investigators: R. Terry Bowyer Institute of Arctic Biology, University of Alaska, Fairbanks AK 99775, 907-474-5311; G. M. Blundell Department of Biology and Wildlife, University of Alaska Fairbanks; Lawrence Duffy Department of Chemistry and Biochemistry, University of Alaska, Fairbanks; Thomas Dean Coastal Resources Associated, Inc., 1185 Park Center Dr., Suite A, Vista CA 92083; Stephen Jewett Institute of Arctic Biology, University of Alaska, Fairbanks; Merav Ben-David Institute of Arctic Biology, University of Alaska, Fairbanks and NVP collaborators[1]

Abstract: We continued our studies of the effects of the *Exxon Valdez* oil spill on populations of river otters *Lutra canadensis* inhabiting previously oiled (Herring Bay on Knight Island) and nonoiled (Jackpot Bay) areas of Prince William Sound.

In 1996, we documented that our index of population size (latrine site abandonment vs population size) was likely affected by social dynamics and no longer reflected population status. Thus, we returned to capture-recapture methods to develop a population estimate. Since the original method we used was unavailable, we have developed of a new approach based on identification of individual otters from feces using DNA microsatellites. Technique development and field sampling is complete.

Unlike data from 1996, otters did not exhibit significant differences in various health or condition variables. Haptoglobin did not vary significantly between oiled and nonoiled areas. Likewise, no significant differences occurred in body mass (corrected for age class, sex, and total length of body), or age structure of populations inhabiting our two study areas.

In 1997, no significant differences existed in marine fish abundance between study areas, or between latrine sites and systematically selected sites (not used by otters) in either study area. We believe it is unlikely that food is limiting populations of river otters. We are in the process of developing a model to predict what otter densities could be supported by fish in each area based on density of fishes, a fish removal experiment, and energetic requirements of river otters.

An area difference continues in P450 values between our oiled and unoiled study sites. In addition to the underarm epithilial samples, we continue to develop more sensitive analyses for P450 assessment in river otters based on mRNA in blood. Refer to companion NVP: P450 abstract.

In our analyses of otter home ranges in oiled and nonoiled areas, we discovered that some telemetered animals moved between study sites. This reduces our power to detect differences in blood or P450 values. Moreover, some animals were using freshwater habitats at Jackpot Bay (telemetry data confirmed with a stable-isotope analysis of otter hair to assess diet [i.e. marine or freshwater]). This use has the potential to bias our body mass data because the prey-base of freshwater systems is lower than for marine environments. Finally, liver enzymes have been unaccountably higher at Jackpot Bay than at Herring Bay in 1996 and 1997. These data indicate that the use of Jackpot Bay as a nonoiled study site is problematical and may cloud our interpretation of river otter recovery. We propose to repeat a 1992 Sound-wide survey of river otters for to rectify this problem. This sampling will be done in conjunction with Project 98348.

[1]*Please see the NVP 97025 summary abstract for primary scientists in the overall study*

Project Number and Title: 97025D - NVP: Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Pigeon Guillemot Recovery*

Principal Investigators: A. David McGuire, Alaska Coop. Fish and Wildlife Research Unit, Univ. of Alaska Fairbanks, Fairbanks, AK 99775 (Phone: 907-474-6242); Pamela E. Seiser, Dept. of Biology and Wildlife, Univ. of Alaska Fairbanks; Lawrence K. Duffy, Institute of Arctic Biology, Univ. of Alaska Fairbanks; Greg Golet, U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK 99503; Michael Litzow, Alaska Biological Science Center, USGS-BRD, 1011 E. Tudor Road, Daniel D. Roby, Oregon Coop. Wildlife Research Unit, Oregon State Univ., Corvalis, OR 97331, and NVP collaborators[1].

Abstract: We examine demography, food, and physiological effects of oil as possible factors constraining recovery of pigeon guillemots *Cepphus columba* after the *Exxon Valdez* oil spill. This element of *NVP* is a companion to *APEX* 97163. We evaluate the significance of these factors, comparing pigeon guillemots at the previously oiled Prince William Sound Naked Island and unoiled sites in PWS (Jackpot Island) and Lower Cook Inlet (Kachemak Bay).

Comparisons to historical data (1978-1980) suggest that various demographic characteristics at Naked Is. are depressed. The 1997 count of 968 birds (1989-1997:~800-1300; $\bar{x}$=1040) compares to 1848 (1978) and 2230 (1979). We find that while hatching success remains similar (1970's to postspill), fledging rates (1997: 0.61 fledglings/nest) are lower. In addition, 14 of 50 nests in 1997 failed due to predation, and predation rates continue to be higher postspill vs historical data. However, using these 1970's data as "prespill" is problematic given the decade time span between those data and the spill. Therefore, we also compare Naked Island to our PWS reference, Jackpot Is. This comparison gives a somewhat mixed picture. While in 1994 (the first year of comparison), variables such as clutch size and fledge/nest were all lower at the oiled Naked Island, those relationships have been variable since then. In 1995, most measures were higher at Naked than Jackpot (clutch sizes similar, higher hatch rates, higher chick growth (12%), fledge weight slightly lower (3%), fledgling/nest higher (15%)). In 1996, nest predation caused a near total loss of production at Jackpot. In 1997, clutch size was slightly lower (3%), hatchling/nest 33% higher and chick growth and fledge weight lower (4% and 10%) at the Naked Island Colony. The value for fledglings/nest was also higher (41%) primarily due to the higher hatchling/nest values. Ultimately, the Jackpot Colony produced fewer, but slightly heavier chicks per initiated nest.

In our 1997 health assessments, we did not find the heightened immune response we saw in 1996 (first year of blood studies) based on blood variables. Chick haptoglobin levels, that had been lower at Naked Island in 1996 vs Jackpot or Kachemak, were not so in 1997.

As suggested by *APEX*, changes in food availability/composition between the 1970's and postspill may be a factor in the lower Naked Island colony productivity. While 1970's to postspill comparison at Naked Island suggest schooling fish abundance is related to colony productivity, the comparison between food type and colony productivity within our PWS comparison is not as obvious. Naked Island actually had a higher % schooling fish in 1997, but slightly lower chick growth (17.9 vs 18.6) than seen at Jackpot Island.

To date, evidence indicates that the population of pigeon guillemots at Naked Island remains lower that the colony levels in the late 1970's. Although higher predation rates subsequent to the oil spill represent a demographic limitation to recovery, food availability also appears to play a role in the lower growth performance and fledging weight of chicks at Naked Island. It is not clear whether physiological effects of oil exposure play a role in a recovery. We have set as a priority in 1998 efforts to complete P450 assays and to conduct other assessments of both chick and adult health.

[1]*Please see the NVP 97025 summary abstract for primary scientists in the overall study*

Project Number and Title: 97025E - NVP: Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Quantification of P450 as a Bioindicator of Continued Exposure of Nearshore Vertebrate Predators to Residual EVOS Oil.*

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A major component of the ongoing Nearshore Vertebrate Predator (NVP) project addresses the question of continued exposure to residual oil from the 1989 *Exxon Valdez* oil spill as a possible factor limiting recovery of the predator species. To evaluate exposure, we are measuring expression of cytochrome P4501A, an enzyme induced by polynuclear aromatic hydrocarbons (PAHs) or halogenated aromatic hydrocarbons (HAHs), and comparing animals from oiled and unoiled areas of western PWS.

Three methods are being used to measure P4501A: (1) quantify the mRNA for P4501A in blood lymphocytes, using cDNA probes, (2) quantify the amount of P4501A in cells, using an immunohistochemical assay (IHC) on skin or foot web samples, and (3) quantify activity of EROD, an enzyme catalyzed by P450, in liver samples. Method 1 is being conducted at Purdue University by Dr. Snyder, and methods 2 and 3 are being conducted at Woods Hole Oceanographic Institute by Dr. J. Stegeman. Differences in methods were necessitated by differences in tissues required the technique and availability among species.

In 1996, sea otters (using blood, mRNA), river otters (using underarm punches, IHC), and sea ducks (samples from Barrow's goldeneyes, collected for another component of the NVP study and used as a surrogate species for harlequin ducks, using web and liver, IHC and liver, EROD) all had significantly higher levels of P4501A in oiled compared to unoiled areas. However, the sea duck samples suggested that IHC was not particularly sensitive in either web or liver samples. While those tissues with IHC showed no significant differences between study areas, the sea duck EROD samples demonstrated a highly significant difference between sites. This leads us to question the sensitivity of web or other epithelial tissues to assess evidence of present levels of exposure. Comparative analyses of 1997 sea otter samples, using blood mRNA versus web punch IHC, will assess IHC sensitivity. Since web punches appear less sensitive we have withheld further analysis of harlequin duck or pigeon guillemot IHC samples, but will conduct blood mRNA analyses in 1998. In addition river otter blood samples will be analyzed by the mRNA method.

Results suggest that animals and birds residing in oiled areas are exposed to hydrocarbons above levels seen at reference sites, at least through 1996. However, we cannot yet state conclusively the source of this contamination--the 1989 spill, other hydrocarbon or PCB contaminants in the environment. In 1998 we will determine if differences persist in P4501A levels, clarify comparability of our three methods and their application in wildlife monitoring programs, collaborate in "dosing" studies to interprete what present levels of P4501A expression might mean as they relate to individual and population-level health issues.

[1]*See NVP 97025 summary abstract for primary scientists in the overall study. We acknowledge the collaboration of Dr. J. Stegeman, Woods Hole Oceanographic Institute, in this component.*

Project Number and Title: 97025F - Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: Sea Urchins as Indicators of the Recovery Status of Sea Otters

Principal Investigators: Thomas A. Dean, Coastal Resources Associates, Inc., 1185 Park Center Dr., Ste. "A", Vista, CA 92083. (760) 727-2004; James Bodkin, Alaska Science Center, Biological Resources Division, 1011 East Tudor Road, Anchorage, AK 99503; Stephen Jewett, Institute of Marine Science, University of Alaska, Fairbanks, AK 99775

Abstract: The sea otter - sea urchin interaction is well described in marine ecology. Sea urchins are a preferred food of sea otters, and where otters are abundant, there are few large sea urchins. Based on this paradigm, we predicted that a lack of recovery of sea otters in heavily oiled portions of Prince William Sound would be accompanied by an increase in the numbers of large urchins and we measured sea urchin populations in order to access the recovery status of otters.

We compared the abundance and size distributions of green sea urchins (*Strongylocentrotus droebachiensis*) from an oiled area (Herring Bay and Bay of Isles in Northern Knight Island) and an unoiled reference area (Montague Island) in Prince William Sound in 1996 and 1997. Densities of urchins were estimated by sampling within each of three depth strata at 60 systematically selected sites in each area. Size distributions were estimated from urchins collected at these sites and from randomly selected sites in preferred sea urchin habitats.

Urchins were found primarily in the lower intertidal zone, especially on protected, gently sloping cobble-boulder beaches. Populations were highly aggregated, and the majority of the urchins were found in a few widely scattered patches with exceptionally high densities. Mean densities of urchins did not differ between Knight and Montague Island. However, there were marked differences in size distributions. Populations at Montague had size distributions that were strongly skewed toward smaller individuals. Few individuals were larger than 20 mm test diameter, the approximate lower size limit of urchins taken by sea otters. The number of these larger urchins per sea otter was more than ten times higher at Knight than at Montague. In addition, the urchins at Montague were found in more cryptic habitats (under large boulders) that may serve as a refuge from predation. The fact that there were more large urchins per otter at Knight, and that they were found in less cryptic habitats, indicates a lack of recovery of sea otters at Northern Knight Island. It also provides evidence that recovery by otters is not food limited.

Project Number and Title: 97025G - Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Sea Otter Prey Availability and the Recovery of Sea Otters*

Principal Investigators: Thomas A. Dean, Coastal Resources Associates, Inc., 1185 Park Center Dr., Ste. "A", Vista, CA 92083. (760) 727-2004; James Bodkin, Alaska Science Center, Biological Resources Division, 1011 East Tudor Road, Anchorage, AK 99503; Glenn Van Blaricom and Allan Fukuyama, BRD, Washington Cooperative Fish & Wildlife Research Unit, WH-10, University of Washington, Seattle, WA 98195; Stephen Jewett, Institute of Marine Science, University of Alaska, Fairbanks, AK 99775; Chuck O'Clair, National Marine Fisheries Service, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801

Abstract: Sea otter's *Enhydra lutris* feed on a variety of prey including clams, mussels, crabs, and sea urchins. Where sea otters are abundant, predation by otters results in a reduction in the density of larger prey and a shift in the size distribution of prey toward smaller individuals. In this report, we summarize data on sea otter prey availability in an oiled and unoiled portion of Prince William Sound. These data are used to determine if sea otter populations have recovered fully following the *Exxon Valdez* oil spill, and if the lack of the lack of recovery may be caused by a lack of food. A greater abundance of large prey at the oiled sites would suggest a lack of recovery and a lack of limitation by food.

The densities and size distributions of clams, mussels, crabs, and sea urchins were measured at an oiled area (Northern Knight Island) and an unoiled area (Montague Island) in 1996 and 1997. Densities and size distributions of each prey species were measured at a series of systematically selected sites using a variety of methods (e.g., direct counts in intertidal quadrats for mussels, collection of sediment samples from quadrats using a diver operated suction dredge for subtidal clams). In addition, we estimated the total number of large prey (of the size eaten by otters) per otter to compensate for known differences in habitats between the two areas.

In almost all cases, the densities of prey were higher at Knight Island than Montague, and size distributions of prey were strongly skewed toward smaller individuals at Montague. For all prey species but one (*Macoma spp.*) there were consistently more prey per otter at Knight Island than at Montague, and on average, there were approximately ten or more times the number of prey per otter at Knight. The one exception (*Macoma*) had about equal numbers of prey per otter at both Knight and Montague.

The generally higher abundances of prey per otter at Northern Knight Island suggests that sea otters populations have not fully recovered. These data further suggest that recovery of sea otters is not limited by the availability of prey.

Project Number and Title: 97025H - Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: *Sea Otter Prey:* Subtidal Clams

Principal Investigators: Allan Fukuyama and Glenn VanBlaricom, Washington Cooperative Fish and Wildlife Research Unit, School of Fisheries, University of Washington, Seattle, WA. 98195 (206) 543-6475

Abstract: We report on the abundance and population structure of subtidal clam populations from oiled and unoiled areas in Prince William Sound, Alaska as one component of the Nearshore Vertebrate Predators project. Clams are the primary prey of sea otters in Prince William Sound. The venerid clams, *Saxidomus giganteus* and *Protothaca staminea*, were the focus on this study though other species such as *Humilaria kennerleyi, Gari californica, Macoma spp., Serripes groenlandicus,* and *Mya truncata* were also important in the diet of sea otters and relatively abundant at the study sites. In addition, data from otter-fed, dead shell record were collected for comparison with the live suction dredge sampling.

Abundances and size distributions of clams were compared at sites within selected oiled (Knight Island) vs. non-oiled (Montague Island) areas. Recruitment and settlement of clams was examined by sampling with diver-held benthic corers. Sampling of larger sizes of clams was done using an underwater suction dredge. Collections were made of dead clam shells fed upon by sea otters by collecting all otter-fed shells along transect lines.

Results from 1996 core collections indicated low numbers of venerid clams from both areas. More juvenile clams of all species were found at Montague Island. More large-sized clams were collected from Montague Island than from Knight Island in both 1996 and 1997. Size-frequency distributions of all larger-sized clams indicated that larger clams were present at Knight Island. The mean size of clams from both areas were about the same in 1996, but clams from Knight Island were larger in 1997. Most of the clams collected in dredge sampling were Macoma spp. at Montague Island while relatively equal numbers of several species were collected at Knight Island. Shells collected from dead shell otter-fed collections indicated that otters were feeding on larger sizes of clams from Knight Island than at Montague Island.

The presence of more clams, as well as sea otters, at Montague Island is an indication that more food may be available at Montague Island. However, clams at Knight Island tended to be larger as shown by collections of live clams and from the otter-fed shell collections. Sea otters were feeding primarily on *Saxidomus* at Knight Island in both years and at Montague Island in 1996. A shift in clam prey was seen at Montague Island in 1997 when more *Macoma* were found. This may be due to the presence of dense clam patches of *Macoma*. Several dense clam patches were found in dredge sampling in both 1996 and 1997.

Further issues exist on the role of recruitment in affecting clam population structure, shifts in clam population structure due to predation by sea otters, and changes in composition of dense clam patches as sea otters increase in population.

Project Number and Title: 97025I - Mechanisms of Impact and Potential Recovery of Nearshore Vertebrate Predators: Mussel Component.

Principal Investigator: Charles E. O'Clair, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801, (907)789-6016, chuck.o'clair@noaa.gov.

Abstract: The purpose of this component was to determine the extent to which the abundance of mussels, *Mytilus trossulus,* as one component of the prey base of sea otters, *Enhydra lutris*, and sea ducks (principally harlequin ducks, *Histrionicus histrionicus*) limits the recovery of these vertebrate predators in areas oiled by the *Exxon Valdez* spill. The objective of one phase of our work in 1997 was 1) to compare rates of mussel growth and mortality in an oiled area (Knight Is.) where sea otter and sea duck abundances declined after the spill with those in an unoiled area (northwest Montague Is.) where these vertebrate predators were unaffected by the spill. Annual estimates of mussel growth and mortality will be used to estimate mussel production in the study areas. Two approaches were taken to estimate mussel growth. In the first, growth was modeled from size-at-age measurements made on a total of 90 mussels aged from acetate peels of sectioned mussel shells from three study locations, Montague Is., Bay of Isles, and Herring Bay. In the second approach, a total of 2300 mussels were tagged for direct, *in situ* growth measurement at 23 sites in the three study locations in May - July 1997. Short-term (1-2 mo.) growth was measured in 1500 of those mussels. Short-term mortality was also recorded at the 23 sites.

Growth of mussels from size-at-age measurements was well described by the von Bertalanffy growth equation. Estimated maximum shell length of mussels at Montague Is.(41.9 mm) was similar to that at Bay of Isles (41.5 mm), but markedly less than that at Herring Bay (79.5 mm). Short-term growth estimated by *in situ* growth measurements from May to July 1997 was highly variable within study locations. Mean monthly growth ranged from 0.2 to 1.2 mm/mon. at Montague Is., 0.5 to 1.5 mm/mon at Bay of Isles, and 0.2 to 1.0 mm/mon. at Herring Bay depending on the site where growth was measured. Growth at Montague Is. ($\bar{x}$ = 0.6 mm/mon.) did not differ from that at Knight Is. ($\bar{x}$ = 0.7 mm/mon.; anova, $p>0.05$). However, growth decreased with increasing tidal height (anova, $p<0.01$), averaging 1, 0.6 and 0.4 mm/mon. at low, mid and high tidal levels, respectively, in the two study areas. Short-term monthly mortality also varied greatly ranging up to 50% in the mid mussel zone at one site on Montague Is.. However, mortality was generally low at most sites, averaging 11.1% at Montague Is., 7.8% at Bay of Isles, and 8.3% at Herring Bay. Mean mortality at Montague Is. did not differ from that at Knight Is. (anova, $p>0.05$). We observed no significant relationship between mortality and tidal height. Estimates of annual growth and mortality will be completed after the 1998 field season. Annual estimates of mussel production combined with estimates of mussel consumption by vertebrate predators will permit us to predict whether mussel biomass at Knight Is. can be sustained in the face of increased mortality from predation as populations of vertebrate predators recover in the oiled area. The carrying capacity of vertebrate predators on Knight Is. will depend on the biomass of prey species that can be sustained over time.

Project Number and Title: 97025J - NVP Project Component - Avian Predation on Blue Mussels.

Principal Investigator: Mary Anne Bishop, Pacific Northwest Research Station, US Forest Service, P.O. Box 1460 Cordova, AK 99574 (Phone: 907/424-7212).

Abstract: The objective of this component was to determine whether differences exist between oiled and unoiled areas with respect to the distribution, abundance and consumption patterns of avian blue mussel predators. For 1997, field work was conducted at Montague Island (Graveyard Point to Mooselips Bay; unoiled area) and included nearshore bird surveys and glaucous-winged gull collections for diet analyses.

From mid-April to mid-May, the most numerous potential mussel predators observed during nearshore boat surveys included: glaucous-winged gull, mew gull, black turnstone and surfbird. Bird abundance and distribution varied within the study area, with significantly higher numbers of birds concentrating in areas with Pacific herring schools or herring spawn deposition. Based on bird days, where 1 bird=1 bird day, the most abundant species in spring at Montague Island was glaucous-winged gull (134,013 bird days over 25 days). In contrast, during spring 1996 we recorded <4,000 glaucous-winged gull bird days over 34 days when no spawn deposition occurred in the Montague Island study area.

In winter 1996-97 and spring 1997 we collected and analyzed stomach contents of glaucous-winged gulls to determine seasonal mussel consumption. In winter, sea stars (primarily *Evasterias trochelli)* occurred in 70% of the gull stomachs (esophagus and proventriculus) and constituted 96% of the aggregate wet weight (n = 10 gulls). In spring, prior to and during active herring spawn deposition, fish (primarily Pacific herring) constituted 98-100% of the aggregate wet weight. After spawn deposition, gulls consumed almost exclusively herring eggs. Blue mussels were found in 10% of the gizzards in spring (n = 30 gulls), however, none were found in the esophagus or proventriculus.

Using a bioenergetic model, we estimated mussel consumption over a 25 day field season for the 7 most numerous mussel predators. Our model is based on field metabolic rates, energy content of blue mussel, assimilation efficiency of blue mussels, and an estimated proportion of daily energy acquired from blue mussels. Assuming that in spring blue mussels comprise 5% of the glaucous-winged gull and 10% of the surfbird diets, these two species were the top mussel predators, consuming 6,645 and 2,880 kg, respectively. Altogether, the top 7 predators consumed approximately 3% of the 1996 estimated total standing crop of blue mussels in the Montague Island study area.

Project Number and Title: 98025K - Competition Between Sea Otters And Predatory Benthic Invertebrates For Bivalve Prey In Prince William Sound, Alaska: Implications For Recovery Of Sea Otters From The *Exxon Valdez* Oil Spill

Principal Investigators: Tamara K. Gage and Glenn VanBlaricom, Washington Cooperative Fish and Wildlife Research Unit, School of Fisheries Box 357980, University of Washington, Seattle, Washington 98195

Abstract: Sea otter (*Enhydra lutris* [L.]) numbers in some areas of Prince William Sound (PWS), Alaska have not yet recovered from the effects of the *Exxon Valdez* oil spill (EVOS). One possible explanation is EVOS-induced changes in sea otter prey populations. We studied effects of predatory benthic invertebrates (sea stars, snails, crabs) on the dynamics of clam populations, the primary prey of sea otters in PWS. We evaluated the hypothesis that high rates of clam consumption by predatory invertebrates are limiting the size of clam populations and consequently, the local recovery of sea otters from EVOS.

We collected data on density and diet of predatory invertebrates at 4 - 10 m MLLW in four study areas, two oiled by EVOS (Bay of Isles and Herring Bay) and two unoiled (located along the west shore of Montague Island). We found the sea star *Pycnopodia helianthoides* (Brandt), to be the most abundant predatory benthic invertebrate in our study areas. However, densities of *Pycnopodia* were not significantly different between oiled and unoiled study areas. Although published literature suggests broad overlap in diets of *Pycnopodia* and sea otters, our data indicate that *Pycnopodia* in PWS have a diverse diet composed primarily of gastropods too small to be of significant nutritional value to sea otters. Clams were present in the diet of *Pycnopodia* , but at very low numbers in all areas. Clam species and size categories typically consumed by sea otters in PWS were poorly represented in sampled *Pycnopodia* diet.

We conclude from our data that predatory invertebrates are not likely significant competitors with sea otters for prey in PWS. It follows that predatory invertebrates are not a significant trophic impediment to the recovery of PWS sea otter populations from the effects of EVOS.

Project Number and Title: 97043B - Monitoring of Cutthroat Trout and Dolly Varden Habitat Improvement Structures.

Principal Investigators: Dan Gillikin, Chugach NF., P.O. Box 129, Girdwood, AK. 99587, (Phone) 783-3242, (FAX) 783-2094

Abstract : This project provides for monitoring of habitat improvement structures and their effects on cutthroat trout and Dolly Varden populations. Interspecific competition with juvenile coho salmon is believed to limit cutthroat trout production in quality pool rearing habitats which is one of the key factors for cutthroat trout survival. Concerns have been raised that certain types of habitat enhancements may increase coho salmon populations. Thereby increase competitive stress on cutthroat trout populations.

During the 1995 field season, USFS, Glacier Ranger District Fisheries crews installed a total of 63 habitat improvement structures under EVOS Restoration Project number 95043B at Otter Lake, Gunboat Lakes, Red Creek and Billy's Hole in Prince William Sound to improve cutthroat trout and Dolly Varden habitats. The distribution and abundance of cutthroat trout, Dolly Varden and coho salmon were monitored at these locations using standard mark recapture techniques to provide baseline information on the various systems prior to enhancement activities. Completed stream surveys were used to determine the proper sampling distribution to trap fish in a stratified random sampling design within the affected stream reaches. Trapping effort was conducted proportional to the availability of three major habitat types (slow, fast and turbulent) found at each project location.

Sampling by Glacier Fisheries Crews in 1996 and again in 1997 suggested that cutthroat trout densities were greatest in the upper reaches of these inlet tributary streams. This is consistent with studies that have shown that cutthroat trout juveniles are pushed to less desirable habitat by the more dominant coho salmon juveniles. Preliminary data seems to indicate that cutthroat trouts utilize all three habitat types nearly equally while coho and Dolly Varden seem to be predominantly utilizing slow water habitat types. Early results from data collected in 1997 also suggest a grater density of cutthroat trout than has been previously observed throughout the project locations and specifically at the habitat enhancement structure installed in 1995. These findings are preliminary and a complete analysis is not yet available. All sixty-three structures were inspected and required only minor repairs. In general all the structural improvements were in good order and functioning as predicted.

Project Number and Title: 97052A - Community Involvement

Principal Investigator:
Patty Brown-Schwalenberg, Chugach Regional Resources Commission, 4201 Tudor Centre Dr., Ste. 301, Anchorage, Alaska 99508

Abstract: The Exxon Valdez oil spill caused severe disruption in the lives of those who live within the oil spill region. Consequently, the contamination and devastation has caused the residents of these communities to be concerned over the safety of wild food sources and the integrity of the environment affected by the oil spill. The majority of the scientific work conducted with Trustee Council funds is done with agencies in state and federal government, often being centered in Anchorage, Juneau, or Fairbanks. The need for this project stems from concern by residents of spill-affected communities that their involvement was not adequately taken into consideration and that the information collected by scientist throughout the spill area was not reaching the communities.

In an effort to enhance communication between the Trustee Council and the communities and to increase involvement in the process, a community facilitator has been hired through subcontracts between Chugach Regional Resources Commission and the village councils in the following communities: Chenega Bay, Tatitlek, Valdez, Cordova, Port Graham, Nanwalek, Seldovia, Kodiak, Seward, and Chignik Lake. Furthermore, a spill area wide community involvement coordinator has been hired by Chugach Regional Resources Commission to facilitate the communication between the communities, Trustee Council, and principal investigators.

Results for FY 97 include continued transaction of scientific information between the Trustee Council and spill-affected communities in the form of monthly community reports regarding any EVOS activity, weekly phone calls between the spill area wide community involvement coordinator and community facilitators, a bi-monthly report on Trustee Council activities sent to the communities by the spill area wide community involvement coordinator, and quarterly meetings of the community facilitators, Trustee Council staff, Alaska Department of Fish and Game staff, and Chugach Regional Resources Commission staff. Other accomplishments include the submittal of community-based proposals that primarily address subsistence restoration. These included the Youth and Elders Conference, a processing facility in Tatitilek, expansion and construction of a hatchery in Port Graham, and operational funds for the shellfish hatchery in Seward.

Community facilitator participation in the annual Restoration Workshop was regarded as very informative and valuable. Other outreach that took place in FY 97 include attendance by the spill area wide community involvement coordinator to the annual Cultural Heritage Week in Tatitlek; a community visit to Chignik Lake, Port Graham and Nanwalek, which included the on-site visit, discussion of local area issue regarding the oil spill, and observation of locally funded EVOS projects. In September, Hugh Short, the new community involvement coordinator was hired and immediately began to become familiar with spill region issues. Along with Pauline Allen, contract administrator for CRRC, Hugh Short attended the annual Public Advisory Group field trip to Kodiak Island. Community meeting were held in Kodiak, Old Harbor, Port Lions, and Larsen Bay. Overall community involvement was increased and communication between the Trustee Council, principal investigators, and community members was enhanced throughout FY 97.

Project Number and Title: 97052-B - Traditional Ecological Knowledge

Principal Investigator: Patty Brown-Schwalenberg, Chugach Regional Resources Commission, 4201 Tudor Centre Drive, Suite 300, Anchorage, Alaska, 99508; (907) 562-6647

Abstract: We are working to include traditional ecological knowledge (TEK) in the restoration program generally and in several projects in particular. TEK is the accumulated knowledge of the residents of an area, based on extensive personal experience with the resources and environment of that area, joined with the knowledge accumulated by past generations passed down through oral traditions or other means. Residents of spill-affected communities have long expressed a desire for their knowledge to play a greater role in the restoration program, and this project attempts to fulfill that desire.

While the project potentially includes the entire spill area, we have worked to date in Prince William Sound and on the lower Kenai Peninsula. Research and planning activities have been conducted in Cordova, Tatitlek, Chenega Bay, and Homer. For FY98, we anticipate continuing to work in the same general area, with the addition of Port Graham, Seward, and Valdez.

In FY97, most of the project effort was directed toward assisting Jody Seitz in her effort to document TEK of herring (Project 97-248). Jody's project was conducted in Cordova, Tatitlek, and Homer, and involved interviews with fishermen, pilots, and others with experience in Prince William Sound and on the outer Kenai. The initial results from this project are very promising, and will be reported by Jody. This effort will continue in FY98.

In addition, we are conducting training and information workshops in several communities. The former are designed to help communities understand what TEK research is about so that they can make better decisions about how to become involved. The latter are designed to bring PIs from various EVOS projects to communities to discuss their research and to gain from the knowledge and perspective of community residents.

We anticipate further progress on this effort in FY98. The initial information workshop, held in Tatitlek in October with Dan Rosenberg of ADF&G went well. We discussed Dan's current research with harlequin ducks and his plans for scoter research in FY98. Both Dan and the participating community members enjoyed the interactions, and look forward to more opportunities to share information and discuss common interests and concerns. We expect that Jody's project will also continue to go well and that she will gather more useful information. We are pleased to be able to support these efforts.

Project Number and Title: 97064 - Monitoring, Habitat Use and Trophic Interactions of Harbor Seals in Prince William Sound.

Principal Investigators: Kathryn J. Frost, Lloyd F. Lowry, and Sara J. Iverson. Alaska Dept. Fish and Game, 1300 College Road, Fairbanks, AK 99701 (KJF and LFL); Dept. Biology, Dalhousie Univ., Halifax, NS, B3H 4J1, Canada (SJI) (KJF phone 907-459-7214, e-mail kfrost@fishgame.state.ak.us")

Abstract: Since 1984, harbor seals (*Phoca vitulina richardsi*) in Prince William Sound (PWS) have declined by over 60% for unknown reasons. More than 300 harbor seals were estimated to have died because of the *Exxon Valdez* oil spill (EVOS), and since then seals have continued to decline at about 5% per year. The objectives of this study were to monitor the status and trend of PWS harbor; to describe their movements, use of haulouts, and hauling and diving behavior; and to study trophic interactions, genetic relationships, and health of harbor seals in PWS compared to other areas. Aerial surveys of 25 trend count sites during 1989-1997 showed a continuing decline in the number of seals during the molt. The 1997 counts of harbor seals in PWS were 35% lower than counts in 1989.

Since 1993, we have captured and sampled 195 seals: 28 in 1993, 36 in 1994, 42 in 1995, 39 in 1996, and 50 in 1997. Sixty-four of these were instrumented with satellite-linked time-depth recorders (SLTDRs). Most seals equipped with SLTDRs remained within PWS near the locations where they were tagged. Several made feeding trips to the Gulf of Alaska, one to Yakutat, one to lower Cook Inlet, and several to the Copper River Delta. Most later returned to PWS. A few seals made regular trips between haulouts in southcentral PWS and glaciers in the north. Subadults tended to make more and longer trips than adult seals and to spend less time hauled out during winter than adults. More seals made trips to the Copper River Delta in 1995 and 1996 (8 of 19) than before then (2 of 30).

In 1997, the focus of our studies changed to pups. We measured the fat content of pups and other juvenile seals we captured using deuterium oxide (D_2O). The D_2O experiments indicated that pup and yearling seals in PWS were fat ($43 \pm 0.8\%$ and $23 \pm 0.9\%$) and in very good condition in early July 1997. Twelve newly weaned pups from southcentral PWS were instrumented with small, 1/4-watt SLTDRs. During the first 6 months, most made local movements within PWS. By early December, six were still transmitting. One of the six was in the Gulf of Alaska and the others remained in PWS. The amount of time spent diving increased from 67% in July to 77% in Aug.-Sept. Dives became gradually deeper with time: 80% of the dives were <50 m in early July, compared to only 40% by Sept.

Forage fishes comprise an important part of the diet of harbor seals. In the mid-1970s, herring, pollock, cod, and eulachon were the most common prey of adults. Capelin and pollock were the main prey of pups and yearlings. One of the suggested causes for the harbor seal decline is a long-term change in forage fish abundance that has resulted in reduced availability of food to seals, particularly pups and juveniles. To evaluate this hypothesis, we first need to obtain recent data about the diet of seals in PWS.

In this study, we have developed a new method for estimating harbor seal diets. This method uses fatty acid signatures in seal blubber in combination with classification and regression tree (CART) analysis. We took blubber biopsies from all seals caught in 1994-1997. In addition, subsistence hunters collected samples of blubber for us as part of the biosampling program. Samples of potential prey were provided by investigators studying forage fish in PWS. To date, fatty acid composition has been determined for more than 300 seals and 800 individual prey. Our results indicate that fatty acids in harbor seal blubber vary by haulout site, suggesting that PWS harbor seals depend on a very localized prey base.

Fatty acid analysis also suggests that large herring and pollock as well as flatfish may dominate the diets of harbor seals from southcentral PWS, while small herring and sand lance may predominate in northern PWS. However, the diets of juveniles differ from those of adults in all areas studied. In 1996, the diets of PWS harbor seals were significantly different than in 1994 and 1995, perhaps reflecting the increased abundance of capelin in 1996.

Project Number and Title: 97076- Effects of Oiled Incubation Substrate on Straying and Survival of Wild Pink Salmon

Principal Investigators: A.C. Wertheimer and R.A. Heintz. Co-investigators: S.D. Rice, A.G. Celewycz, J.F. Thedinga, R.F. Bradshaw, and J. Maselko. NOAA NMFS, Auke Bay Laboratory 11305 Glacier Highway, Juneau, AK 99801. (907) 789-6040, Alex.Wertheimer@noaa.gov.

Abstract: This project examines the effects of oil exposure during embryonic development on the straying, survival to spawning, and gamete viability of pink salmon (*Oncorhynchus gorbuscha*). The objectives for the straying component are to determine the role of oil and other biological factors on straying, and relate these results to straying rates observed for wild populations of pink salmon in Prince William Sound (PWS) after the Exxon Valdez oil spill. A second component examines the influence of incubating in oiled gravel on growth, marine survival and gamete viability.

This is a multi-year project based at our research facility at Little Port Walter (LPW) in southeastern Alaska. This location was chosen for this study because it is removed from the confounding effects of prior oil exposure, and is the site of an ongoing series of Trustee-sponsored oil toxicity studies. The project began in 1995 when wild pink salmon eggs were fertilized and loaded into incubators containing gravel contaminated with known quantities of oil. Exposure levels were monitored throughout incubation. The following spring, fry emerging from the incubators were marked with coded-wire tags (CWT) and released. In addition we marked and released wild fish from the donor stock (Lover's Cove creek) and the stock endemic to the hatchery drainage (Sashin Creek) to provide estimates on natural straying rates. Between September and October 1997, we recovered adult fish that either returned to Sashin or Lover's Cove creeks, strayed to locations within a 50 km radius of LPW or were caught in commercial seining operations. Exposed fish returning to LPW were counted, measured and spawned to determine how oil influenced their growth, marine survival and gamete viability.

Preliminary analysis of the number of marked fish recovered in streams where fish were not released indicates lower straying rates than has been reported for PWS. More than 4,000 marked fish were identified among the 680,000 adult fish sampled. Approximately 74% returned to the Sashin Creek weir and 14% to Lover's Cove Creek. Another 1.5% were recovered in streams where fish were not released and 10% were recovered in commercial operations. The actual straying rates will be calculated when the presence of CWT in the marked fish is verified and tags are decoded. X-ray analysis of tag placement in all the straying and a sample of homing fish is underway and currently precludes recovering the tags from these fish.

Analysis of the growth and survival of fish recovered at the Sashin Creek weir demonstrated exposure to very low concentrations of oil during incubation reduced fitness of the exposed fish, with effects throughout the life history of the fish. Prior to release, reductions in survival of pink salmon embryos from fertilization to the eyed stage of development were detected at aqueous concentrations of total polynuclear aromatic hydrocarbons (TPAH) of 5.3 ppb. Fish exposed to 19 ppb TPAH demonstrated reduced growth a nearly 70% reduction in marine survival. Analysis of the effects of oil exposure on gamete viability is underway.

Project Number and Title: 97127 – Tatitlek Coho Salmon Release

Principal Investigators: Gary Kompkoff, Tatitlek IRA, Box 171, Tatitlek, AK 99677 (Phone 907-325-2311)

Abstract: This project was proposed by Tatitlek IRA council and has been undertaken in cooperation with ADF&G, Prince William Sound Economic Development Council and the Valdez Fisheries Development Association. The objective of this project is to create a coho salmon return to Boulder Bay near the village of Tatitlek. Traditional subsistence resources available to residents of Tatitlek were severely disrupted by the oil spill and this project was initiated to provide coho salmon to fishermen near Tatitlek until other resources injured by the spill, such as harbor seals, could recover.

The coho salmon return was created through an annual release, beginning in 1990, of 20,000 coho smolts near the village. The smolts are produced at the Solomon Gulch Salmon Hatchery under an agreement between its operator, the Valdez Fisheries Development Association and the Tatitlek IRA council. The smolts are transported from the hatchery to Tatitlek by boat, placed in net pens for about two weeks and then released into the wild. Coho are currently returning to Tatitlek and are being utilized by the subsistence and sport fishermen.

Project Number and Title: 97131 - Nanwalek, Port Graham and Tatitlek subsistence clam restoration

Principal Investigators: Jon Agosti, Qutekcak Shellfish Hatchery, Box 369, Seward, AK 99664, (907) 224-5181; Jeff Hetrick and David Daisy, Chugach Regional Resources Commission, 4201 Tudor Centre Drive, Suite 211, Anchorage, AK 99508, (907) 562-6647; Dr. Ken Brooks, Aquatic Environmental Sciences, 664 Old Eaglemount Road, Port Townsend, WA 98368, (360) 732-4464.

Abstract: Clams were once a major subsistence resource in the Native communities of Nanwalek and Port Graham in lower Cook Inlet and Tatitlek in Prince William Sound. Local clam populations have been decreasing in recent years and their contribution to the subsistence harvest has been greatly reduced. There are probably several reasons for this including changes in currents and beach patterns, increasingly heavy sea otter predation and the *Exxon Valdez* oil spill. The oil spill impacted the wild clam populations and their importance as a subsistence food in two ways. First, some clam beds suffered from direct oiling. Second, even though the oil did not directly impact many clams, they have a tendency to accumulate, concentrate and store the toxic contaminants from non-lethal amounts of oil. This has badly eroded the confidence of the villagers in the healthfulness of the remaining wild clam populations as a subsistence food.

The project goal is to provide the project villages with safe, reliable, easily accessible sources of clams for subsistence use. Project objectives for 1997, the third year of the project, were to continue to improve hatchery production techniques for littleneck clams (*Protothaca staminea*), develop culture techniques for cockles (*Clinocardium nuttalli*), continue work with the nursery ponds near the hatchery and experiment with a tidally driven fluidized upwelling nursery system (FLUPSY), seed test plots on beaches near the project villages, and test predator control coverings on razor clam beaches near Eyak.

An experienced shellfish hatchery technician was hired in June 1996 to operate the shellfish hatchery in Seward with the goal of bringing the hatchery and adjacent nursery pond operations up to standard. Many of the littleneck clam production problems in the hatchery and nursery pond have been cleared up. In addition, the project is investigating the potential of remote tidally operated fluidized upwelling systems (tidal FLUPSY) for producing nursery stock. A prototype tidal FLUPSY is being tested this year at Tatitlek using 5 mm seed produced by the hatchery. Results to date have shown that significant seed growth is possible with the FLUPSY.

Very little work has been done in culturing cockles. Dr. Ken Brooks of Aquatic Environmental Sciences in Port Townsend, Washington has been contracted to develop procedures for spawning cockles for this project. His work so far has met with limited success.

Littleneck clams from the hatchery were seeded on small test plots in July 1996 and August 1997 on three different beach types near the project villages at the –1.5, 0 and +1.5 tide levels. These test plots are used to determine growth rates on each beach type as well as test predator control measures. Sampling to date indicates that 8 mm to 10 mm clam seed should reach harvestable size in less than three growing seasons on all beach types. As expected, growth was best at the lower tide levels. Additional predator control tests are also being conducted on razor clams near Eyak (Cordova).

PROJECT NUMBER AND TITLE: 97139A1 - Salmon Instream Habitat and Stock Restoration - Little Waterfall Barrier Bypass Improvement.

PRINCIPAL INVESTIGATOR: Steven G. Honnold, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 211 Mission Road, Kodiak, Alaska, 99615 (907) 486-1873.

ABSTRACT: Restoration work began at Little Waterfall Creek in 1994 as result of surveys conducted on Kodiak Island to evaluate instream habitat and stock restoration techniques for wild salmon stocks. These surveys were intended to identify potential sites that could provide mitigation for instream habitat damage that resulted from the *Exxon Valdez oil spill.* Data from these surveys indicated that Little Waterfall Creek contained a significant amount of spawning habitat that was underutilized by pink and coho salmon due to an ineffective barrier bypass structure. Further surveys revealed that this barrier bypass structure was deficient due to steep gradients and excess water velocity.

The primary objective of this restoration project was to improve salmon passage through this bypass, thus, increasing escapement to underutilized spawning habitat upstream of the barrier. The priorities of the project were to renovate the bypass to reduce the gradients and to design resting pools to minimize water velocity. Pink and coho salmon production data were assessed in conjunction with the renovation work to determine pre-project status and for later comparison to post project data. Specifically, escapement, preemergent fry indices, and relative abundance of rearing juveniles (coho) upstream and downstream of the barrier were assessed.

The bypass renovation was completed in the fall of 1995, with gradients reduced from 27% to 17-20% and the addition of two resting pools and an entrance pool. The steeppass sections were staggered between pools to reduce the velocity of stream flows. Prior to this project, the 15 year (1981-1995) average proportion of the escapment to use the bypass was ~20%. In 1996, Little Waterfall Creek pink salmon escapment was poor (5,500); however, 44% of the escapement (2,400) passed through the improved bypass. Passage in 1997, improved further to 59% (~8,800 peak live) of the escapement (15,000) or three-fold more than the pre-project average. Coho escapement surveys in 1997 were hampered by high water conditions which prevented assessment of bypass use.

Project Number and Title: 97139A2, Port Dick Creek Restoration Project.

Principal Investigators: Wes Bucher, Alaska Department of Fish and Game, Homer Alaska, 3298 Douglas Place, Homer, Alaska 99603

Mark Dickson, Alaska Department of Fish and Game, 3298 Douglas Place, Homer, Alaska 99603. (907) 235-8191.

Geoff Coble, Coble Geophysical Services, 1213 Ocean Drive, Suite #7, Homer, Alaska 99603

Abstract: Restoration surveys on the outer coast of the Kenai Peninsula resulted in the identification of the potential to restore pink and chum salmon spawning habitat in a dry tributary in the Port Dick Creek watershed. Port Dick Creek is located approximately 25 miles southeast of Homer on the Kenai Peninsula. The primary project goal involves the restoration of native Port Dick Creek Pink Salmon, *Onchorynchus gorbusca* and Chum Salmon *Onchorynchus keta* stocks. This is being accomplished through in-stream habitat restoration and evaluation in two intermittent spawning tributaries of Port Dick Creek.

Feasibility studies conducted from 1990 through 1995 supported the project design and excavation in June 1996 of approximately 3000 m^3 of dry tributary gravel deposits to create additional stable spawning habitat. In July and August 1996, 572 pink and 300 chum salmon voluntarily colonized the two tributaries and spawned, depositing a potential 775,800 eggs.

In April through mid-June 1997, a 2-person crew used fyke nets to enumerate emigrating pink and chum salmon fry. An estimated 290,869 fry were counted through the fyke net producing a preliminary egg to fry survival rate of 37.5%. This survival rate compared favorably with mean survival rates for pink and chum salmon of 54.7% and 27.0% respectively found in the literature (Lister et al., 1980; Heard, 1978).

Spawning channel stability is being monitored with ongoing results in channel fill, scour, and gravel transport. Long term streambed stability analyses have already dictated additional monitoring. Physical parameters such as channel temperature are collected and compared to fry emergence for the currently available data.

In July and August 1997, pink and chum salmon adults again entered the restored tributaries to spawn. Ground surveys indicate that the number of salmon colonizing the tributaries this year is larger than last year, though final numbers are not currently available.

Project Number and Title: 97139C1 - Montague Island Riparian Rehabilitation

Principal Investigators: David Schmid, Ken Hodges, USDA Forest Service. P.O. Box 280, Cordova, AK 99574. (907) 424-7661

Abstract: A number of watersheds on the west side of Montague Island were clearcut in the 1960's and 1970's without leaving buffer strips along the streams. In addition, large woody debris was removed from the streams in the belief that salmonid migration and spawning area would be improved. As a result of these practices, the streams have suffered increased erosion, stream widening, loss of pools, erratic flows, and high bedload movement. Pink salmon *(Oncorhynchus gorbuscha)* and chum salmon *(O. keta)* redds in downstream areas are subject to displacement and desiccation. Coho salmon *(O. kisutch)* and Dolly Varden char *(Salvelinus malma)* spawning and rearing areas are also adversely affected.

In 1994, we built 32 instream structures made of logs and boulders. The structures are intended to take the place of the large woody debris that was removed and are meant to create pools, trap sediment, and reduce water velocity and erosion. A control area downstream from all of the structures was established to determine whether the effects of the structures would cause changes in substrate size or channel characteristics below. Maps of the structure sites and the control area were drawn in 1994 and again in 1997.

We also thinned thick stands of young Sitka spruce *(Picea sitchensis)* in the riparian areas. In some areas, only the competing Sitka alder *(Alnus sinuata)* and willow *(Salix spp.)* were removed, while in other areas some of the Sitka spruce was removed as well. Thinning the stands is intended to accelerate the growth of the remaining trees, which will provide the source of large woody material in the future. Mainstem and whorl growth of the Sitka spruce were measured and compared between thinned and unthinned sites.

Most of the structures were built in the mainstem of Hanning Creek and its tributaries. Although all of the structures survived bankfull flows during the first summer, many of the structures in the mainstem have failed or have become ineffective as the stream has shifted during the ensuing years. Structures in the smaller tributaries which were designed to create or enhance fish habitat have been more effective. Juvenile fish have been observed using the pools and cover areas. The remaining structures do not appear to have significantly reduced the overall stream velocities or bank erosion.

Removal of competing alder and willow increased Sitka spruce growth initially, but later monitoring showed no significant differences between thinned and unthinned areas. In areas where Sitka spruce was removed as well, the remaining spruce continue to show greater growth rates.

Project Number/Title: 97142/Status and Ecology of Kittlitz's Murrelet in Prince William Sound

Investigators: Robert H. Day (Principal) and Debora A. Nigro, ABR, Inc., P.O. Box 80410, Fairbanks, AK 99708-0410 (Phone of RHD 907/455-6777; e-mail of RHD bday@abrinc.com)

Abstract: This project investigated aspects of the ecology of Kittlitz's murrelet (*Brachyramphus brevirostris*) in four glaciated fjords in northern Prince William Sound (PWS) during 3-week cruises in early (May-June) and late summer (July-August) 1996 and 1997. The small size of its world population, its restricted distribution, and uncertainty over impacts to its PWS population from the *Exxon Valdez* oil spill result in conservation concerns. The objectives of this study were to: (1) conduct population surveys in the four bays; (2) estimate population sizes; (3) determine distribution and habitat use; (4) develop and measure indices of reproductive performance; and (5) describe trophic levels and feeding ecology.

Kittlitz's murrelets were common on nearshore surveys, uncommon on offshore surveys, and rare on pelagic surveys. In early summer 1996, Kittlitz's murrelets exhibited late arrival in icier and colder bays (Unakwik Inlet, College Fjord) and early arrival in less icy and warmer bays (Harriman Fjord, Blackstone Bay); in all other cruises, Kittlitz's murrelets were found throughout all bays, probably because ice and temperature conditions were less severe. Numbers decreased rapidly after 1 August, as birds left the bays. Populations in all bays were small and collectively totaled ~1,410 ± 1,389 (95% CI) birds in 1996 and ~1,280 ± 648 birds in 1997. Kittlitz's murrelets selected for tidewater glaciers at two levels: highest overall densities in those bays with the most tidewater glaciers (College and Harriman fjords) and, across all bays combined, a preference for glacial affected habitats within bays. Kittlitz's murrelets exhibited relationships between density and percent ice cover, secchi depth (as an indicator of water clarity), and sea-surface temperatures but did not exhibit relationships with sea-surface salinity.

The percentage of breeding-plumaged Kittlitz's murrelets was smaller in early summer 1996 than in any other cruise, suggesting that birds in early 1996 were not physiologically prepared for breeding. Ratios of juveniles:older birds indicated that reproductive output in all bays was extremely low in 1996 and completely absent in 1997. Flock sizes exhibited distinctive patterns through time but could not be interpreted in the context of reproduction. Numerous mixed-species "pairs" of Kittlitz's and marbled murrelets were observed. Feeding frequency was higher in nearshore than in offshore areas but showed little relationship to time of day, tidal stage, and habitat type. Feeding frequency also was related to the strength of tidal currents. The few birds seen feeding ate fishes, primarily sandlance, and primarily from 0- or 1-year age classes; there appeared to be much overlap with marbled murrelets (*B. marmoratus*) in prey species and mean size of prey. There was a negative relationship between mean water depth and the density of Kittlitz's murrelets in early summer 1996 but not during other cruises.

These results suggest that Kittlitz's murrelets in these bays had fairly small population sizes and low reproductive output during both years. There is a possibility of a population decline since the early 1970s, although the baseline is of questionable validity. A widespread lack of reproduction in this species has been recorded previously; consistently low reproductive output would result in population declines.

Project Number and Title: 97144 - Common Murre Population Monitoring

Principal Investigators: David G. Roseneau, Arthur B. Kettle, and G. Vernon Byrd, U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, 2355 Kachemak Bay Dr. (Suite 101), Homer, Alaska 99603-8021 (Telephone 907/235-6546; e-mail <dave_roseneau@fws.gov>)

Background: The Barren Islands, in the northwestern Gulf of Alaska, supported one of the largest breeding concentrations of common murres *(Uria aalge)* in the path of the *Exxon Valdez* oil spill. When winds and currents swept oil through the region during April and early May 1989, many of these seabirds were killed: they comprised 74% of 30,000 bird carcasses recovered by 1 August. Based on this information and a computer modeling study, estimates of mortality suggested that 74,000-315,000 murres died after contacting floating oil. Because mortality appeared to be high, the U.S. Fish and Wildlife Service (FWS) conducted *Exxon Valdez* Oil Spill Trustee Council-sponsored common murre damage assessment and restoration studies at the Barren Islands during 1989-1991 and 1992, respectively. These projects obtained data on numbers of birds attending the colonies. During 1990-1992, Exxon-sponsored studies collected additional information on Barren Islands murre numbers. In 1993-1994, we counted birds at the East Amatuli Island - Light Rock and Nord Island - Northwest Islet colonies during Trustee Council-sponsored restoration monitoring Projects 93049 and 94039. Although complete censuses were not made in 1995, we counted three sets of East Amatuli Island - Light Rock monitoring plots during APEX Project 95163J. In 1996 and 1997, we revisited the islands and censused murres at both colonies as part of restoration monitoring Projects 96144 and 97144.

Abstract: The 1997 project objective was the same as that of previous restoration studies—to monitor the recovery of murres at the Barren Islands colonies. The islands are located at about 58° 55' N, 152° 10' W, between the Kodiak archipelago and the Kenai Peninsula. Study sites consisted of East Amatuli and Nord islands and two closely associated islets, East Amatuli Light Rock (Light Rock) and Northwest Islet. These areas, comprising the East Amatuli Island - Light Rock and Nord Island - Northwest Islet colonies, contain all known murre nesting habitat in the island group. Counts were made from small boats by two observers using the same methods employed during the 1993-1996 studies. We censused East Amatuli Island - Light Rock and Nord Island - Northwest Islet completely to obtain whole-colony estimates and estimates on major subdivisions of the colonies (e.g., East Amatuli Island, Light Rock). Smaller plot sets (multicount plots) were counted at least five times for statistical analyses of among-year differences and trends in population size. Plots were treated as sample units and results were pooled with 1989-1992 FWS, 1990-1992 University of Washington (UW), and 1991 Dames & Moore (D&M) data. Linear regressions were run to test for trends, and one-way analysis of variance (ANOVA), Tukey HSD multiple pairwise comparisons, and two-tailed *t*-tests were used to check for differences among years at the at the 0.1 significance level. Differences between 1997 results and averages of previous postspill counts were tested with one-sample *t*-tests. Although trends were not present on some plot sets, significant increases on two sets (Light Rock and East Amatuli Island - Light Rock multicount plots BMP 3-4) and the fact that 1997 results were significantly higher than the averages of previous postspill counts on four others (East Amatuli Island - Light Rock, Nord Island - Northwest Islet, and multicount plots BMP1-8 and BMP 1-11; $P < 0.1$ in all cases) suggested that murre numbers were starting to increase at the colonies. The presence of large numbers of nonbreeding birds in 1997, probably 3- and 4-year-old subadults from the strong 1993-1994 chick cohorts, also suggested that population recovery was underway. Recensusing the Barren Islands murre colonies in 1999, when 3-, 4-, 5-, and 6-year-old birds produced in 1993-1996 will be present, may provide information needed to satisfy recovery goals for this injured species in the spill area.

Project Number and Title: 97145 - Anadromous and resident forms of cutthroat trout and Dolly Varden in Prince William Sound.

Principal Investigators: Gordon H. Reeves (reevesg@fsl.orst.edu) and Kitty E. Griswold, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331 541-750-7314; Kenneth Currens, Northwest Indian Fisheries Commission, 6730 Martin Way E., Olympia, WA 98516 360-438-1181, ext. 374.

Abstract: Searun cutthroat trout (*Oncorhynchus clarkii clarkii*) and Dolly Varden (*Salvelinus malma*) are found distributed throughout PWS. They exhibit two forms, anadromous which spends time in freshwater and the marine environment, and resident, which spend their entire life in freshwater. The anadromous forms of each species were identified as having been injured as a result of the *Exxon Valdez* oil spill because the growth rate of populations in oiled areas was less than that observed in populations in unoiled areas. The purpose of our study was twofold. One was to examine the relation among populations of each species in PWS. We are doing this by examining the relation among anadromous of each species throughout PWS and by examining the relation between the resident and anadromous forms of each species in selected drainages. The second goal is to develop a potential restoration plan for these species. We have completed two field seasons and have collected preliminary results on genetic and life history features of these populations

We collected anadromous cutthroat trout at 13 sites and anadromous Dolly Varden at 14 sites in summers of 1996 and 1997. We collected resident forms of cutthroat trout at three sites and of Dolly Varden at three sites. Fish were captured with hook and line, baited minnow traps, seines, and electroshockers. We are using genetics and life-history analysis to determine the relation among the populations. We are employing three genetic techniques, protein electrophoresis, mitochondrial DNA (mtDNA) and microsatellites. We are determining life-history attributes (e.g., growth rates, time of ocean entry, ocean-freshwater movement) by examining patterns on the otolith.

All results at this point are preliminary because we have not completed all the analysis. Because we completed our 1997 sampling in September, none of these samples have been analyzed yet. Based on 17 restriction enzymes in 80 cutthroat trout from sites throughout PWS, we determined that mitochondrial DNA appeared to have limited ability to differentiate the populations we are studying. Preliminary results from 100 cutthroat trout using nine microsatellite primers suggest that there may be sufficient variation to describe the relations among populations. Allozyme results on cutthroat trout collected in 1996 indicate that there are some significant differences among populations. Preliminary analyses of growth rates suggest that the growth rates of anadromous cutthroat trout on the east side of PWS, the unoiled area, are greater than that of populations from the west side of PWS, which includes oiled areas.

Allozyme screening for Dolly Varden is currently being performed. Dolly Varden are also currently being screened for mtDNA and microsatellite variation.

It is unclear at this time what the results of this study will mean to the restoration effort. We need to complete the analysis of all samples before we can make any definitive statement. The initial results from the growth study on cutthroat trout suggest that changing the criteria for recovery from having equal growth to having equal growth among populations in oiled and unoiled areas to requiring consideration of potential geographic influences may be appropriate.

Project Number and Title: 97149 -Archaeological Site Stewardship

Principal Investigators: Douglas R. Reger, Office of History and Archaeology, Alaska Department of Natural Resources, 3601 C Street, Suite 1278, Anchorage, AK, 99503-5921, (907) 269-8725
Debra Corbett, Regional Office, U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK, 99503, (907) 786-3399

Abstract: Site steward activities in the Kodiak Island area focused primarily in the Kiavak Bay and Uganik Bay areas. Site stewards in the Kiavak Bay area monitored KOD-098, KOD-099 and KOD-100 for vandal activities. The monitors photographed the sites, made sketch maps of current conditions and collected several artifacts off the beach. The artifacts were in danger of loss to the tides and were appropriately documented prior to collection. A report on those activities is in preparation.

Steward activities in the Uyak Bay and Uganik Bay areas have not been reported to date although local residents did track the sites. A meeting of stewardship program participants in the Kodiak Island area is planned during January or early February.

Stewardship activity in the Kachemak Bay area included monitoring visits to SEL-001, SEL-030, SEL-248, and SEL-250. A visit to SEL-248 was made during the spring with site stewards and the regional coordinators. Several new sites in the Seldovia area were visited and a brief meeting was held with the Seldovia Native Association. Reports are being prepared for steward activities. Some damage was seen at SEL-030 but little new damage was found at the other sites. Documentation of erosional damage continued at SEL-001 with support from the U.S. Fish and Wildlife Service.

Sites in the Kenai area continued to be monitored and site stewards continue to aid in documenting sites being damaged. KEN-190 was mapped and testing begun to document status of the site. No new vandal damage was noted at KEN-252 although weathering of the structure continues. Habitat restoration measures by the Alaska Division of Parks at KEN-262 protected the site from continued damage by fishermen. SEL-063 was monitored for fishing related activities with no damage reported. Site stewards in the Kenai area helped document a site, KEN-076, which is to be partially destroyed by a stabilization project. Their help also allowed their level of training to be expanded.

U.S. Fish and Wildlife personnel worked with the Kenaitze Indian Tribe in documentation of several site features along the upper Kenai River as part of a combined stewardship project. The project incorporated training with documentation of an endangered site.

Project Number and Title: 97159 - Effects of the Exxon Valdez Oil Spill on Marine Birds in Prince William Sound, Alaska.

Principal Investigator: David B. Irons, USFWS, 1011 E. Tudor Rd., Anchorage, Alaska. Phone 907/786-3376, e-mail David_Irons@mail.fws.gov

Abstract: This study was undertaken to determine effects of the EVOS on summer marine bird populations in Prince William Sound (PWS). The 1996 survey data analyzed here were previously summarized by Agler and Kendall (1997) in their final report on project 96159. This abstract uses a subset of that data plus pre-spill data and asked a different question than they asked (i.e., we asked if there was an oil-spill effect, rather than, were species recovering). To determine effects, we compared post-spill population levels with pre-spill population levels in oiled an unoiled areas and tested if the population change was different in the oiled and unoiled areas. Indices of population levels were obtained by conducting nearshore marine birds surveys using small boats during summer. Preliminary analyses showed that cormorants, goldeneyes, mergansers, murres, and pigeon guillemots showed negative effects and had not recovered by 1996. Loons showed a negative effect and recovery is uncertain. Harlequin ducks and black oystercatchers showed negative effects and are showing evidence of recovery. Glaucous-winged gulls, terns and bald eagles showed positive effects. Mew gulls showed no effect. Effects on scoters, black-legged kittiwakes and murrelets are yet to be determined. This is the first study to investigate and demonstrate population effects on several species of marine birds seven years after the EVOS.

Project Number and Title: 97161 - Differentiation and Interchange of Harlequin Duck Populations Within the North Pacific

Principal Investigators: Buddy Goatcher, U.S. Fish & Wildlife Service, Ecological Services, 825 Kaliste Saloom Rd. Building 2, Suite 102, Lafayette, LA 70508; Denny Zwiefelhofer, Kodiak National Wildlife Refuge, 1390 Buskin River Road, Kodiak, Alaska 99615; Kim Scribner, Dept. of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824-1222; Dan Esler, Alaska Biological Sciences Center, Biological Resources Division, U.S. Geological Survey, 1011 E. Tudor Rd., Anchorage, AK 99503

Participating Geneticists: Richard Lanctot, Sandra Talbot, Barbara Pierson, and John Pearce, Alaska Biological Science Center, Biological Resources Division, U.S. Geological Survey, 1011 E. Tudor Rd., Anchorage, AK 99503.

Abstract: Molecular genetic analyses and direct observations of color-banded individuals were used to assess the degree of movements and inferentially population differentiation among geographically separate wintering/molting aggregations of harlequin ducks (*Histrionicus histrionicus*). The primary area of study encompasses Exxon Valdez oil spill impacted areas on the northeast coast of the Alaska Peninsula (Katmai National Park), Kodiak Island Archipelago (Kodiak National Wildlife Refuge along the Shelikof Straits) and Prince William Sound. Other samples which were collected from across the North Pacific Rim contributed additional insight to the extent of population structuring at larger geographic scales.

New microsatellite libraries were constructed and additional loci were characterized. Individuals (N=756) were assayed for variation at four bi-parentally inherited and one sex-linked (Z-specific) microsatellite loci. Collections included four sampling locales within Prince William Sound (N=224), four locales from Kodiak Island and Katmai National Park and Preserve (N=285), and 5 additional locations across the Pacific Rim including Washington State, British Columbia, Queen Charlotte Islands, Aleutian Islands, and the Bering Sea and Russia (N=247). No significant differences in microsatellite allele frequency were observed among sampling locations within Prince William Sound or among locales from Kodiak/Katmai. Further, allele frequencies were not demonstrably different between PWS and Kodiak/Katmai regions. Greater spatial variation in allele frequency was observed across the Pacific Rim, though differences were not statistically significant. Harlequin ducks appear to be genetically panmictic with regard to nuclear DNA loci across their wintering range along western North America.

PCR primers were developed for a 385 bp region of the hypervariable portion of the mitochondrial (mt)DNA genome. Sequence analysis of 163 bp of this region produced 8 distinct haplotypes. To date 49 individuals have been sequenced from across the Pacific Rim. These preliminary data indicate the presence of greater spatial structuring. Larger numbers of samples are being screened from each population to provide an estimate of female-mediated gene flow.

A total of 681 harlequin ducks was captured and banded at Katmai and Kodiak trapping locations since July 1996. To date, band observations include 4 hunter kills, 16 recaptures, 21 color band, and 13 coded color band observations. Distances from capture location determined from band observations (n=33) ranged from 0 to 54 km (mean = 3.8 km). Rate of recapture at Katmai and Kodiak trapping locations was approximately 10%.

Project Number and Title: 98162A - Natural History of Viral Hemorrhagic Septicemia (VHS) in Wild Juvenile Pacific Herring

Principal Investigators: Richard Kocan & Paul Hershberger, School of Fisheries, Box 355100, Univ Washington, Seattle, WA 98195; (206) 685-2984, kocan@fish.washington.edu; and James Winton, Western Fisheries Research Center, 6505 NE 65th, Seattle, WA 98115.

Abstract: From 1995 through 1997, wild juvenile herring were captured by purse seine or netted from bait-balls in Puget Sound. They were immediately assayed for VHSV, then kept in captivity and observed for 3-6 months. To determine if they were immune to VHS, they were challenged with 10 times the known minimum lethal dose of VHSV (> 5,000pfu/ml) and observed for signs of disease.

Previous studies (FY 95-96) demonstrated that VHSV causes disease in nonimmune juvenile herring and that the virus is transmitted to uninfected fish via water. With one exception, no virus was isolated from > 800 free-ranging 0-year wild herring assayed immediately after capture between 1995-1997. However, after 3-5 days in captivity, these same fish experienced epizootics which resulted in > 50% mortality within 2 weeks. Survivors of the epizootic became solidly immune to challenge infection, with no virus-related mortality and no virus in their tissues. One-year-old herring exhibited the same disease course, but with significantly less mortality. About 15% tested positive for the virus within one week following capture, then returned to "0" prevalence with < 1% mortality. After one month, these fish were also solidly immune to challenge infection with VHSV.

In June and July of 1997, 0-year herring responded exactly as described above. However, the first isolate of VHSV came in August of 1997, when a single fish (1/100) tested positive for VHSV with a titer of 300,000 pfu/gm tissue. Significantly, there was no subsequent epizootic in the remaining fish, no dead fish tested positive for VHSV, and when the group was challenged with VHS virus, they were all solidly immune to reinfection.

VHSV can be isolated from wild herring by the time they are 4 months old, and they appear to be extremely susceptible to the pathologic effects of the virus. Based on virus assays performed on groups of 100 newly captured wild fish, it appears that under normal circumstances < 3% of the 0-year fish are carrying active infections. Because 0-year herring undergo a massive epizootic when confined, and subsequently become solidly immune as survivors, we believed a very small percentage of wild fish carry active infections and that under conditions of confinement, they transmit the disease to the remaining nonimmune fish, thus causing the epizootics.

However, a single infected wild 0-year individual in a school of immune herring is strong evidence that epizootics do occur in 0-year fish and that the survivors represent fish that did not succumb to the infection. These fish are immune to reinfection, and only exhibit disease and mortality if their immune system becomes compromised. Three possible scenarios exist for development of disease resistance in wild herring: 1) The virus is transmitted at a low rate to relatively few fish and along with age resistance the population becomes immune over a long period of time; 2) Epizootics occur in wild 0-year herring and the survivors become immune to reinfection; and 3) Little or no virus transmission occurs during early life stages and a large portion of the adult population is nonimmune to epizootics when the conditions for transmission are right. The ultimate effect of disease on herring populations of any age depends on which of these situations prevailed in prior years.

This study offers evidence that epizootics that result in mortality of 0-year fish may have a profound influence on the subsequent recruitment of that particular year-class into the spawning population.

Project Number: 97162B - Viral hemorrhagic septicemia virus in herring from the spawn-on-kelp fisheries.

Principal Investigators: Paul Hershberger and Dick Kocan, School of Fisheries, Box 355100, Univ. Washington, Seattle, WA 98195, ph. (206) 543-4606, paulh@fish.washington.edu; Gary Marty, VM:APC, Univ. California. One Shields Ave. Davis, CA. 95616-8732.

Abstract: Discovery of viral hemorrhagic septicemia virus (VHSV) in fishes from the west coast of North America has prompted investigations into virulency, activation, and spread of the causative agent. Laboratory data from Puget Sound, Washington has demonstrated that wild herring actively express VHSV following purse seine capture and confinement. Experiments described here were designed to determine whether activities associated with the closed pound spawn-on-kelp (SOK) fisheries in Puget Sound, Washington and Prince William Sound (PWS), Alaska may similarly contribute to active infections of VHSV in associated herring. Herring tissue samples were taken for VHSV assays on consecutive days post impoundment from 1 Puget Sound SOK pound in 1996 and 3 PWS pounds in 1997. Additional data from the PWS study included herring age and sex, water temperature and dissolved oxygen, water-borne VHSV particles within the pounds, and VHSV tissue titers from naturally spawning herring outside the SOK pounds.

None of the herring entering the Puget Sound pound tested positive for VSHV upon initial capture (day 0), while 12.2% (5/41) of the herring tested VHSV+ after being held in the pound only 1 day. The SOK fishers obtained a product of sufficient quality after this time and subsequently released the fish, thus negating the possibility of obtaining tissue samples past 1 day of confinement. A more thorough time course of VHSV infection was obtained for the PWS samples, demonstrating increased VHSV tissue titers shortly after introduction to the pounds, followed by a subsequent decrease in titers several days later. None of the naturally spawning, wild fish tested positive for VHSV and only 15% of the dead herring from within the pound tested positive. Larger percentages of younger fish (4-6 year olds) tested positive for VHSV than older fish (7-10 year olds). Water quality within and outside the pounds was similar and no VHSV was found in any water samples.

Conclusions: 1) Capture and confinement of herring associated with SOK fisheries appear to result in activation of VHSV infections in wild herring. 2) These herring develop short-term infection and VHSV is eliminated after approximately 8 days, probably through a stimulated immune response. 3) The majority of herring mortality within the pounds was not associated with VHSV infections. 4) Wild herring captured in the vicinity of the pounds showed no signs of disease nor could VHSV be isolated from their tissues. 5) Older herring are less susceptible to active VHSV infection than younger fish within the pounds.

Project Number and Title: 97162C - Investigations of Disease Factors Affecting Declines of Pacific Herring Populations in Prince William Sound: Part III: Laboratory Studies on Herring Fitness.

Principle Investigator: Christopher J. Kennedy, Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada, V5A 1S6 (604/291-5640, email: ckennedy@sfu.ca).

Abstract: Although near-record spawning biomass returns of Pacific herring, Clupea harengus pallasi, were predicted in Prince William Sound for 1993, the population crashed when less than half of the >100,000 tons of spawning herring returned. Several hypotheses have been put forward to explain this population decline which include the direct or indirect effects of oil or its components on herring survival and fitness. Due to the prevalence of Viral Hemorrhagic Septicemia Virus (VHSV) and *Ichthyophonus hoferi* (ITP) in spawning herring sampled from Prince William Sound (PWS), these two pathogens have also been considered likely to be involved in the morbidity of herring in PWS. The main objectives of this component of the project, therefore, are aimed at understanding the effects of these three stressors, hydrocarbons, VHSV and ITP on the survival and fitness (mainly the biochemical and immunological status) of Pacific herring.

Adult Pacific herring were collected off the west coast of Vancouver Island, B.C. The disease state of these fish was determined. Examinations for ITP and VHSV proved negative, therefore in this respect, fish were considered healthy and representative of healthy populations. Herring were exposed to an oil water dispersion (OWD) for 21 days using a modified oil generating apparatus developed by Carls et al. North Slope crude oil was used to generate several concentrations of the OWD. During the exposure period, fish were examined for: 1) acute mortality, 2) alterations in 'stress' biochemistry, and 3) immunological parameters. Following OWD exposure, fish were then exposed to either VHSV or ITP to examine the effects of multiple stressors.

Exposure to OWD for 21 days did not result in significantly higher mortalities than in control fish. These results are in contrast to earlier studies in which juvenile fish were exposed to similar concentrations. This indicates that OWD is more acutely toxic to juvenile herring than adults.

Biochemical parameters which have been shown to be good indicators of 'stress' in fish, including plasma cortisol, glucose and lactate, and hematocrit were measured at several times during exposure to OWD. Significant increases in plasma cortisol, lactate, glucose and hematocrit were seen in fish exposed to OWD, indicating that OWD induces a classic 'stress response' in adult herring. Similarly, juvenile herring also exhibited a similar response with values returning to control levels by 4 days.

Immunological performance, as measured by circulating blood chemistry and cell composition, was affected by exposure to OWD. Hematocrit, leucocrit, differential white blood cell counts and plasma lysozyme levels were not significantly different from controls at either 7 or 21 days. However, macrophage function, as evidenced by phagocytosis and respiratory burst activity was suppressed by oil exposure. The relevance of these measurements to the ability of adult herring to resists disease is being addressed by experiments in which these fish are further challenged by VHSV and ITP.

The results of this study indicate that an OWD of North Slope crude oil is not as acutely toxic to adult as juvenile herring, although both exhibit a classic biochemical 'stress response' and altered immunological capacity.

Project Number and Title: 97162D (field component) - Investigations of disease factors affecting declines of Pacific herring populations in Prince William Sound, AK.

Principal Investigator: Gary D. Marty, VM:APC, Univ. of CA, One Shields Ave., Davis, CA 95616-8732; phone: 530-754-8062; e-mail: gdmarty@ucdavis.edu

Abstract: The estimated numbers of spawning of Pacific herring (*Clupea pallasi*) in Prince William Sound (PWS), Alaska, declined nearly 80% between 1992 and 1993. In 1993, a virus (viral hemorrhagic septicemia virus, VHSV) and no other significant disease-causing agents was isolated from herring in PWS. In 1995-1997, study included fish from a reference site, Sitka Sound, in which the herring population was increasing. The study determined the role of disease in the decline of Pacific herring populations. This included intensive study of VHSV in the spawn-on-kelp pound (net-pen) fishery in the northeastern region of PWS during the 1997 fishery.

METHODS: Adult Pacific herring were sampled from PWS in October 1996 (n = 160), March 1997 (prespawning, n = 80), and April 1997 (spawning, n = 180), and from Sitka Sound in March 1997 (spawning, n = 250). Fish from PWS were subjected to complete necropsy, including histopathology that was not done on fish from Sitka. From each of three closed commercial spawn-on-kelp pounds in April 1997, daily 40-fish samples were examined for external lesions, and their internal organs were assayed for VHSV.

RESULTS: In spring 1997, VHSV prevalence was significantly greater in fish from PWS (15%) than Sitka (0.8%), and PWS virus prevalence was significantly greater than in any other year sampled (1994, 4.7%; 1995, 1.8%; 1996, 0.0%). VHSV was not isolated from PWS fish in October 1996, and no samples from fall 1995 or fall 1996 were positive for VHSV. VHSV was more common in females, younger fish, fish with severe external lesions, and fish with hepatocellular necrosis (liver cell death). Prevalence of a fungal disease, *Ichthyophonus*, in fish from PWS in 1997 (18%) was less than in previous spring samples (1994 and 1995, 29%; 1996, 25%).

In the spawn-on-kelp fishery, VHSV prevalence in initial samples varied from 12.5% on day 0 (pound #1), to 0% and 25% on day 1 (pounds 2 and 3). VHSV sample prevalence peaked 2 or 4 days after capture (15-30%), and then declined to 0 to 7.5% on the last sample date, 6 to 8 days after capture. VHSV prevalence was not associated with fish density, and water samples from within pounds at slack tide were negative for virus. VHSV prevalence in 46 dead fish (15%) was no different than the prevalence in 40 live fish (12.5%) randomly sampled from the same pound 5 days after capture. Two 40-fish samples of Pacific herring naturally spawning near the pounds were negative for VHSV.

CONCLUSIONS: Pacific herring populations in PWS did not recover in 1997, and increased VHSV prevalence is consistent with population decline predicted for the 1998 fisheries. Continued decrease in *Ichthyophonus* prevalence is evidence against this fungus being a significant cause of population decline. VHSV expression was associated with spawn-on-kelp pounds and sick fish, but VHSV was not the major cause of fish mortality within the pounds. Lack of virus in water and fish samples outside the pounds is evidence that closed pounds do not represent a severe threat to the feral fish population. However, some of these results are different from laboratory study results, and a proposed second year of pound study is needed.

Project Number and Title: 97163 A - Forage Species Studies in Prince William Sound

Principal Investigators: Lewis Haldorson and Thomas Shirley, Juneau Center, School of Fisheries & Ocean Sciences, University of Alaska Fairbanks, 11120 Glacier Highway, Juneau, Alaska 99801, (907) 465-6446

Abstract: This APEX project has the objective of estimating the species composition, biomass and distribution of forage species utilized by avian predators in Prince William Sound. The abundance and distribution of forage fishes was estimated in three areas (north, central, south) that encompass foraging sites for seabird colonies injured by EVOS. An additional study area near Montague Island was added to the study in 1997. Hydroacoustic surveys of offshore and nearshore (within one km) zones were conducted during July and August 1997 with supporting net and video sampling to identify acoustic targets. Offshore, relatively few forage fish aggregations were encountered, except in the Montague area where juvenile walleye pollock, eulachon, herring and capelin were all present northwest of Montague Island. In the nearshore survey forage fish composition varied among the three areas; within each area there were locations where forage species were concentrated. In all areas forage fishes were found in relatively small but dense schools. In the North area, young-of-the-year herring were the principal forage species, and were most abundant in Port Fidalgo and Port Gravina. The Central study area had concentrations of adult herring around Naked Island. In the South area herring were also the most abundant forage species, with schools of adult and older juveniles mainly in Prince of Wales Passage. Herring were the most prevalent forage species in nearshore waters throughout the three study areas.

In 1997, summer water temperatures near the surface were typically two to three degrees (centigrade) higher than in 1995 and 1996; although below about 20 m depth temperatures in 1997 were often colder than in 1996.

In Spring (May), Summer (July/August) and Fall (October), sampling was conducted to determine if differences in the planktonic production systems exist within Prince William Sound. Temperature, salinity, chlorophyll concentrations, plankton abundance and fish distributions were sampled at process study sites within the three major study areas. Preliminary analyses indicate that planktonic production differs markedly in the North and South. For example, in May, the South study site had much higher chlorophyll levels than the North, whereas krill abundance was higher in the North than in the South. The predominant krill in the North was T. inermis, but in the South, where E. pacifica predominated, T. inermis was the least abundant krill. In the Fall, the North had very large aggregations of young-of the-year herring, whereas the South had none; however, krill were more abundant in the South than in the North.

Project Number and Title: 97163B - APEX: Seabird/Forage Fish Interactions

Principal Investigator: William D. Ostrand, U.S. Fish and Wildlife Service, 1011 E. Tudor Rd. Anchorage, Alaska 99503, (907) 786-3849

Abstract: We sought to determine if there was a relationship between seabird abundance and indices of Black-legged Kittiwake (*Rissa tridactyla*) productivity relative to forage fish biomass. We also examined the relationship between abundance of all seabirds, abundance of Marbled Murrelets (*Brachyramphus marmoratus*), and forage fish biomass in relation to bottom depth at an intermediate scale. Working with the University of Alaska, Fairbanks, School of Fisheries and Ocean Sciences, we simultaneously collected hydroacoustic data on forage fish abundance and seabird locations in three study areas of Prince William Sound, Alaska. During July - August 1995 and 1996 we sampled pelagic transects. In 1996 we also surveyed 22 nearshore blocks, 10 x 1 km, within our major study areas to improve our sampling of habitats associated with the greatest seabird activity. Kittiwake productivity data were collected at colonies located within the three study areas. Seabird/forage fish comparisons were made graphically at a course scale (study areas as the sample units). We made intermediate scale (nearshore study blocks as the sample units) comparisons using linear regression. At our course scale, forage fish biomass near shore corresponded to kittiwake numbers observed during surveys and the number of chicks at colonies. At our intermediate scale, fish biomass did not predict seabird numbers. However, we determined seabird abundance, Marbled Murrelets abundance, and forage fish biomass were negatively related to the mean bottom depth of the sampling blocks. We used Geographic Information Software to map shallow nearshore habitats within Prince William Sound that may be areas of higher concentration of both seabirds and their forage.

Project Number and Title: 97163C - APEX: Trophic interactions between sympatric and allopatric forage fish aggregations.

Principal Investigators: Molly V. Sturdevant, Lee B. Hulbert and Audra L. J. Brase. NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801 (907-789-6041), molly.sturdevant@noaa.gov.

Abstract: This component of the Alaska Predator Ecosystem Experiment (APEX) investigates the trophic interactions of forage fish prey of seabird populations which were impacted during the *Exxon Valdez* Oil Spill. We analyzed 1180 forage fish specimens and 110 plankton samples from Prince William Sound to compare diet composition, diet overlap and prey selection, feeding shifts when fish occurred in single species aggregations (allopatrically) versus in multi-species aggregations (sympatrically). The principal forage species examined were juvenile pollock (*Theragra chalcogramma*) and herring (*Clupea harengus* pallasi) collected offshore by trawl in 1994-1995, and juvenile herring, Pacific sandlance (*Ammodytes hexapterus*), and pink salmon (*Oncorhynchus gorbuscha*) collected along shore by beach and purse seine in 1996.

Diets of pollock and herring overlapped in October-November 1994-1995 when their distributions overlapped; these species did not occur sympatrically in July-August. At 3 of the 4 stations where young-of-the-year (YOY) pollock and YOY herring co-occurred there was significant overlap (> 60%) in the numbers and biomass of prey items consumed (Horn's Overlap Index). Significant differences (Tukey pairwise ANOVA, $p < 0.05$) existed between allopatric sets of YOY herring or YOY pollock and some of the sympatric sets in which they co-occurred. Allopatric YOY pollock (n=1 set) generally consumed greater numbers of prey, whereas allopatric YOY herring (n=1 set) consumed greater biomass, in comparison to the sympatric sets (n=4) in which they occurred. Euphausiids made up a consistent, significant (Tukey pairwise ANOVA, $p < 0.05$) difference in prey of co-occurring herring and pollock, with walleye pollock typically consuming greater biomass than herring.

Preliminary results for juvenile sandlance and herring in July-August, 1996 suggest that diet composition did not shift between allopatric (n=6 sets each) and sympatric (n=3 sets) fish aggregations. Both species consistently consumed large percentages (55-86% biomass or number) of small calanoids, roughly in proportion to their availability in the zooplankton. The mean density of plankton was lower at stations where sandlance and herring occurred sympatrically than at stations where they occurred allopatrically.

Neither juvenile herring nor juvenile pink salmon prey composition appeared to shift between allopatric (n=8 sets herring; n=3 sets pinks) and sympatric (n=6 sets) aggregations in July-August, 1996. However, both species' stomachs were more full in allopatric samples than in sympatric samples. Small calanoid copepods were prominent in herring diets, while fish and hyperiids were prominent in pink salmon diets. Although both species' diets varied greatly among stations, larvaceans were consistently consumed in greater proportion than their availability in zooplankton samples. Mean plankton density was higher (approximately 4000 vs. 3000 organisms/m^3) in areas where the fish occurred allopatrically compared to where they occurred sympatrically.

Project Number and Title: 97163E - APEX: Kittiwakes as Indicators of Forage Fish Availability.

Principal Investigators: David Irons and Rob Suryan. U.S. Fish and Wildlife Service, 1011 E. Tudor Rd., Anchorage, Alaska. 99503, 907/786-3376, david_irons@mail.fws.gov.

Abstract: As part of the Alaska Predator Ecosystem Experiment (APEX) project, our field work began during the summer of 1995 and consisted of studies of population biology, reproductive biology and foraging ecology of Black-Legged Kittiwakes (*Rissa tridactyla*) in Prince William Sound (PWS). Detailed studies were conducted at colonies in the northeast (Shoup Bay), central (Eleanor Island), and southwest (N. Icy Bay), representing the various oceanographic conditions in PWS.

In 1990, the year following the *T/V Exxon Valdez* oil spill, productivity of Black-legged Kittiwakes in PWS decreased and had not recovered as of 1995. Studies during this period indicated the decline in productivity resulted from decreased food availability and increased predation. Productivity in 1996 was the first indication that conditions may be similar to pre-1990 levels. This, however, did not hold true in 1997; a summer of increased sea surface temperatures and marine conditions potentially affected by a strong El Nino. These "abnormal" conditions, however, provided interesting comparisons among our three study sites and contrasts with previous years in determining how kittiwakes respond to variable food resources.

Hydroacoustic and trawl data (APEX component A) from previous years indicated that fish biomass was greater in northeast vs. central and southwest study areas corresponding with high productivity at Shoup Bay, moderate at Eleanor Island, and low at N. Icy Bay. Species composition of forage fishes also differed as did diets of kittiwakes among the three colonies; particularly with Pacific herring (*Clupea herrengus*) more consistent at Shoup Bay and capelin (*Mallotus villosus*; a species more associated with Gulf of Alaska waters) more frequent in chick meals at Eleanor Island and N. Icy Bay. Sand lance (*Ammodytes hexapterus*) was present at all colonies.

In 1997 we observed changes in forage fish distribution that had a greater negative affect on kittiwakes at Shoup Bay than Eleanor Island and N. Icy Bay. Mean foraging trip distance (44 km) and duration (6 hrs) significantly increased at Shoup Bay resulting in decreased chick growth (15 g/day) and productivity. Foraging trip distance (35 km) and duration (5.6 hrs) also significantly increased at Eleanor Island, but had little effect on chick growth (16.5 g/day) and the change in productivity was not as dramatic. In contrast, conditions improved compared to previous years at N. Icy Bay. Foraging trip distance (19 km) and duration (2.7 hrs) decreased from last year while chick growth was similar (16.4 g/day) and productivity increased.

The majority of foraging activities for kittiwakes in 1997 were near the southern boundaries of PWS where thousands of birds were observed foraging. This resulted in reduced foraging effort for kittiwakes at N. Icy Bay, increased effort at Eleanor Island with some effect on productivity and greatly increased effort at Shoup Bay with more significant effect on chick growth and productivity.

Project Number and Title: 97163F - APEX: The Breeding and Feeding Ecology of Pigeon Guillemots at Prince William Sound, Alaska

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Dan Roby, Oregon Cooperative Wildlife Research Unit, Department of Fisheries and Wildlife, 104 Nash Hall, Oregon State University, Corvallis, Oregon 97331-3803

Abstract: We are studying population size, diet, chick growth, and productivity of pigeon guillemots (*Cepphus columba*) in central Prince William Sound, Alaska, in an effort to understand what factors are limiting the recovery of this species following the *Exxon Valdez* Oil Spill (*EVOS*). In this abstract we report that the percent schooling fish in the diet affects chick growth, and suggest that the reduced availability of high quality schooling fish may have constrained the recovery of pigeon guillemots following the *EVOS*.

Pigeon Guillemots are diving seabirds that forage near shore and feed on both benthic and schooling fish. At the population level guillemots may be considered generalist, although individuals often specialize on particular prey items. They are therefore well suited for studies relating diet to reproductive performance. During nine of the past twenty years, intensive studies have been made of chick diet, adult diet specialization, and chick growth rate at Naked Island.

Pigeon guillemot chick diet varied significantly from 1978 to 1997 (n=5,534 identified prey items, P<0.001). The principle prey item that fluctuated during the course of this study was Pacific sand lance (*Ammodytes hexapterus*), a high quality schooling fish, that declined from 60% in 1979 to a low of 10% in 1994. Regression analyses suggest that chick growth rate was affected by the percent occurrence of high quality schooling fish in the diet (n=9 years, r^2=0.52, P=0.028). When adults that specialized on schooling fish are compared with those that specialized on benthic fish, significant differences are found in the growth patterns of the chicks. Chicks that received primarily schooling fish had significantly higher growth rates (21.4±0.8 vs. 17.4±1 grams·day^{-1}, n=43, P=0.030), and tended to attain higher peak masses (486±16 vs. 445±9 grams, n=62, P=0.062) than those that received primarily benthic fishes. The improved growth of guillemot chicks fed diets rich in schooling fish may in part be a function of the relatively high energy densities of these prey, however we also found that schooling fish were delivered to nestlings at a higher rate (1.11±0.1 vs. 0.8± 0.04 deliveries·nest^{-1}·hr^{-1}, n=70, P=0.014) than benthic fishes. In addition, we found that adults that specialized on schooling fish tended to have a larger brood size at fledging than those that specialized on benthic fish (1.6±0.15 vs. 1.3±0.07 chicks·nest^{-1}, P=0.092), suggesting that there may be differences in productivity, as well as growth, that are related to diet.

The recovery of pigeon guillemots following the *EVOS* may be constrained by low availability of high quality schooling fishes in the diet. This interpretation is supported by our findings that 1) the percentage of these fishes was higher in the chick diet before the *EVOS* than it has been since, and 2) chick growth rate, peak mass, and productivity appear to be maximized only when schooling fish comprise a major portion of the diet. Alternative explanations for a lack of recovery in this injured seabird species are also being considered.

Project Number and Title: 97163 G - APEX: Diet Composition, Reproductive Energetics, and Productivity of Seabirds Injured the *Exxon Valdez* Oil Spill

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Abstract: The basic premise of this component of the APEX Project is that a shift in the marine trophic structure of the *Exxon Valdez* oil-spill area has prevented recovery of injured seabird resources. Specifically, the research addresses whether shifts in diet quality may have constrained reproduction in pigeon guillemots (*Cepphus columba*), common murres (*Uria alga*), and marbled murrelets (*Brachyramphus marmoratus*), all resources injured by the spill. The major hypothesis tested is that differences in the nutritional quality of forage fishes are a primary determinant of energy provisioning rates to seabird nestlings, which influences growth and survival of young.

During the 1995 - 1997 breeding seasons, we collected samples of forage fishes and nestling meals and measured nestling growth rates, provisioning rates, and nesting success in relation to diet for black-legged kittiwakes *(Rissa* tridactyla) nesting at Eleanor Island (oiled site), Shoup Bay (non-oiled site), and North Icy Bay (non-oiled site) in Prince William Sound and Gull Island, Chisik Island, and the Barren Islands (all reference sites) in Lower Cook Inlet. We also collected these data for pigeon guillemots nesting at Naked Island (oiled site), Jackpot Island (non-oiled), and Kachemak Bay (reference site).

We used proximate analysis to measure lipid, water, ash-free lean dry matter, and ash contents of 1,311 fish from 32 species to estimate energy density and identify factors contributing to its variation, including species, size, sex, reproductive status, season, location, and year. Energy density varied widely both inter- and intraspecifically. Lipid content (% dry mass) was the primary factor determining energy density of individual fish. Lipid content ranged from 2% to 61% of dry mass, resulting in a five-fold difference in energy density (2.0 to 10.8 kJ/g wet mass). Eulachon (*Thaleichthys pacificus*) and lanternfish (family Myctophidae) had the highest lipid contents. Of the main forage fishes consumed by seabirds, juvenile herring (*Clupea harengus pallasii*), pre-spawning sand lance (*Ammodytes hexapterus*), and pre-spawning capelin (*Mallotus villosus*) had the highest energy densities. Prowfish (*Zaprora silenus*), juvenile Pacific tomcod (*Microgadus proximus*), and juvenile walleye pollock (*Theragra chalcogramma*) had the lowest energy densities. Nearshore demersal fishes (e.g., gunnels, pricklebacks, sculpins) were intermediate in lipid content and energy density. Fishes high in lipid had less water and more protein as a proportion of lean mass than low-lipid fishes, further enhancing the nutritional value of high-lipid fishes.

Seabirds, marine mammals, and predaceous fishes can experience multifold differences in energy intake rates based solely on the type of forage fishes consumed. This may be especially significant for diet selection by piscivorous seabirds during the breeding season, when food for their developing young must be transported from the foraging area to the nest site.

Project Number and Title: 97163I - APEX: Project Leader

Principal Investigator: David Duffy, Alaska Natural Heritage Program and Department of Biology, University of Alaska Anchorage, 707 A Street, Anchorage AK 99501, (907-257-2784 afdcd1@uaa.alaska.edu)

Abstract: This project provides scientific oversight and coordinationamong the subprojects of the Alaska Predator Ecosystem Experiment (APEX) investigating whether a change in food reouscres in the Northern Gulf of Alaska has prevented recovery of seabirds following the spill of the *Exxon Valdez*. The past year saw the addition of a modelling component to APEX, as well as the addition of a study on the trophic role of jellyfish in Prince William Sound. Protocols for field work were also produced by the investigators.

The project is now at its midpoint and the basic conclusions appear to be that a major change in trophic conditions did occur, producing a shift from high-lipid forage fish to low-lipid forage fish species. Low-lipid foods appear to limit either numbers of breeders or growth of young birds. Low fledging rates resulting from slow growth have been associated with reduced survival. Further field work will assess the impact of the past warm/dry year and the ongoing El Nino event on fish and bird populations. Modelling will be used to formalize our knowledge of these relationships and to map areas of special importance to seabirds and fish in Prince William Sound, as a tool for avoiding development in areas where resources might be damaged.

Project Number and Title: 97163I-2 and 97064 - Spatial Distribution of Harbor Seals and Forage Fish in Prince William Sound, Alaska. Conducted as part of Monitoring, Habitat Use and Trophic Interactions of Harbor Seals in Prince William Sound

Principal Investigators: Tracey A. Gotthardt, Kathryn J. Frost, and David C. Duffy. Biological Sciences Department, University of Alaska, Anchorage, 707 A. Street, Anchorage, AK 99501 (TAG and DCD); Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701 (KFJ). (TAG phone 907-257-2788, e-mail "attag@uaa.alaska.edu").

Abstract: Harbor seals, one of the most commonly occurring marine mammals in Prince William Sound (PWS), have been experiencing a population decline for the past twenty years. Although the exact reasons for this decline remain unknown, one of the leading theories suggests that a long-term ecosystem wide shift has altered the tropic structure and the availability of forage fish on which seals and other APEX predators depend upon for survival. In order to address the restoration of this species, it is first necessary to determine not only what harbor seals eat, but also the type of forage that is available for them to eat and the locations where seal go to forage.

Harbor seal diving behavior patterns within Prince William Sound were monitored by ADF&G using satellite-linked time-depth recorders (SLTDR's) (Restoration Project Number: 97064), and their dietary composition has been estimated using fatty-acid signature techniques (Restoration Project Number: 97064). The distribution and abundance of potential prey species within PWS was assessed by the APEX project (Restoration Project Number: 97163A) through the use of hydroacoustic sampling and mid-water trawls. Additionally, the Alaska Department of Fish and Game has monitored herring spawn deposition along shorelines in PWS, as well as performed mid-water trawls to determine pollock biomass. The combined results of these studies were used to assess the relationship between spatial and temporal distributions of harbor seal foraging activity and the availability of potential prey species. Although harbor seal and forage fish projects were not designed to compliment each other, and differences in scale and scope of study designs exist, we were able to integrate these data sets using GIS technologies.

Foraging strategies of seven seals tagged in September 1995 were investigated in this project (three juvenile females, three adult females and one juvenile male). APEX trawls suggest that herring and young pollock overwinter in bays and protected areas. Four of the seven seals spent time within bays during winter months, making relatively shallow dives (mean 40 m). Of the seven seals, four made trips to the Copper River Delta (three of these seals remaining there to forage from March to May when satellite transmissions ceased). Two seals visited Middleton Island for brief foraging bouts between October and March, diving to a maximum depth of 244 meters with an overall dive depth averaging 36 m. Seals which overwintered in the Montague Straits area made relatively shallow dives (< 50 m) and fewer long distance foraging trips, perhaps in response to herring overwintering in the same area.

Project Number and Title: 97163J - APEX: Barren Islands Seabird Studies

Principal Investigators: David G. Roseneau, Arthur B. Kettle, and G. Vernon Byrd, Alaska Maritime National Wildlife Refuge, 2355 Kachemak Bay Drive (Suite 101), Homer, Alaska 99603-8021 (Telephone 907/235-6546; e-mail <dave_roseneau@fws.gov>)

Abstract: The objective of this APEX component was to monitor breeding and foraging parameters of common murres (*Uria aalge*), black-legged kittiwakes (*Rissa tridactyla*), and tufted puffins (*Fratercula cirrata*) at the Barren Islands, Alaska. By comparing information from these species with results from other years, we are investigating responses of seabirds to changes in food availability and quality. The three study species were chosen because of their different foraging behaviors. Both murres and puffins dive to capture prey, but puffins usually feed closer to their breeding colonies and to shore, and closer to the surface than do murres. Kittiwakes are surface feeders. Because the foraging strategies of these species differ, their responses to changes in forage fish availability may also differ, giving us the opportunity to learn how changes in the prey base affect seabird reproductive success. This project began in 1995; data from projects conducted in earlier years are also available for comparison.

As in 1995 and 1996, we monitored egg-hatching and chick-fledging success, timing of the breeding season, foraging trip duration and nest attendance by adults, and the diet, feeding frequency, and growth rate of chicks. Most data were collected by regularly observing nest sites in study plots with binoculars; we also visited nests to measure chicks and collect diet samples.

In 1997, results varied among the study species. Productivity of murres (the number of chicks fledged per nest) was high, as it has been since 1994, and nest attendance and fledgling weight were higher than in 1996. The timing of murre nesting events was earlier than during the previous year; these events have occurred earlier each year since at least 1993. The diet of murre chicks was similar to that of 1995 and 1996; 94% of the items fed to chicks were capelin (*Mallotus villosus*). Kittiwake productivity was much lower and the timing of nesting later than in 1995 and 1996. Growth rate of kittiwake chicks, however, did not vary significantly during 1995-1997. Preliminary results show that as in 1996, kittiwake chick diet consisted mainly of Pacific sand lance (*Ammodytes hexapterus*) and capelin. Productivity of tufted puffins was similar to that of 1996 and lower than in 1995. The growth rate of tufted puffin chicks was low, although higher than in 1996. The diet of tufted puffin chicks was diverse and remarkably similar to that of 1996; chicks were fed mainly capelin, walleye pollock (*Theragra chalcogramma*), and Pacific sand lance.

During the 1990's, reproductive success has been low in some years at some seabird colonies in the Gulf of Alaska, Cook Inlet, and Prince William Sound. There is evidence that the composition of the prey base changed between the 1970's and the 1990's. While success of kittiwakes and puffins has varied among the study years, success of common murres has been high since 1994. Additional data analysis and 1998-1999 field work will help identify the ecological processes that effect these patterns, and help assess the ability of seabird populations to recover from the *Exxon Valdez* oil spill.

Project Number and Title: 97163K - APEX: Using Predator Fish to Sample Forage Fish

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Background: Evaluating the influence of fluctuating prey populations (e.g., forage fishes) is critical to understanding the recovery of seabirds injured by the T/V *Exxon Valdez* oil spill; however, it is expensive to conduct hydroacoustic and trawl surveys to assess forage fish stocks over broad regions. As part of the 1995 *Exxon Valdez* Oil Spill Trustee Council Alaska Predator Ecosystem Experiment, we tested the feasibility of using sport-caught Pacific halibut *(Hippoglossus stenolepis)* to obtain spatial and temporal information on capelin *(Mallotus villosus)* and Pacific sand lance *(Ammodytes hexapterus)*, two forage fishes important to piscivorous seabirds. We examined halibut stomachs collected from cooperating vessels in a 150-200 charter boat fleet fishing throughout Cook Inlet waters during late May - early September. Catch locations and dates provided information on geographic and seasonal variation in the incidence of capelin and sand lance in seven eastern inlet subunits between Ninilchik and Shuyak Island. Data on prey brought to black-legged kittiwake *(Rissa tridactyla)*, common murre *(Uria aalge)*, and tufted puffin *(Fratercula cirrhata)* chicks at Cook Inlet colonies were collected simultaneously as part of the APEX project to help evaluate the sampling technique. The pilot study conducted in 1995 indicated sufficient types and amounts of data could be collected to test several APEX hypotheses concerning the relationship between seabird reproductive success and forage fish availability. As a result the study was refined and continued in 1996 and 1997.

Abstract: In 1997, we were able to sample over 1400 halibut stomachs. About 55% of the stomachs had identifiable contents. Only about 30% of the stomachs with contents contained forage fish in 1997 compared to 95% in 1995 and 77% in 1996. Of over 3,000 individual prey items, capelin accounted for only 8% in 1997, a substantially lower value than in 1995 (60%) and 1996 (49%). In 1997, sand lance were found in 17% of the stomachs with prey. This value was a little lower than in 1995 (23%) and higher than 1996 (7%), but rigorous comparisons of the sand lance component are limited by the relatively large fraction of unidentified forage fish remains in 1995 (12%) and 1996 (21%), some of which were probably sandlance. Only 1% of the forage fish were unidentifiable in 1997. Comparisons of forage fish among areas in Lower Cook Inlet have not yet been completed, and the picture may be further clarified later. Nevertheless, it appears that if halibut are accurate indicators of the relative abundance of forage fish, capelin were less available in the food web in 1997 than they had been in 1995 and 1996.

Project Number and Title: 97163L (APEX) Synthesis and Analysis Gulf of Alaska of Small-Mesh Trawl Data 1953 to 1997; Including Forage Fish Icthyoplankton Analysis 1972 to 1996.

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Abstract: Large declines of apex predator populations (murres, kittiwakes, harbor seals, and Steller sea lion) have occurred in the Gulf of Alaska since the 1970s. Changes in composition and abundance of forage species may be responsible for the decline of these predator populations and their chronic low population levels. In an effort to delineate changes in forage species and a trophic regime shift, if any, over the last several decades, we have gathered together historical fishery-independent scientific survey data to address this question.

This project analyzes small-mesh trawl sampling results from near-shore surveys in the Gulf of Alaska conducted by the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G). The data for analysis was collected starting in 1953 and continues through 1997. The current data series includes about 10,000 individual trawl tows during this time period.

Recently there has been information presented that the Gulf of Alaska ecosystem has undergone some abrupt and significant changes (Piatt and Anderson, 1996). The extent and degree of these changes is poorly documented and is important in determining future strategies for management of the marine ecosystem. Analysis of the historic data is a first step in gaining an appreciation for the rapid and abrupt changes that have occurred in the marine species complex in the last five decades. The data from small-mesh shrimp trawl cruises provides an opportunity to review changes in the composition of forage species that occurred through time in the Gulf of Alaska. The current status of species and there relative abundance in the ecosystem can only be judged by the long-term historical perspective provided by this unique data set.

Twenty-six years (1972-97) of shrimp trawl survey catch data was analyzed in order to reveal changes in the species composition of demersal biomass in the Gulf of Alaska. A shrimp-dominated crustacean species community (mostly *Pandalus goniurus* and *P. borealis*) came to an end in the late 1970's and has not yet regained its former level of biomass. Changes in community structure continued with the decline of capelin (*Mallotus villosus*) in the late-1970s, followed by a build-up of gadid fishes (Pacific cod and walleye pollock) in 1978-83 and bottom dwelling flat fishes in 1984 to the present. Overall, the biomass index, as represented by shrimp sampling trawl, has declined to less than one-half of its former size under the recent fish-dominated environment. This epibenthic regime shift was accompanied by a rapid increase in water temperature which may largely be responsible for the observed abrupt temporal change in species composition. Current analysis is concentrating on defining the role of temperature induced predation which may be a primary factor in explaining the failure of crustacean stocks as well as some forage species to rebuild.

Project Number and Title: 97163M - APEX: Cook Inlet Seabird and Forage Fish Studies (CISeaFFS)

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Abstract: CISeaFFS ("Sisyphus") was initiated in 1995 as a long-term research project to characterize relationships between seabird population dynamics, foraging behavior and forage fish densities in lower Cook Inlet-- the area in which most seabirds were killed by the EVOS. CISeaFFS is a collaborative project of the Alaska Biological Science Center and the Alaska Maritime National Wildlife Refuge (AMNWR), with major funding and logistic support from the EVOS Trustees under the APEX Project (Apex Predator Ecosystem Experiment), the Biological Resources Division of the U.S. Geological Survey, the U.S. Fish and Wildlife Service, and the Alaska Department of Fish and Game.

From 1995 through 1997, populations, productivity, diets and foraging behavior of 6 seabird species (murre, kittiwake, guillemot, puffin, cormorant, gull) were studied at three seabird colonies in lower Cook Inlet (Chisik, Gull and Barren islands). Oceanographic measurements, seabird and hydroacoustic surveys, trawls, and beach seines were conducted in waters around (<40 km) each colony. In all years, offshore and southern waters of Cook Inlet were dominated by juvenile walleye pollock and capelin, important prey for murres and puffins. Nearshore waters were dominated by sand lance, which were consumed by seabirds (e.g., kittiwakes, guillemots, murres) in proportion to their local abundance. Acoustically-measured forage fish biomass was lowest around Chisik Island, moderate in Kachemak Bay, and highest around the Barren Islands. Correspondingly, seabird breeding success in all years ranged from relatively low in the Chisik Island area to relatively high in the Barren Islands area. Populations of seabirds at Chisik Island continued a long-term decline, whereas populations at Gull and Barren islands are stable or increasing. Behavioral studies revealed that seabirds worked harder (longer foraging trips, less "free" time) at colonies where nearby fish densities were lower. Breeding success at all three colonies varied between years, with 1996 being the best year for production, and 1995 and 1997 being slightly worse for seabird breeding success. There was little evidence for adverse effects of the 1997 El Niño event on seabirds, and water temperatures through summer were similar to those observed in 1996.

Project Number and Title: 97163N – APEX: Effects of Diet Quality on Post-natal Growth of Seabirds Captive Feeding Trials

Principal Investigators: Marc D. Romano and Daniel D. Roby, Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, OR 97331 romanom@ucs.orst.edu

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Abstract: Declines in the availability of certain schooling forage fishes (sand lance *Ammodytes hexapterus*, herring *Clupea harengus*, capelin *Mallotus villosus*) have potentially contributed to the lack of recovery of some fish-eating seabirds that were injured by the *Exxon Valdez* oil spill. These forage fish tend to have high lipid content and, consequently, are assumed to have high nutritional value as food for nesting seabirds. This study tests the hypothesis that composition of the diet is one factor constraining the growth and development of piscivorous seabirds.

We raised seabird nestlings (Black-legged Kittiwakes *Rissa tridactyla* and Tufted Puffins, *Fratercula cirrhata*) in captivity on rations of either capelin, sand lance or herring as representative of high-quality forage fish, or walleye pollock (*Theragra chalcogramma*)as representative of low-quality forage fish. Experimental treatments included iso-biomass and iso-caloric comparisons of chick growth between low- and high-lipid fish types. Seabird nestlings fed rations of either sand lance, herring or capelin had much higher growth rates of body mass and somewhat higher growth rates of wing length than nestlings fed the same biomass of pollock. Differences in mass gain between nestlings fed capelin/sand lance/herring vs. pollock were more pronounced than differences in wing growth, suggesting that undernourished nestlings allocate food intake more to structural development than body mass. We conclude that when provisioning rates of seabirds to their young is constrained, the lipid content and nutritional quality of forage fish fed to nestlings has a marked effect on growth rates, and potentially, on reproductive success.

Project Number and Title: 97163Q - APEX: Seabird Demographics in Relation to Prey: Computational Results.

Principal Investigators: R.G. Ford, Ecological Consulting, Inc., 2735 N.E. Weidler St., Portland, OR 97232 (503) 282-0799 <eci@teleport.com>, D.C. Schneider, Memorial University of Newfoundland, St. John's, Newfoundland, A1B 3X7 Canada, D.A. Ainley, H.T. Harvey & Associates, P.O. Box 1180, Alviso, CA 95002.

Abstract: The general hypothesis of the APEX project is that a change in the relative abundance of forage fish has prevented recovery of injured avian populations. The modeling results are based on data provided by other investigators, including David Irons, Rob Suryan, Evelyn Brown, Lewis Haldorson, William Ostrand, Kathy Kuletz, and Greg Golet. In 1997, the modeling component identified a series of quantifiable linkages between chick production and food supply.

Two submodels have been constructed: (1) a demographic model that relates colony productivity to foraging behavior, and (2) a foraging model that relates foraging behavior to prey availability. Results from (1) indicate that colony performance depends on several factors in addition to foraging behavior, but that trip duration or trip distance can account for much of the observed variation in colony performance. Results from (2) indicate that traplining is a realistic foraging model and that trip time and distance can be predicted based on the distribution of prey. Computational results point to the need for better information on prey distribution, and encounter rates of seabirds with prey. Chase sequences of radio-tagged kittiwakes and concurrent aerial surveys of prey species calibrated with acoustic data may prove useful in obtaining this information.

Project Number and Title: 98163S - APEX: Jellyfish as competitors and predators of fishes

Principal Investigator: Jennifer E. Purcell, University of Maryland Center for Environmental Science, Horn Point Laboratory, P.O. Box 775, Cambridge, MD 21613 (410) 221-8431, email purcell@hpl.umces.edu)

Abstract: Jellyfish have been shown to reduce zooplankton populations, therefore, they are potential competitors with forage fish for zooplankton foods. Jellyfish also are known to eat fish eggs and larvae. If forage fish populations are negatively affected by jellyfish, the populations of vertebrate predators of the forage fishes (e.g. seabirds, fishes and marine mammals) also may be negatively affected. The ultimate goals of this study are to evaluate whether jellyfish harm forage fish populations by reducing the zooplankton foods needed by the fish, and by feeding on fish eggs and larvae. The specific objectives are to determine: 1) the dietary overlaps between the various species of jellyfish and fish, 2) the feeding rates on zooplankton and ichthyoplankton, 3) the distributions and abundances of jellyfish species in Prince William Sound (PWS), and 4) historical patterns in abundance in the Gulf of Alaska.

During an APEX cruise July 30 to August 4, 1997, jellyfish *(Cyanea, Aurelia, Pleurobrachia, and Aequorea*) were collected from 21 stations in PWS for gut content analysis. All of these species are documented predators of zooplankton and ichthyoplankton. Gut content analyses of these specimens are underway; preliminary data show that *Cyanea* consumed mostly copepods and larvaceans. The diets of the jellyfish will be compared with diets of forage fishes to determine the dietary overlaps. The amounts of zooplankton and ichthyoplankton consumed by jellyfish will be estimated from the numbers of prey in the gut contents divided by experimentally measured digestion times, in combination with densities of jellyfish and their prey (APEX collaborators Haldorson, Shirley, Sturdevant).

In 1996, the large jellyfish *Cyanea, Aurelia*, and *Aequorea* were very abundant in PWS. In 1997, *Cyanea* was distributed in all sampling areas, *Aurelia* was seen in large aggregations, but *Aequorea* was not common. Distribution and abundance data for these large species and for other, smaller species are being compiled from SEA and APEX data in 1996 and 1997 (collaborators Brown, Cooney, Coyle, Norcross, Stokesbury, Haldorson, Shirley, Sturdevant).

Trawl data from the Gulf of Alaska were summarized during peak jellyfish biomass in August through October, 1973 - 1995 (APEX collaborators Anderson and Piatt). Jellyfish (probably *Chrysaora*) biomasses were similar (10 - 20 kg/km) in most years, with an unusually high biomass in 1980 (110 kg/km). The anomalous abundance peak in 1980 occurred at the same time as a transition from predominantly shrimps before 1980 to predominantly ground fish species afterwards (Piatt and Anderson 1996), however, no marked differences in jellyfish abundance exist before or after 1980.

(1) **Project Number and Title:** 97165 - Genetic Discrimination of Prince William Sound Herring Populations

(2) **Principal Investigators:** Jim Seeb, Alaska Department of Fish and Game, Commercial Fisheries Management and Development, Genetics Laboratory, 333 Raspberry Rd., Anchorage, Alaska, 99518, (907) 267-2385, JimS@fishgame.state.ak.us.

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(3) **Abstract:** The Prince William Sound Pacific herring (*Clupea pallisi*) fishery was curtailed in 1993 and remained closed through the spring of 1996. The Alaska Department of Fish and Game recovery effort includes incorporating knowledge of genetically derived population structure into harvest management. In this continuing project we are delineating the structure of Prince William Sound population(s) and related North Pacific populations using both nuclear and mitochondrial DNA analyses. Tests for temporal and spatial diversity within years and temporal stability across years will be conducted.

Preliminary results of year-one nuclear DNA analyses (microsatellite) indicate very high levels of genetic diversity. The divergence estimates suggest very limited genetic exchange between the Bering Sea/Kodiak Island populations and the PWS populations, and there is evidence of significant levels of genetic divergence within PWS. The mtDNA results also suggest dramatic differentiation between Gulf of Alaska and Bering Sea populations, a high degree of genetic variability in the ND1 gene of Pacific herring, and heterogeneity between Kodiak and PWS populations. Repeat sampling is required to determine if the observed pattern of differentiation is consistent over time.

Project Number and Title: 97166 - Herring spawn deposition and reproductive impairment.

Principal Investigators: Mark Willette, Greg Carpenter and John Wilcock. Alaska Department of Fish and Game, Box 669 Cordova, AK 99574 (907-424-3214).

Abstract: Underwater dive surveys of deposited eggs and acoustic techniques were used to estimate the 1997 adult spawning population of Pacific herring *Clupea pallasi* in Prince William Sound (PWS). A stratified random sampling design was employed to estimate the number of herring eggs deposited. Divers estimated the number of eggs within a systematically placed 0.1^2 m quadrat along transects randomly selected from all areas of spawn identified during aerial surveys. Diver estimates of egg numbers were corrected for systematic bias using an inverse prediction procedure that compared diver egg counts and gravimetrically determined laboratory egg counts for the same quadrats. The spawn deposition estimate of the spawning biomass of herring was 21,020 tons with a 95% confidence interval ranging from 11,676 tons to 30,363 tons. The total biomass from 1997 was approximately 6,649 tons less than the 1996 biomass estimate. Even though the total herring biomass decreased, the total miles of spawn in 1997 increased by approximately 58% from 1996 mainly due to increased spawning in the Southeast and Northern areas of PWS.

This project is also evaluating the feasibility of using acoustic echointegration techniques to estimate herring biomass immediately prior to spawning. Net sampling was conducted to estimate species, size and age composition of the insonified fish. The acoustic survey was conducted by ADF&G staff and the Prince William Sound Science Center. The survey consisted of two consecutive trips in areas where adult herring are historically known to spawn. Preliminary herring biomass estimates for the first and second legs totaled 41,226 and 18,913 tons, respectively. Acoustic biomass estimates are being compared with spawn deposition biomass estimates to evaluate the cost effectiveness and accuracy of each method. At present, the spawn deposition estimates are used in conjunction with aerial observations of spawn distribution and basic biological information (age composition, sex ratios, average size and fecundity) to forecast spawning returns the following year using an age structured assessment (ASA) population model.

Project Number and Title: 97167 – Preparation and curation of seabirds salvaged from the Exxon Valdez spill.

Principal Investigator: Sievert Rohwer, Curator of Birds, Burke Museum, University of Washington, Seattle, Washington 98195-3010.

Abstract: The University of Washington Burke Museum has received three grants to salvage and preserve samples of birds that were casualties of the Exxon Valdez oil spill. National Science Foundation Grant 92-18534 enabled us to send a crew of workers to sort the carcasses as they were thawed for incineration, and to ship a subset of these birds to the Burke Museum for preparation. NSF Grant 93-16045 supported preservation of many of these birds, but was insufficient to complete the task because these heavily oiled and, often, rotten specimens were slow to prepare. Grant 97167 from the Exxon Valdez Oil Spill Trustee Council allowed us to complete this project.

With the initial NSF sort, we salvaged smaller samples of species that were well-represented in collections, and all individuals of species that were either of known scientific interest, rare in collections, or impossible to collect in large numbers The following specimens have been preserved from this endeavor:

Genus species	skins	skeletons	wings
Gavia pacifica	1	1	1
Gavia immer	9	24	17
Gavia adamsii		10	3
Podiceps auritus	8	24	22
Podiceps grisegena	20	18	24
Fulmarus glacialis	1	19	12
Pterodroma inexpectata		1	1
Puffinus griseus		24	13
Puffinus tenuirostris	11	37	29
Phalacrocorax sp.		3	
Phalacrocorax auritus	3	4	4
Phalacrocorax pelagicus	126	182	153
Phalacrocorax urile	17	26	20
Branta bernicla		1	
Somateria spectabilis		1	1
Polysticta stelleri		1	
Histrionicus histrionicus	22	42	40
Clangula hyemalis	4	10	12
Melanitta nigra	12	8	20
Melanitta perspicillata	1	4	4
Melanitta fusca	11	7	14
Bucephala clangula	2	2	3
Bucephala islandica	11	14	13

Genus species	skins	skeletons	wings
Haliaeetus leucocephalus	7	69	60
Lagopus lagopus		1	
Haematopus bachmani		1	1
Stercorarius parasiticus		1	1
Larus canus		1	1
Larus glaucescens	1	6	4
Rissa tridactyla		58	37
Uria aalge	40	48	47
Uria lomvia	6	10	9
Cepphus columba	17	28	25
Brachyramphus marmoratus	14	64	28
Brachyramphus brevirostris	12	33	26
Synthliboramphus antiquus	17	30	25
Ptychoramphus aleuticus	3	40	8
Cyclorrhynchus psittacula	4	8	6
Aethia cristatella		1	
Cerorhinca monocerata	3	10	4
Fratercula cirrhata	18	23	64
Fratercula corniculata	6	16	13
Asio flammeus		1	
Corvus caurinus		14	5
Corvus corax		3	
totals	**407**	**929**	**770**

These specimens are available for scientific study at the Burke Museum. Inquiries about using them should be addressed to Chris Wood, Ornithology Collections Manager, Burke Museum, Box 353010, Universtiy of Washington, Seattle, WA 98195.

Project Number and Title: 97169 - A Genetic Study to Aid in Restoration of Murres, Guillemots and Murrelets to the Gulf of Alaska

Principal Investigators: Vicki Friesen, Department of Biology, Queen's University, Kingston, Ontario K7L 3N6, Canada. (613) 545-6156, friesenv@biology.queensu.ca.

John F. Piatt, Alaska Biological Science Center, Biological Resources Division, USGS, 1011 East Tudor Road, Anchorage, AK 99503. (907) 786-3549, john_piatt@usgs.gov

Abstract: Populations of common murres (*Uria aalge*), pigeon guillemots (*Cepphus grylle*), marbled murrelets (*Brachyramphus marmoratus*) and Kittlitz's (*B brevirostris*) murrelets from the Gulf of Alaska are failing to recover from the *Exxon Valdez* Oil Spill. We are conducting genetic analyses to aid in their restoration by: 1) measuring gene flow among colonies, 2) identifying appropriate reference or 'control' sites for monitoring, and 3) identifying the populations affected by the spill. DNA samples have been obtained from 330 common murres, 90 guillemots, 225 marbled murrelets and 25 Kittlitz's murrelets from across the North Pacific.

Because most colonies in this area were probably founded recently (since recession of the Wisconsin glaciers), we are surveying variation in genes with high mutation rates: cytochrome b and the control region for mitochondrial DNA, and microsatellites and introns for nuclear DNA. To date, we have refined protocols for screening variation in cytochrome b and the control region in murres and guillemots, ten introns in all species, and at least six microsatellites in each species. All available samples from marbled murrelets have been screened for variation in ten introns and three microsatellites. Analyses suggest that murrelets from different sampling regions are genetically differentiated, and that allele frequencies at several loci change in the spill area. Approximately 72 murres and 90 guillemots have been screened for variation in the mitochondrial control region. Results indicate that genotype frequencies vary regionally. These preliminary analyses suggest that murres and murrelets from the spill area may be part of a larger, regional population within which limited gene flow occurs. Gene flow in guillemots may be more restricted. If these findings are upheld following analysis of more loci and more samples, natural dispersal may be assumed to play a limited role in recovery of murres and murrelets from the Spill, but to have little potential in aiding the recovery of guillemot populations.

Project Number and Title: 97170 - Isotope Ratio Studies of Marine Mammals in Prince William Sound

Principal Investigator: Donald M. Schell, Inst. of Marine Science /Water and Environmental Research Center, Univ. of Alaska Fairbanks, Fairbanks AK 99775

ABSTRACT: This study consists of two major tasks -- (I) investigation of reasons for the major declines of harbor seal populations in the western Gulf of Alaska including Prince William Sound, and (II) provision of analytical support in the form of stable isotope ratio analysis for EVOS investigators.

Ia. Validation studies on captive harbor seals and sea lions are continuing at the Mystic Marinelife Aquarium on two harbor seals and two adult female sea lions. The animals have been infused at several month intervals with C-13 and N-15 labeled glycine which is then incorporated into the whiskers as a marker. The results from these experiments are still in need of further corroboration and the two seals are being moved to Seward SeaLife Center to continue the study. The data to date reveal that the growth characteristics are very different for sea lion versus harbor seal vibrissae with the former growing continuously and the latter growing in late winter-spring and ceasing about June. The results also show rapid turnover of the amino acid carbon in the animal but significant retention of the amino nitrogen through transamination.

IIb. A retrospective study of carbon and nitrogen isotope ratios in archived marine mammal tissues was conducted as a means of assessing changes in the carrying capacity of the marine ecosystem and as a means of identifying any potential changes in trophic structure and food webs of the region. Isotope ratios of carbon and nitrogen offer an alternate means of assessing relative rates of primary productivity since they are determined primarily by the growth rates of the algal cells. In high latitude ecosystems algal growth rates determine the seasonal production and total energy supply to the system. By using baleen plates from 30 bowhead whales archived at the Los Angeles County Museum and recently taken by native hunters, we have assembled a year by year record of average carbon and nitrogen isotope ratios back to 1947. From this record we infer that primary productivity in the Bering Sea (and presumably the Gulf of Alaska) was at a higher rate over the period 1947 - 1965 and has then declined until 1995, the last sampling date. The carbon isotope ratios for 1994 and 1995 are the lowest observed since 1947. Nitrogen isotope ratios also declined for over thirty years and show oscillations on a two - four year periodicity that may be in response to changes in trophic structure in the zooplankton community. The indicated decline in productivity in the North Pacific and Bering Sea may be a contributive factor to the observed declines in the populations of some marine mammals and sea birds in the region. Archived and recent marine mammal samples also show the decline in isotope ratios over the past two decades. Zooplankton biomass estimates by Japanese investigators correlate well with the isotopically indicated changes in primary production supporting the inferences derived from the isotope ratios. See also the poster by A. Hirons and D. Schell

II. The analytical work has been successfully provided and several thousand samples from investigators have been run to help provide information for both trophic transfers and transport of offshore production into the Prince William Sound area. At this date most samples from marine mammals, sea and river otters, potential prey species and zooplankton have been analyzed or are in the process of completion. A new mass spectrometer, installed in July 1997, is now providing additional capacity and back-up for instrument services.

Project Number and Title: 97170A - Isotope Ratio Studies of Marine Mammals in Prince William Sound

Investigators: Amy C. Hirons and Donald M. Schell, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, AK 99775

ABSTRACT: The number of harbor seals (*Phoca vitulina*) in Prince William Sound (PWS) has declined to approximately one-fourth of the 1975 population and food web dynamics are being investigated as a possible cause. Stable carbon and nitrogen isotope ratios ($\delta^{13}C$ and $\delta^{15}N$) are established in the primary producers of the food chain and provide information of prey consumed at different locations and trophic levels within PWS and the adjacent Gulf of Alaska (GOA). Offshore prey have more depleted values than those of the same species within PWS. In the sound prey from pelagic and benthic environments have similar $\delta^{15}N$ values but the benthos is more enriched in ^{13}C than pelagic species. Satellite tracking data of harbor seals tagged by Alaska Department of Fish and Game personnel (ADFG) reveal some seals leave PWS to feed in the Gulf of Alaska for extended periods of time. Foraging on inshore, enriched organisms is evident in the enriched isotope ratios observed in the seal vibrissae. The nutritional values of these prey, if benthic, relative to pelagic prey, such as herring and capelin, are likely lower. Stable isotope values from archived and modern harbor seal tissues from 1949-1997 showed that no significant difference in the $\delta^{15}N$ values occurred during the past forty-nine years and this indicates no trophic shift occurred during that time. However, during the years since the early 1970s, a decrease in the $\delta^{13}C$ became evident in the bone collagen of three species of phocids, including harbor seals, and otariids in the southern Bering Sea and throughout the Gulf of Alaska. This decline tends to follow the trend in declining zooplankton biomass estimates and primary productivity rates as exhibited by the stable isotope records in bowhead whale baleen (see poster by D. Schell and A. Hirons). All these data in combination may be an indicator that the carrying capacity of the northeastern Pacific Ocean and Bering Sea has declined since the 1970s and implies serious consequences for top trophic level organisms which require high primary productivity to support the minimum prey density necessary for successful recruitment.

Project Number and Title: 97180 - Kenai River Habitat Restoration & Recreation Enhancement Project

Principal Investigators: Mark Kuwada, Division of Habitat and Restoration Alaska Department of Fish & Game, 333 Raspberry Road, Anchorage, Alaska 99518, (907) 267-2277

Art Weiner, Ph.D., Natural Resources Manager II, Alaska Department of Natural Resources, 3601 C Street, Suite 980, Anchorage, Alaska 99503 (907)-269-8424

Abstract: Adverse impacts to the banks of the Kenai River total approximately 19 miles of the river's 166 mile shoreline. Included in this total are 5.4 river miles of degraded shoreline on public land. Riparian habitats have been impacted by trampling, vegetation loss and structural development. This riparian zone provides important habitat for pink salmon, sockeye salmon and Dolly Varden, species injured by the *Exxon Valdez* oil spill. The project's objectives are to restore injured fish habitat, protect fish and wildlife habitat, enhance and direct recreation and preserve the values and biophysical functions that the riparian habitat contributes to the watershed. Restoration/enhancement techniques include revegetation, streambank restoration, elevated boardwalks, floating docks, access stairs, fencing, signs, and educational interpretive displays.

Every major public landowner along the Kenai River was involved in this project through participation on an Interdisciplinary Team (IDT) that established qualifying criteria and a priority ranking system for funding. The IDT reviewed and ranked project designs. Seven projects were funded in 1996 and completed in 1997. Seven projects were nominated by public land managers for 1997-98 funding; six were funded and will be completed during the spring/summer of 1998.

Projects completed during the 1997 field season include 1) barrier, stairway and walkway installations at the Kenai Beach Dunes dipnetting area near the mouth of the Kenai River; 2) walkway, fishing platform, and streambank bioengineering installations at Rotary Park near the Soldotna airport; 3) walkway, access ramp, floating dock, and streambank bioengineering installations at Ciechanski State Recreation Site and Big Eddy State Recreation Site; 4) walkway and fishing platform installations at Funny River State Recreation Site; 5) walkway, exclusion fencing, and fishing platform installations at the Russian River; and 6) walkway installations at the ADF&G sonar site off of Endicott Drive at River Mile 19.

Projects planned for 1998 include restoration of heavily damaged sites at the Slikok Creek State Recreation Site, Bing's Landing State Recreation Site, and Russian River Angler Trail. In addition, two properties acquired in the EVOS Small Parcel program will be rehabilitated: the Kobylarz and Cone properties.

Project Number and Title: 97186 & 97188 - Coded Wire Tagging and Otolith Thermal Marking as Tools for Fisheries Management

Principal Investigator: Timothy Joyce, Alaska Department of Fish and Game, Commercial Fisheries and Management and Development Division, Cordova, AK 99574, (907)424-3214

Abstract: Five salmon hatcheries in Prince William Sound used coded wire tags as a stock identification tool from 1987 through 1997. Initially, coded wire tagging was the tool of choice to provide fisheries managers with a reliable means of assessing the magnitude of wild and hatchery stocks present during a fishery opening. Stock composition information was then used to adjust the area and time allowed to fishermen for future fishery openings. Several problems with coded wire tagging led to the development and evaluation of otolith thermal marking for pink salmon. Both stock identification tools have provided important information used to manage commercial harvests. Coded wire tag recoveries provided new run-entry information for Eshamy sockeye salmon, which was used to justify a time and area closure to protect the wild Eshamy stock. Coded wire tags and otolith thermal marks have been used to generate estimates of hatchery contribution to the pink salmon fishery, which were used by fishery managers to regulate commercial openings targeting hatchery stocks while protecting wild stocks.

The magnitude of the Prince William Sound hatchery pink salmon release each year makes it makes it nearly impossible to obtain a mark-to-unmarked ratio of less than 1 in 600 for coded wire tags. Because of this low marked to unmarked ratio, a large recovery effort was required and there remained a great deal of uncertainty about our estimates of hatchery and wild fish to the fishery openings. Several assumptions regarding tag loss and differential mortality of tagged fish also created skepticism regarding the estimated hatchery contribution number. Although 1997 was the first year in which otolith thermal marks were available as a management tool, it quickly became apparent that otolith thermal mark stock composition data could be generated faster, and ,because all hatchery fish were marked, we obtained more precise estimates than would have been possible from coded wire tags. Information obtained from otolith recoveries in 1997 was used to justify harvesting pink salmon adults that were concentrated in Hidden Bay, an area previously not fished because of the unknown stock composition. Otolith thermal marks also provided information on the amount of coded wire tag loss that occurred after pink salmon fry were released and to examine the purity of hatchery brood stocks. In one year of use, otolith thermal marking has become the tool of choice for managing the Prince William Sound pink salmon fishery.

Project Number and Title: 97190 - Construction of a Linkage Map for the Pink Salmon Genome

Principal Investigator: Fred W. Allendorf, Division of Biological Sciences, University of Montana, Missoula, MT 59812, (406) 243-5503

Abstract: The initial objective of this research is to construct a linkage map for pink salmon (*Oncorhynchus gorbuscha*) Such maps provide the necessary information for understanding genetic variation in species A genetic map plays a similar role for a geneticist that a geographical map plays for the explorer of new territories. For many years, genetic maps could only be constructed in a few model species that were suitable for extensive genetic manipulation (e.g., fruitflies and mice) Recent advances in molecular genetics now make it possible to construct a detailed genetic linkage map in almost any species. The human genome map has received much recent attention.

We have completed a detailed map of over 500 genes in pink salmon from the Armin F. Koernig hatchery of the Prince William Sound Aquaculture Corporation. Several different types of polymerase chain reaction (PCR) based molecular markers are being used· random amplified polymorphic DNA's (RAPDs; 35 markers), microsatellites (uSats; 12 markers), amplified fragment length polymorphisms (AFLPs; 379 markers), and paired interspersed nuclear elements (PINEs, 131 markers). We are currently using centromere-linkage analysis of half-tetrads to consolidate the map into 26 linkage groups corresponding to the 26 pairs of chromosomes in pink salmon. We have analyzed 71 gynogenetic diploid progeny for 90 total markers. The AFLP markers tend to map closer to their centromeres than either the uSat or PINE markers ($P<0.05$).

The completion of a genome map for pink salmon will allow us to address important genetic issues related to the restoration of pink salmon. In addition, we will use pink salmon as a model species for understanding the genetic basis of variation in other salmon species (e.g., sockeye (*O. nerka*), chum (*O. keta*) and chinook (*O. tshawytscha*) salmon). We will test for genetic effects on traits of special importance and for the effects of natural selection by comparing the genetic characteristics of young fish released into the marine environment with the sexually mature fish that return two years later. This will allow us to test for genes having a major effect on marine survival and other traits of interest (for example, size and time-of-return). This aspect of the research will be performed at the Alaska SeaLife Center.

The linkage map will allow us to use an extremely powerful experimental design to measure a multitude of genetic characteristics for the first time in any salmonid fish The most powerful aspect of this experiment will be the capability of measuring fitness in wild fish for loci spread throughout the genome. In the case of males, fitness will be estimated by survival from egg to sexual maturity In the case of females, we will use both survival and the number of eggs produced so that we can take into account both survival and fertility.

Project Number and Title: 97191A - Injury to Salmon Embryos and Preemergent Fry in Prince William Sound

Principal Investigators: T. Mark Willette[1], Andrew K. Craig[1], and Brian G. Bue[2],
[1]Alaska Department of Fish and Game, 401 Railroad Avenue, P.O. 669, Cordova, AK 99574 (907) 424-3212
[2]Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518-1599

Abstract: We examined pink salmon embryo mortality in intertidal and upstream areas of oil-contaminated and reference streams in Prince William Sound. Embryo mortality was elevated in oil-affected streams during the falls of 1989, 1990, 1991, 1992 and 1993 ($P<0.023$ for all years). However; no statistical difference was observed in the falls of 1994, 1995 and 1996 ($P>0.473$). In 1997 we again saw elevated mortalities in oil-affected streams ($P=0.033$). We are currently investigating possible causes for this result.

We also tested the hypothesis that the differences in embryo mortality observed in the field were due to naturally occurring environmental variables that differed systematically between the oil-contaminated and reference streams. Gametes were collected from adults in spawning condition from eight oil-contaminated and eight reference streams, and matings were conducted at a hatchery. The resulting embryos were incubated in controlled environmental conditions. Embryos originating from oil-contaminated streams showed elevated mortalities when compared to the embryos from reference streams in 1993 ($P=0.012$), but not in 1994 ($P=0.543$). Results from the controlled incubation study support the results in the field study.

Project Number and Title: 97194 - Pink salmon spawning habitat recovery.

Principal Investigators: Michael L. Murphy and Stanley D. Rice, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Hwy, Juneau, AK 99801 (Phone 907/789-6036), mike.murphy@noaa.gov, jeep.rice@noaa.gov.

Abstract: The objective of this study is to examine the level of oil contamination at pink salmon streams in Prince William Sound to document initial levels of oil exposure and subsequent habitat recovery after the *Exxon Valdez* oil spill. Results of this study are meant to complement and help interpret other Trustee studies of oil-related embryo mortality in pink salmon.

We analyzed over 300 sediment samples from 172 stream deltas that were collected by ADF&G in 1989-91, and we collected and analyzed an additional 71 samples from 12 stream deltas (11 oiled, 1 non-oiled) in 1995 to determine habitat recovery. Most samples were taken from stream banks immediately adjacent to pink salmon spawning areas. Samples were fast-screened by ultraviolet fluorescence to measure total concentration of petroleum hydrocarbons (TPHC), and samples with detected oil were analyzed by gas chromatography/mass spectroscopy to determine concentrations of polynuclear aromatic hydrocarbons (PAHs).

In 1989, TPHC was bimodally distributed: 65 streams (38%) were "heavily oiled" (mean TPHC >1,000 μg/g) 22 streams (17%) were moderate to lightly oiled and 85 streams were "non-oiled" (TPHC below method detection limit of 2 μg/g). Oiling depended on exposure to ocean currents in the oil trajectory. In 1995, petroleum hydrocarbons were still detected in sediment at 8 of 11 oiled streams: mean TPHC ranged up to 240 μg/g, and total PAH concentration in individual samples ranged up to 2,800 ng/g. The residual PAHs had high molecular weight, and relative abundance was consistent with weathered *Exxon Valdez* oil. Using a negative exponential model to interpolate between mean concentrations in 1989 and 1995 indicated that many oiled stream deltas still had a total PAH concentration higher than 3,800 ng/g through the 1992-1993 salmon incubation period. This concentration is the lowest sediment concentration that has been associated in the laboratory with impaired survival of pink salmon embryos (Trustee Study 95191b). These results indicate that leaching of residual weathered oil into incubation substrate could explain persistent elevated embryo mortality in pink salmon from oiled streams through 1993.

Project Number and Title: 97195 - Pristane Monitoring in Mussels and Predators of Juvenile Pink Salmon & Herring

Principal Investigator: Jeffrey W. Short, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, Alaska 99801-8626, (907) 789-6065, jeff.short@noaa.gov.

Abstract: Pristane is an alkane hydrocarbon produced by *Neocalanus* copepods, which are the largest natural source of pristane in Prince William Sound (PWS). Ecologically, these copepods are an important link from phytoplankton to production of higher-order consumers such as juvenile herring and pink salmon in PWS during Spring. Lipophilic pristane acts as a natural tracer molecule for lipid produced by these copepods. When consumers ingest these copepods, most of the lipid (& pristane) is absorbed across the intestine, but some is excreted as feces. These pristane-labeled feces may disperse in the water column and then be accumulated by suspension-feeders such as mussels. Thus, monitoring pristane concentrations in mussels in PWS may provide a semi-quantitative indication of juvenile fish production in the sound during Spring.

We established 30 monitoring stations in PWS in 1994 where we collected repeated samples of intertidal mussels during Spring. We sampled many of these stations monthly in 1994 beginning the end of April thru the end of July, and we sampled most stations biweekly in 1995, 1996, and 1997 beginning late-March thru the end of July. Additional samples were collected from 22 stations in early February of 1997 to verify the absence of pristane in mussels during winter.

The 1997 pristane-production index, an integrated measure of pristane in mussels at all stations during the March through July portion of the sampling season, was higher than in 1996 but lower than in 1995. This indicates the abundant *Neocalanus* forage base characteristic of PWS in recent years persisted through 1997. However, pristane concentrations generally increased as a single pulse during early May 1997, in contrast with the 2 successive pulses (one during early April followed by another during early May) in 1995 and 1996. Also, a smaller secondary increase of pristane concentrations in mussels was evident at many stations in August in 1997, but not in prior years. The causes of these timing differences among years is not clear.

More surprising were the high pristane concentrations observed in mussels collected in early February. Concentrations ranged to nearly 20 times values present by mid-March, and the median changed by a factor of 4.5. The synchrony of the decline at most of the stations sampled in February indicates a wide distribution of the winter pristane source within PWS. Whether this winter source is fecal material somehow produced as a result of predation on *Neocalanus* eggs or adults in PWS, or some other undiscovered source or incorporation mechanism remains to be established.

Project Number and Title: 97196 - Genetics of Populations of Pink Salmon Inhabiting Prince William Sound

Principal Investigators: Christopher Habicht, William B. Templin, Lisa W. Seeb and James E. Seeb, Alaska Department of Fish and Game Genetics Program, 333 Raspberry Road, Anchorage, Alaska 99518. (907) 267-2169

Abstract: An array of conservation and restoration alternatives has been proposed for "species" impacted by the *Exxon Valdez* oil spill. But, species-based proposals often do not provide the resolution needed to conserve the genetic diversity present within the populations that make up the species. This is especially true for injured pink salmon *Oncorhynchus gorbuscha* in ecologically diverse Prince William Sound (PWS) where between-population diversity provides optimal production and a biological buffer to environmental change. Our goal was to examine naturally occurring genetic markers to delineate the population structure of PWS pink salmon to provide a genetic basis for fish management by identifying restrictions to gene flow.

We are testing for restrictions in gene flow among the five management regions and two hatcheries within PWS, among streams within these regions, and between upstream- and tidal-spawners and early- and late-spawners within streams using allozyme and mtDNA markers. The even and odd year-classes are genetically distinct because pink salmon have a two-year life cycle and earlier studies demonstrated no gene flow between year classes. Therefore, we collected data from two years from each year-class. We made 27 collections in 1994, 16 in 1995, 25 in 1996, and 24 in 1997. Each collection consisted of 100 pink salmon collected on spawning areas.

Over the past year, we statistically analyzed the 1995 collections and finished laboratory analysis of the 1996 collections. In the odd-year class, we found significant differences among streams (allozymes and mtDNA). Significant differences between early and late collections were observed using allozymes in two of the three streams tested; however, mtDNA data did not detect such differences. No differences were detected between tidal and upstream collections in the four streams tested using either technique. These results contrast with the even-year class (1994) analysis where we found significant differences between upstream and tidal collections within two of the five creeks tested.

These results support managing wild populations of odd-year pink salmon in PWS at least on a temporal level, considering local subpopulation structure, rather than as a single interbreeding population, within year-classes. Our 1997 collections in combination with the 1995 collections will allow us to examine regional barriers to gene flow as were found in the even-year collections. The 1997 collections will also provide another opportunity to investigate upstream-tidal differences on collections where "upstream" sites were further separated from tidal than they were in the 1995.

Project Number and Title: 97210 - Prince William Sound Youth Area Watch

Principal Investigators (Project Coordinators): Roger Sampson, Joshua Hall and Jennifer Childress, Chugach School District, 9312 Vanguard Drive Suite 100, Anchorage, AK 99507 (Phone: 907-522-7400)

Abstract: The project involves students from the Chugach School District as well as all impacted communities around Prince William Sound in projects funded by the Trustee Council. Students were involved in four different projects during FY 97. Students also initiated local restoration projects in their own communities. These restoration projects, along with the experiences that students bring back to their schools, make Youth Area Watch a program that impacts a wide range of people and is well connected to rural Prince William Sound communities.

Students from Chenega Bay, Cordova, Hinchenbrook Island, Seward, Tatitlek, Valdez and Whittier were involved in research projects during FY 97. These projects include:

- blue mussel collection/pristane hydrocarbon analysis
- harbor seal biosampling
- juvenile herring AWL
- meteorologic/oceanographic data collection.

Mel Henning was the project coordinator for Youth Area Watch during FY 97. His responsibilities included: supervision of the students and coordinating the activities between the scientists and the students to bridge the gap between hard scientific research and meaningful application of project activities. Mel Henning's retirement at the end of FY 97 led to the hiring of Joshua Hall and Jennifer Childress who will be sharing the position of project coordinator in FY 98.

In FY 97, Youth Area Watch increased the awareness of youth regarding the effects of the oil spill and encouraged their involvement in research, restoration and management of subsistence resources. The youth in Prince William Sound were involved in research projects that may directly affect their communities in the future. They also initiated local restoration projects to improve their communities on a more short-term basis. The success of long-term restoration and management of subsistence resources is dependent on youth involvement, and therefore on having support from the students of Prince William Sound. The future responsibility of appropriate resource management and restoration will be carried on under their stewardship.

Project Number and Title: 97214 - Documentary on Subsistence harbor Seal Hunting.

Principal Investigators: Gary Kompkoff, Tatitlek Village Council, Tatitlek, Alaska and William E. Simeone, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska (907) 267-2309

Abstract: The video, *Alutiiq Pride: A Story of Subsistence*, was produced with funds from the Trustee Council. The film documents all facets of harbor seal hunting, including the ecological and biological knowledge hunters use to hunt seals. In FY 96, through a competitive process, Taylor productions of Anchorage, Alaska, was awarded the contract to produce the documentary. In March of 1996 the Taylor Productions film crew accompanied Tatitlek seal hunters on a ten-day hunt in Prince William Sound. In April the production crew, along with ADF&G staff members, spent a week in Tatitlek conducting and filming interviews with village elders and hunters about the importance of seal hunting for the community. The video has been publicly shown in Tatitlek, Cordova (at the Harbor Seal Commission meeting), Anchorage, and Seward (at the recent Trustee Council meeting). Copies of the video have been distributed to federal and state agencies, and various nongovernmental organizations. It is planned to show the film on the local PBS stations and ARCS. It has also been entered in several film competitions.

Project Number and Title: 97220 - Eastern Prince William Sound Wildstock Salmon Habitat Restoration

Principal Investigators: David Schmid, Ken Hodges, USDA Forest Service. P.O. Box 280, Cordova, AK 99574. (907) 424-7661

Abstract: Subsistence harvests of marine resources declined considerably following the *Exxon Valdez* oil spill. The Village of Eyak, working with the U.S. Forest Service, proposed a project to restore or enhance wildstock salmon habitat in Eastern Prince William Sound to create additional subsistence opportunities. Local youth would also have an opportunity to work on this project and learn about habitat management and enhancement techniques.

In 1996, basinwide habitat surveys were conducted on 10 streams in the Eastern Prince William Sound area near Cordova. The data were used in a habitat-based limiting factors analysis to determine what habitat factors might limit coho salmon *(Oncorhynchus kisutch)* production in these streams. We concluded that the scarcity of overwintering habitat was limiting production in most streams and that Plateau Creek in the Port Gravina area provided the best opportunity for habitat enhancement.

In 1997, 12 instream structures made of logs and boulders were built to create additional winter habitat. The structures were designed to provide quiet backwaters and cover areas where juvenile fish can minimize energy expenditure during the winter and escape high flows associated with snowmelt in the spring. During both years, local youth were hired to conduct the surveys and build the structures.

The structures created approximately 220 sq. meters of winter habitat. However, an inspection of the structures in late October showed that one structure had failed because of high flows, and some habitat was lost due to substrate deposition in the lower velocity areas. Juvenile coho salmon were observed at several structure sites.

In 1998, we plan to repair or replace any structures that have failed. We also plan to make population estimates at each site before smolt migration to determine the effectiveness of the structures. Originally we had planned to build 15-20 structures in 1997, but large numbers of pink salmon *(O. gorbuscha)* entered the system earlier than anticipated, and construction had to be stopped. Several additional structures may need to be built in 1998 to create sufficient winter habitat to significantly increase the number of returning adults.

Project Number and Title: 97225 - Port Graham Pink Salmon Subsistence

Principal Investigators: Ephim Anahonak, Port Graham Salmon Hatchery, Box 5543, Port Graham, AK 99603, (907) 284-2233; Paul McCollum and David Daisy, Chugach Regional Resources Commission, 4201 Tudor Centre Drive, Suite 300, Anchorage, AK 99508, (907) 562-6647

Abstract: The goal of this project is to increase subsistence gathering opportunities for the Port Graham and Nanwalek villages by increasing the fry to adult survival of Port Graham hatchery pink salmon during the hatchery's broodstock development phase. Local runs of coho and sockeye salmon, the more traditional subsistence salmon species, are at low levels. This is putting more subsistence pressure on pink salmon at a time when the hatchery is building broodstock and needs to utilize as many of the returning adults as possible for hatchery spawning. A way to help mitigate this problem is to apply strategies that will increase marine survival (the number of hatchery released fry that return as adults).

The principal strategy being applied to increase marine survival is to increase the size of the fry prior to release into the wild. Pink salmon fry emerge from the incubators weighing 0.24 grams on average. Experiments on pink salmon fry around the state have shown that rearing the fry to at least double their emergent weight before releasing them can significantly enhance marine survival. The project objective in 1997, the second year of the project, was to release two marked lots of pink salmon fry of about the same weight but with different release dates.

Except for a small lot of 25,000 eggs, all pink salmon eggs (1.9 million) were incubated in ambient temperature water. The resultant 1.8 million fry emerged from the incubators the end of April. These were split into two equal lots. The first lot was reared in saltwater pens and released at the height of the first mature zooplankton bloom at the end of May. Average weight was about 0.6 grams. The second lot was held until it June 9 when it had achieved an average weight of 1 gram. Around 20,000 of these fish were marked with a coded wire tag (cwt).

The 25,000-egg lot was incubated on heated water. The 20,000 resultant fry were placed in a raceway containing 5.5° C saltwater and reared there until the water temperature of Port Graham bay reached 5.5° C at which time they were transferred to a pen in Port Graham bay. The intent was reared this lot to an average weight of 1 gram for release into the first mature zooplankton bloom at the end of May. However, while in the raceway these fish developed a bacterial infection (*Pseudomonas*). The fish couldn't be marked until the infection was cleaned up. This postponed the release until June 6. All fish in this lot were cwt marked (around 18,000). The average weight was 1.4 grams.

Marine survival from the 1996 release was over 4%. No analysis of the return was conducted because none of the 1996 released fish were marked due to equipment problems. The hatchery took about 12 million eggs

Project plans for 1998 call for holding about 4 million fry until they achieve an average weight of 1 gram. A lot of about 200,000 fry will be incubated and reared in heated water to achieve an average weight of between 1 and 1.5 grams in time for release during the mature zooplankton bloom. All released fish will have otolith marks achieved by manipulating the incubartion water temperature during egg development.

Project Number and Title: 97230 - Valdez Duck Flats Restoration Project

Principal Investigator: Executive Director, Prince William Sound Economic Development Council, P.O. Box 2353, Valdez, Alaska 99686, (907) 835-3775

Abstract: The purpose of this project is to develop a conceptual plan to aid in the recovery of spill-affected resources that rely on the Valdez Duck Flats for habitat. The Valdez Duck Flats provide habitat for marbled murrelets, bald eagles, common loons, common murres, harlequin ducks, pink salmon, sockeye salmon, sea otter, harbor seals and various intertidal and subtidal organisms. Because of their proximity to the city center of Valdez and the Richardson Highway, the flats are at risk of habitat degradation from commercial development and visitor overuse. In addition, this site presents a unique public educational opportunity as a spill restoration site on the south central Alaska road system. The Valdez Duck Flats could be used to educate the public on the effects of the oil spill, resources that were impacted, their value to the public and their continued sensitivity to disturbance. There are opportunities for joint facilities between state, city and federal governments, and educational opportunities for the local school district and community college.

The project focuses on the western half of the Valdez Duck Flats. The study area extends westward from the western edge of the old townsite to the Richardson Highway and the present city center of Valdez. This is the area where improving and controlling public access is most feasible and also where potential commercial development could occur.

Existing and potential land use issues affecting the Valdez Duck Flats were identified through interviews with key stakeholders in a focus group format and through use of a survey of local residents and businesses. Approximately 2,400 community surveys were distributed and 155 completed surveys were returned. A biological assessment of the Valdez Duck Flats was prepared using information from one site-reconnaissance visit and published and unpublished sources. Drawing from community meetings, agency contacts and a user survey, the contractor prepared a community needs assessment that describes existing and potential human uses and valuable characteristics of the flats. Program facility options were identified and will form the basis of a conceptual plan after extensive public review. Options include construction of viewing platforms, a visitor center northwest of the Richardson Highway, a pile-supported boardwalk across from the visitor center and a trail connecting the boardwalk to the Dock Point Trail.

The contractor, Dames & Moore, submitted a *Draft Conceptual Plan* in September 1997. A *Final Conceptual Plan* is due April 15, 1998.

Project Number and Title: 97231 - Marbled Murrelet Productivity Relative to Diet and Fish Abundance

Principal Investigator: Kathy Kuletz, U.S. Fish and Wildlife Service, 1011 E. Tudor Rd., Anchorage, Alaska 99503. (907)-786-3453. kathy_kuletz@mail.fws.gov.

Abstract: The marbled murrelet (*Brachyramphus marmoratus*), a small diving seabird, was injured in the 1989 *Exxon Valdez* oil spill. Recovery may be inhibited by an apparent shift in the marine ecosystem of southcentral Alaska that began in the late 1970s. The marbled murrelet restoration project joined with APEX (Project 97163; Alaska Predator Ecosystem Experiment), to study the processes controlling the abundance of apex predators. Our goal was to examine the relation between marbled murrelet productivity, diet, and forage fish abundance in Prince William Sound (PWS), Alaska. The murrelet project will eventually model terrestrial & marine features that determine marbled murrelet abundance and distribution in southcentral Alaska.

Because marbled murrelets do not nest in colonies and their nests are hard to find, we developed an index of productivity based on at-sea surveys, to obtain juvenile densities and the ratio of juveniles-to-adults. We counted adult murrelets at sea in early June (incubation) and adult and juvenile murrelets in July-August (fledging period) using 25 ft. boats. Each study site in PWS had ~50 km of shoreline (n = 4 sites in 1995, 1 in 1996, 3 in 1997), and was surveyed 3-4 times in June and 7-10 times in July-August. In 1997, we monitored murrelet diet by observing adult murrelets on the water, holding fish prior to delivery to their chicks (n = 60 surveys, 164 identified prey). We obtained fish biomass for transects within murrelet study sites from APEX hydroacoustic surveys (total areas covered by APEX surveys were larger).

In both 1995 and 1997, nearshore fish biomass was positively correlated with juvenile murrelet density at sites (In 1995, $r^2 = 0.64$, $P = 0.2$; in 1997, $r^2 = 0.99$, $P = 0.003$), and Naked Island had the highest productivity. At Naked (the site with 1996 data), lower juvenile murrelet density in 1996 paralleled lower fish biomass that year. In 1997, chick diet was Pacific herring (49%) and Pacific sand lance (43%), plus some gadids, sandfish, and smelts. However, spatial differences in diet were apparent. The percentage of sand lance:herring was 94:0 at Naked, 45:55 at Galena and 8:80 at Jackpot. Fish held for chicks were usually larger than what adult murrelets ate. Juvenile density and murrelet chronology varied among sites. At Naked, we found 1.5 juveniles/km^2, and at Galena and Jackpot, 0.7 juveniles/km^2. Juveniles appeared earlier and peaked in numbers earlier at Naked than at other sites. As in 1995, the June number of adults correlated with the number of juveniles at sites, and thus, the ratio of June adults:juveniles may estimate productivity more reliably than July-August ratios of adults:juveniles.

Our results supported the hypothesis that seabird productivity reflects forage fish abundance and suggested that spatial differences occur within PWS. We propose that low fish abundance, and possibly, late arrival of juvenile herring at Jackpot resulted in lower murrelet productivity compared to Naked Island, where sand lance appeared to be available all summer. The 1997 results suggest that diet may also influence murrelet chronology and fledging success. Because the use of different prey species varied both spatially and temporally, we will need additional years of diet information to determine if differences in prey quality affect murrelet productivity.

Project Number and Title: 97244 - Community-based Harbor Seal Management and Biological Sampling

Principal investigators: Monica Riedel, Alaska Native Harbor Seal Commission, Box 2229, Cordova, AK 99574; 907-424-5882 and James A Fall, Subsistence Division, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518; 907-267-2359.

Abstract: Harbor seals (*Phoca vitulina*) are among the injured biological resources of Prince William Sound that have not recovered following the *Exxon Valdez* Oil Spill The continued decline in seal numbers throughout Alaska is of particular concern to Alaska Natives for whom seals are of traditional, subsistence, and cultural importance. The premise of this project is that restoration of harbor seal populations will be facilitated by involving subsistence users in research and management activities and through facilitating the involvement of traditional knowledge in scientific studies Objectives are to:

- Train local technicians and hunters in biological sample collection procedures
- Maximize sampling efficiency and coordination with other harbor seal projects
- Evaluate the program's effectiveness and develop a long-term funding plan
- Collect life history and harvest information about the harbor seals harvested in each village

In FY97, the Alaska Native Harbor Seal Commission convened a workshop in Cordova to encourage communication among the state's seal hunters/users and with agencies involved in seal research and management An important outcome of this workshop was the strong support voiced by subsistence hunters and scientists for the biosampling program carried out by this project. Attendees were also informed on the latest research on harbor seal populations in the spill area.

The biosampling training program begun under Project 96244 was continued and expanded in FY 97 to include Kodiak Island communities. Additional training sessions occurred. Training sessions included participants in the Youth Area Watch Project (#97210). To date, over 21 hunters and 20 youth have been trained in the scientific techniques of biosampling. Additionally, training sessions have focused on traditional knowledge and values regarding the respectful harvest and use of harbor seals. As a result, there is a growing group of adults and youth with training in both western scientific methods and their own indigenous value system. This is the formula for true stewardship and the model to follow for long-term monitoring

To date, project participants have collected a full set of samples from 69 harbor seals harvested for subsistence purposes in Prince William Sound, Cook Inlet, and Kodiak Island, plus additional head and stomach samples Samples collected in the program have been archived at the University of Alaska Museum or dispersed to a variety of researchers for current or future analysis of the diet, genetics, reproductive status, health, and contaminant loads of the state and region's harbor seals

This program continues to support and promote communication and cooperation among those concerned for the health and sustainability of Alaska's harbor seal population. Workshops have brought together concerned users, managers, and researchers to discuss issues and share information on an ongoing basis Biological sampling of subsistence-harvested seals has provided researchers with tissue samples they need to study and better understand the seals' continued decline in the oil-impacted region. It has also provided a means by which to involve concerned hunters and youth in the statewide, on-going research of a vital subsistence resource.

Project Number and Title: 97247 Kametolook River Coho Salmon Restoration Project

Principal Investigators: Lisa Scarbrough and James McCullough; Scarbrough, Alaska Department of Fish and Game, Subsistence Division, 333 Raspberry Road, Anchorage, Alaska, 99518 (907) 267-2396, LisaS@fishgame.state.ak.us; McCullough, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 211 Mission Road, Kodiak, Alaska, 99615, (907) 486-1813, JimMc@fishgame.state.ak.us.

Abstract: Subsistence users from the remote South Alaska Peninsula Native Village of Perryville noted declines in the coho salmon (*Oncorhynchus kisutch*) run in the nearby Kametolook River since the *Exxon Valdez* oil spill (EVOS). The Trustee Council began funding this project in Federal Fiscal Year 1997 with the intent of restoring the coho salmon run to historic levels. This project is a continuation of an evaluative phase of the project funded through the EVOS criminal settlement (Grant Agreement Number 2168588). Although limnological, juvenile and adult fisheries data were not available or severely limited before the salmon decline, it was determined through the evaluation phase that instream incubation boxes in conjunction with self imposed harvest limits by subsistence users were the preferred alternatives for restoration this salmon run. In 1997, the Alaska Department of Fish and Game, Habitat and Restoration Division, aided the project by providing an Environmental Assessment. In 1997, a Finding of No Significant Impact was signed for NEPA compliance.

Community involvement by the villagers of Perryville is an integral part of restoring the Kametolook River coho as a subsistence resource. As part of the community involvement portion of the project, an aquarium has been set up in the village school where students actively participate in incubating coho salmon from egg to fry stage and releasing the fry into the Kametolook River. In May 1997, about 125 fry from the school aquarium project were released and again in mid-December local project assistants plan to transport about 300 eyed eggs from an incubation box to the school aquarium. In addition, the Perryville Village Council has hired local assistants that received training to assist ADF&G with fieldwork including: genetic and pathological sampling, incubation box installation, egg takes and incubation techniques, and year around monitoring of the boxes and environment.

In 1997, two production type instream incubation boxes were installed in the upper reach of the Kametolook River, these boxes replaced and were in addition to a small test incubation box that has successfully incubated eggs. In 1997, the Kametolook River coho escapement was an estimated 724 salmon, nearly four times the estimated escapement during 1996. The increased escapement is attributed to the self imposed closure of the upper river by the villagers and a commercial fishing closure in marine waters during nearly the entire coho salmon run. To date (12-9-97), several attempts to capture ripe coho salmon have generally been unsuccessful, eggs from only seven females have been deployed in the incubation boxes. To increase the egg take, next years project should include the use of salmon holding pens to make the recovery of ripe salmon easier.

Project Number and Title: 97254 - Delight and Desire Lakes Sockeye Salmon Restoration

Principal Investigator: Jim A. Edmundson, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 34828 Kalifornsky Beach Road, Soldotna, Alaska 99615, (907) 260-2917, Jime@fishgame.state.ak.us.

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Abstract: Delight and Desire lakes are important producers of sockeye salmon *Oncorhynchus nerka* in East Nuka Bay, lower Cook Inlet. During 1975-1987, the total return (catch and escapement) for both systems combined averaged 54,000 sockeye salmon; however, since 1988 the run averaged 27,000. Between 1988 and 1997, the commercial catch of sockeye salmon in the East Nuka Bay subdistrict averaged only 7,600, but between 1975 and 1987 catches were much larger and averaged 31,400. In 1989, the *Exxon Valdez* oil spill (EVOS) fouled beaches and near shore waters of Nuka Bay, and light oiling was observed near the outlets of Delight and Desire lakes. Although Delight and Desire lakes historically produced higher sockeye returns, there is no direct evidence that oil contamination affected marine survival and exacerbated or caused the recent decease in sockeye production. However, reduced harvest and inadequate sockeye salmon escapement were identified as injured resources by the EVOS Trustee Council. In 1997 limnological and fishery investigations were conducted to assess the rearing capacity of Delight and Desire lakes and determine the feasibility of using nutrient enrichment to accelerate the recovery of these salmon stocks. Nutrient enrichment can increase the forage base (zooplankton biomass) for rearing sockeye juveniles resulting in more numerous or larger sized smolt and a corresponding increase in adult returns.

Project Number and Title: 97255 - Genetic Stock Identification Provides a Tool to Manage Kenai River Sockeye Salmon

Principal Investigators: L. W. Seeb, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Genetics Laboratory, 333 Raspberry Rd., Anchorage, AK 99518; 907/267-2249; FAX 907/267-2442; lseeb@fishgame.state.ak.us

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Abstract: Genetic data from sockeye salmon (*Oncorhynchus nerka*) were collected from the Kenai River, a major sockeye salmon-producing system in Cook Inlet, Alaska, as well as all other significant spawning populations that contribute to mixed stock harvests in Cook Inlet. The products of 29 enzymes encoded by 67 protein loci were resolved from samples collected from 47 spawning locations in Upper Cook Inlet from 1992 to 1995. Allozyme data revealed a substantial amount of genetic diversity among populations. Mixed stock analyses using maximum likelihood methods with data from 27 loci were evaluated to estimate the proportion of Kenai River populations in Cook Inlet fisheries. Simulations indicate that Kenai River populations can be identified in mixtures at a level of precision and accuracy useful for fishery management. Samples from the commercial fisheries were analyzed both inseason (within 48 h) and postseason. The contribution of Kenai River populations to the Cook Inlet fisheries varied from 16.4% to 90.9%. Mitochondrial and nuclear DNA data were also analyzed for their usefulness for management of this fishery. Preliminary results demonstrated potential. Results from this study are currently being used in the management of Kenai River sockeye salmon fisheries.

Project Number and Title: 97256B - Sockeye Salmon Stocking at Solf Lake.

Principal Investigators: Dan Gillikin, Chugach NF., P.O. Box 129, Girdwood, AK. 99587, (Phone) 783-3242, (FAX) 783-2094 and Patrick Shields, Limnology Laboratory (ADF&G), 3428 Kalifornsky Beach Rd. #8 Soldotna, AK 99669, (Phone) 262-9368, (Fax) 262-4709

Abstract : This project is designed to benefit subsistence users of Prince William Sound, specifically the residents of Chenega Bay. Solf Lake in Herring Bay on Night Island has been recognized for many years as an opportunity to establish a self-sustaining sockeye salmon run. Habitat improvements to the lakes outlets were made in 1978, 1980 and 1981 to provide access to the lake for anadromous fish. The lake was never stocked, investigations during the 1996 field season suggest that it is currently only utilized by resident Dolly Varden but has adequate zooplankton biomass to support a sockeye salmon population. There are two phases to this project: Phase 1 began in FY96 and has verified the ability of Solf Lake to support a sustainable population of sockeye salmon. Phase 2 plans to stock the lake with 100,000 sockeye salmon fry in 1998 and start construction to ensure access to Solf Lake for returning adult sockeye salmon.

Sampling for the years 1982-1984, 1986, and 1996 found the total macro zooplankton biomass averaged 500 mg m^2. Assuming this amount of forage is available each year to sockeye fry, the stocking level for the first three years in Solf Lake could be as high as 400,000 fry. Monitoring of the zooplankton once per month during June-October may determine that stocking level could be increased, provided the zooplankton community did not show a significant impact. Based on the available spawning area it is estimated that Solf Lake could sustain a run of approximately 10,000 sockeyes without supplementation. An escapement of approximately 4,500 fish would be required to fully seed the system and not deplete the zooplankton populations, leaving 5,500 harvestable sockeyes.

Stream survey results of the 2 outlets indicate that while smolt passage is possible, upstream migration by adults is questionable. It has been determined that the old structure which dams the impassable outlet requires extensive reconstruction, planned for in FY98 in order to provide adequate flow for fish passage at the lakes new outlet. An engineering survey of this site was completed in FY97 with the final design pending. The outlet that is planned to provide fish access to the lake required reconstruction of an irrigation type control dam, and was completed in FY97. Additional stream channel modifications to this outlet are planned for in FY99.

On April 7th of this year the Prince William Sound Copper River Regional Fisheries Planning Team (RPT.) and the Forest Service discussed a brood stock source, mixed stock issues and stocking levels. The RPT approved the project and recommended stocking 100,000 fry to achieve the goal of 10,000 adult fish returning to Solf Lake. The RPT also approved the use of the early run Eyak fish as a brood stock. The Prince William Sound Aquiculture Corporation (PWSAC) has prepared the Fish Transport Permit (FTP) and has included the Solf Lake Project in their Area Management Plan. Egg collection occurred in early July of this year and the fry are currently being reared at the Main Bay Hatchery facility in Prince William Sound.

Project Number and Title: 97258 - Sockeye Salmon Overescapement Investigations

Principle Investigators: Dana C. Schmidt, Ken Tarbox, and Stan Carlson. Alaska Department of Fish and Game, 34828 K Beach Road, Soldotna, Alaska 99669, Phone (907) 260-2909

Abstract: The objective of this study was to evaluate the effects of large escapements of sockeye salmon (*Oncorhynchus nerka*), following the EXXON Valdez oil spill (EVOS), on the subsequent productivity of major sockeye salmon systems in the Kenai River system. In Kenai and Skilak Lakes, these investigations have identified a zooplankton based production model that explains the in-lake recruitment of smolt.

The 1995 Kenai/Skilak Lake production model that predicted fall sockeye salmon abundance from the variables of mainstem spawners, spring Cyclops biomass, and summer Cyclops biomass, continues to describe most of the recruitment variation with the addition of the 1996 data. However, the 1996 fall sockeye salmon fry abundance in Skilak and Kenai Lakes was the lowest in the 11 y record. We speculate that an effect on emergent fry production followed the large 1995 fall flood (>1/100 y). Summer *Cyclops* biomass during the summer of 1996 was also the lowest in the 11y record.

The 1997 Kenai River sockeye salmon run forecast would be expected to be quite high if the dominant parent year fall fry, spring fry, and smolt relative abundance correctly predict adult returns. This year also aligns with the dominant cycle year observed in 1982, 1987, and 1992. However, the sibling component present in the 1996 Kenai run (age 4) was weak, suggesting either poor marine survival or a marine age shift strongly favoring 5 year old fish. The 1997 adult return indicated marine survival was lower than expected.

Because of the high predictability of the seasonal zooplankton model on Skilak/Kenai Lakes in determining fall fry recruitment, similar approaches are being applied to other glacial lakes.

This was the close out year for this project. A final report is in preparation.

Project Number and Title: 97259 - Coghill Lake Sockeye Salmon Restoration

Principal Investigator: Jim A. Edmundson, Stan Carlson, Gary Kyle, and Patrick Shields, Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 34828 Kalifornsky Beach Road, Soldotna, Alaska 99615, (907) 260-2917, Jime@fishgame.state.ak.us.

Abstract: Prior to the 1990-1994 run decline, Coghill Lake consistently produced the highest single-system sockeye salmon *Oncorhynchus nerka* catches in Prince William Sound. Although limnological and juvenile fisheries data are not available before the run decline, we hypothesized that sockeye salmon fry produced from consecutive years (1980-1982) of high escapements might have overgrazed the zooplankton forage base and reduced the lake's sockeye salmon rearing capacity. In 1993, the *Exxon Valdez* Oil Spill Trustee Council approved a nutrient enrichment stock restoration project for Coghill Lake to mitigate the oil damaged fishery resources. During 4 years of nutrient enrichment (1993-1996), the seasonal mean phosphorus concentration increased 22%, algal biomass (mainly edible genera for zooplankton consumption) increased 220%, and the standing stock (density) of the prevalent zooplankton (*Cyclops*) increased 117% compared to pre-enrichment years (1988-1992). The sockeye salmon smolt population abundance averaged 263,604 before enrichment compared to 940,411 during treatment. This increased smolt production is attributed to increases in primary and secondary production because the number of smolts produced per spawner also increased during enrichment. The trophic level responses to nutrient enrichment in meromictic, glacially influenced Coghill Lake were similar to those observed for other clearwater holomictic and meromictic lakes treated in Alaska.

Project Number and Title: 97263- Assessment, Protection and Enhancement of Wildstock Salmon Streams in the Lower Cook Inlet.

Principal Investigators: Walter Meganack, Jr. Port Graham Corporation, P.O. Box 5569 Port Graham Alaska 99603-5569 (907) 284-2212

Dr. Douglas J. Martin, Martin Environmental, 2103 N. 62nd St Seattle Washington.

John L. Hall and Arvid J. Hall, Taiga Resource Consultants, P.O. Box 750 Girdwood, Alaska 99587 (907) 783-2416

Abstract: This project was designed to replace lost subsistence services resulting from the *Exxon Valdez* oil spill. The first phase of this project was to conduct an inventory and assessment for enhancement projects on the four major salmon streams in the Lower Cook Inlet (LCI) oil spill area. During FY98 and FY99 restoration and enhancement projects will be implemented with instream fisheries habitat improvement techniques, primarily creation of spawning channels, removing natural barriers to spawning and constructing wall-based rearing structures. A literature and data survey search was conducted on the four streams. We then conducted fisheries habitat assessments with aerial photos to the USDA Forest Service Region 10 protocols. During the field season we surveyed the stream reaches to verify the Region 10 channel types and inventory stream reaches with no existing data. With this existing and the newly obtained data we have designed six enhancement projects on three streams in the survey area primarily for coho salmon *(Oncorhynchus kitusch)*.

Project Number and Title: 97272– Chenega Chinook Release

Principal Investigators: Jeff Milton, PWSAC, PO Box 1110, Cordova AK 99574, (907) 424-7511 ext. 111

Abstract: The key objective of this project is to provide a return of adult chinook salmon to subsistence users in and around Crab Bay. During the spring of 1997 PWSAC released ~50,000 chinook salmon smolt in Crab Bay near the native village of Chenega. This project was completed with this final release and adult chinook should be returning into the year 2000.

Project Number and Title: 97290 - Hydrocarbon Data Analysis, Interpretation, and Database Maintenance for Restoration and NRDA Environmental Samples Associated with the *Exxon Valdez* Oil Spill

Principal Investigators: Jeffrey W. Short and Bonita D. Nelson, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, Alaska 99801-8626, (907)- 789-6065, jeff.short@noaa.gov, bonita.nelson@noaa.gov.

Abstract: The Auke Bay Laboratory provides data and sample archiving services for all samples collected for hydrocarbon analysis in support of *Exxon Valdez* Trustee Council projects. These data represent samples collected since the oil spill in 1989 to the present and include environmental and laboratory Response and Restoration data as well as Subsistence data. Additionally, we provide interpretive services for the hydrocarbon analyses. Currently, the database contains results of the hydrocarbon analysis of more than 13,000 samples and collection information from more than 46,000 sediments, tissues, water, or oil samples. The primary purpose of this project is to maintain the integrity of the database, incorporate new data and continue hydrocarbon data interpretive services. The second purpose is to make the results of the hydrocarbon analyses available to principal investigators, resources managers and to the public. This service is expected to have activity through synthesis period of the next two years. The third purpose of this project is to maintain the integrity of archived samples in freezers many of which have not yet been analyzed for hydrocarbons.

Project Number and Title: 97291 - Chenega Shoreline Restoration

Principal Investigators: Dianne Munson, DEC; 555 Cordova Street, Anchorage, Alaska 99501, (907) 269-3080, dmunson@envircon.state.ak.us

Christine Brodersen, NOAA, NMFS, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, Alaska, 99801, (907) 789-6098, chris.brodersen@noaa.gov

Abstract: This restoration project was developed in response to concerns raised by citizens of Chenega Bay that residual *Exxon Valdez* oil contained in beach sediments continues to affect local use and perception of area shorelines. On the basis of their value to area residents and the extent of oil present, three beach segments were selected for cleaning on the north end of Latouche Island and two on the northeast end of Evans Island, all near Chenega Bay, in southwestern Prince William Sound. All are all characterized as moderate to high-energy environments with substrates consisting mainly of boulder or cobble-boulder armor overlying gravel sediments.

The treatment process was to meet three objectives: 1) a 50 percent reduction in observable oil residue in surface and subsurface sediment; 2) a significant decrease in the levels of measurable petroleum hydrocarbons in the surface and subsurface sediment; and 3) no significant environmental impact on biota and no evidence of petroleum hydrocarbons being introduced into the water column.

The selected process was successfully demonstrated in a 1993 pilot test on Latouche Island. It involves injecting a cleaning agent (a d-Limonene-based surfactant trade named PES-51®) into beach sediments using an "air knife" – a high-pressure air injection tool. Once injected, the surfactant releases oil trapped in the beach sediments. The surfactant-oil mixture is forced to the surface and washed down the beach using large quantities of ambient temperature seawater where it is collected using standard oil recovery techniques.

The shoreline treatment project was overseen by the Alaska Department of Environmental Conservation. The shoreline treatment work was conducted by the Chenega area Native corporation, ESC, Inc., with beach treatment crews comprised primarily of local shareholders. The National Oceanic and Atmospheric Administration (NOAA) conducted scientific monitoring to determine reductions in oil levels, and impacts of the process on biota and water quality. Treatment took place over the 35 days of June 16 - July 20, 1997. A total of 20,000 pounds of oily sorbent material was generated and disposed of at a permitted facility. Visual observations suggest that, at least, the extent of surface oiling was significantly reduced. Conclusions as to reductions in measurable oil levels and impacts on local biota and water quality await the results of the NOAA monitoring program which will be completed after final field work scheduled for next summer.

Project Number and Title: 97291A- Chenega Shoreline Restoration: Monitoring

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Abstract: In June and July of 1997, at the request of residents of Chenega Bay, *Exxon Valdez* crude oil was removed from 10,000 m^2 of beach on the north end of Latouche Island (mostly in Sleepy Bay) and on the northeast corner of Evans Island. The Chenega Shoreline Cleanup was overseen by the Alaska Department of Environmental Conservation and is described in the preceding abstract. There was concern over how well the proposed cleaning methods would work and whether they would cause significant environmental damage; our objective was to determine how thoroughly the cleanup removed oil, and to assess any damage to intertidal organisms and contamination of the surrounding water. All of our assessments involve comparing samples and photographs taken in May of 1997, before the cleanup, with samples and photos from July of 1997, just after the cleanup, and May of 1998, a year later.

Determining the effectiveness of the cleaning process required developing new sampling methods. Oil on these beaches is mostly mousse mixed into the dirt and gravel, covered with a layer of dry asphalt and distributed very erratically around and under large rocks. Therefor we sampled by collecting all of the oil (and loose rock and dirt) directly below a ¼ m x ¼ m quadrat, extracted the oil from each sample and weighed it, giving results in weight of oil per area of beach. To assess cleaning effectiveness, we selected 62 sample sites, all of which were badly oiled and large enough to place three quadrats within them, one for each sample time; 52 of those were in areas subsequently cleaned. Sample analyses are in progress. The 22 "before" samples analyzed so far contained a *lot* of oil, from 0.5 to 9 kg / m^2. Reductions in the associated "after" samples range from 90% to no change at all; mean reduction of about 50%.

To document any major damage the cleaning may have caused to intertidal plants and animals, we compared the "before" and "after" numbers of small animals and the degree of algal cover in 120 fixed intertidal quadrats, the numbers of sea stars on fixed sections of the beach, and photographs. At this point it appears the cleanup did not cause any widespread intertidal biological damage.

To assess water quality and the potential for subtle biological consequences of the cleanup, we analyzed mussel and chiton tissues for petroleum hydrocarbons (HCs) and d-limonene, the chief component of the cleaning surfactant used. Chitons accumulated neither HCs nor limonene. Filter-feeding mussels greatly concentrate contaminants from the water around them; some of the naturally-occurring mussels directly below the cleaned areas did take up low levels of HCs and d-limonene during the cleanup. Caged mussels moored below the water surface just outside the operations area did not accumulate significant levels of HCs or limonene.

Preliminary Conclusions: With about 1/4 of the samples analyzed, cleaning was effective in removal of oil in most sample plots. Biological damage was minimal. However, the 1998 samples will be the most important, since long term effectiveness and long term damage are more meaningful than any short term effects.

Project Number and Title: 97302 - Prince William Sound Cutthroat Trout, Dolly Varden Char Inventory

Principal Investigator: Merlyn Schelske, USDA Forest Service. P.O. Box 280, Cordova, AK 99574 (907) 424-7661

Abstract: There has been a good deal of uncertainty about the distribution of Dolly Varden char *(Salvelinus malma)* and cutthroat trout *(Oncorhynchus clarki)* in Prince William Sound. As an example, earlier studies stated that there are only a few lacustrine systems in the Sound with the anadromous forms of these species. However, after consultation with local residents, it appears that these species are more widespread than previously believed. It was also found that many populations which are well-known to local residents are not documented in the Alaska Anadromous Waters Catalog. Both of these species have been listed as having been injured by the *Exxon Valdez* oil spill, but their recovery status is unknown. Without knowing such basic information as the number of watersheds with populations of these fish, it is difficult to determine the extent of their injury or recovery. The objective of this project is to better document the distribution of both anadromous and resident forms of these species and make this information available for researchers, resource managers, and the public in general.

To obtain information on Dolly Varden char and cutthroat trout populations, interviews were conducted with local residents, gray literature and agency records were read, and more than 30 field sites were sampled to verify the presence of these species. The field surveys also included the identification of barriers that would separate anadromous and resident populations. Stream and barrier locations have been recorded with a global positioning system (GPS) unit. The data are now being compiled for inclusion in geographic information systems (GIS) and the Anadromous Waters Catalog.

Project Number and Title: 97304 - Kodiak Island Borough Master Waste Management Plan

Principal Investigator: Jerome Selby, Kodiak Island Borough, 710 Mill Bay Road, Kodiak, AK 99615, (907) 486-9300

Project Manager: Ron Riemer, Kodiak Island Borough, 710 Mill Bay Road, Kodiak, AK 99615, (907) 486-9341

Abstract: Communities within Kodiak Island Borough generate various waste streams that may be entering, degrading and preventing recovery of the spill area. During this past year, we have inventoried these waste streams, determined the major problems, developed potential solutions, and determined ways to implement the solutions.

The project is structured around a Committee comprised of representatives from each of the six remote villages (Akhiok, Karluk, Old Harbor, Ouzinkie, Port Lions, and Larsen Bay) and the road system community of Chiniak. The Committee includes representatives from Alaska Department of Environmental Conservation, Kodiak Area Native Association, U.S. Coast Guard, and the Kodiak Island Borough. An environmental consultant, Montgomery Watson, was selected to assist with the project. The Committee met several times during the year to identify and prioritize problems, develop solutions, and identify and pursue funding for the solutions.

The waste streams and potential impacts on the marine environment were inventoried in each village. Meetings were held in each village to encourage public participation. The Committee prioritized the list of problems and the consultant developed regional solutions to the major problems. The Committee prioritized the potential solutions and determined which solutions to seek implementation funding. The following is a list of the priority issues and potential solutions

1. Raw sewage is discharged onto the land and into surface waters in several villages. Wastewater problems in the villages result from the lack of training, operator attention, proper tools, and spare parts. Improper use of the sewers by residents also contributes to the problems. The Plan includes a training program for the operator and backup operators, community education programs, and bringing the systems up to proper operating conditions.
2. Used oil from boats, diesel generators, and vehicles accumulate in the villages or receive improper disposal. Most of the villages do not have a method to collect used oil and dispose of it properly. Oil is stored in drums and cans that eventually deteriorate, spilling the oil. The villages need to establish a collection point for used oil and install a used oil burner to recover the heat value. Oily rags and oil filters should be collected and burned.
3. Landfills now receive trash, used oil, household hazardous wastes, scrap metals, batteries, and most anything that is thrown away. Landfills attract bears to the villages and scatter the trash. Windblown trash gets into the streams and ocean. Leachate from the landfills ends up in the ocean. Solutions include providing a fence around the landfills; diverting drainage away from the landfills; providing training and developing operation plans; educating residents on solid waste practices; burning trash to reduce volume; collecting and shipping household hazardous wastes, batteries, scrap metals, and aluminum cans off island for recycle or proper disposal.
4. Fuel delivery systems pose a threat to the local marine environments. Fuel is delivered to the villages by barge, pumped into fuel storage tanks, and trucked from the storage tanks to the residential tanks. All of these activities create the possibility for significant release of fuel oil to the marine environment. A spill prevention program needs to be established in the villages. A spill response program is being developed.

Project Number and Title: 97306 - Ecology and Demographics of the Pacific Sand Lance in Lower Cook Inlet, Alaska.

Principal Investigators: Martin Robards, Memorial University of Newfoundland, St. Johns, Newfoundland, Canada. martin_robards@nbs.gov

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Abstract: Sand lance are one of the principle forage fish species found in the Gulf of Alaska and are the dominant fish in many nearshore communities. Despite their importance, there is a lack of information pertaining to their life history and environmental requirements.

We monitored sand lance habitat, abundance, growth, age structure, and maturity at three sites within Cook Inlet: Kachemak Bay, Chisik Island, and the Barren Islands. Fish were collected using beach seines, mid-water trawls, digging in intertidal substrates, and from the diets of seabirds and halibut. Sand lance burrowing habitat (essential in their life history) was found to be restricted to fine gravels and sand. The size structure of the substrates that they use indicates that sand lance possess physiological adaptions to overcome both low oxygen levels and stranding above the water line at low tide. Abundance and growth of sand lance varied within Cook Inlet, apparently in accordance with food availability. Fish at the Barren Islands and in Kachemak Bay were fast-growing and numerous compared to slower-growing and less abundant populations at Chisik Island. Age structure at the oceanically-influenced Barren Islands was almost entirely young-of-the-year, whereas in Kachemak Bay and at Chisik Island a full complement of ages was represented, up to a maximum of 7 years. Sand lance mature in their second year. Gonads develop rapidly from July until spawning in early October. Spawning was observed at high tide in the intertidal zone, and eggs were subsequently exposed to freezing conditions each day until hatching in late December/ January.

Project Number and Title: 97320E – SEA: Juvenile Salmon Predation.

Principal Investigators: Mark Willette and Mark Clapsadl, Alaska Department of Fish and Game, P.O. Box 669, Cordova, Alaska. 99574 (Phone 907/424-3214).

Abstract: This project is a component of the Sound Ecosystem Assessment (SEA) program. SEA is a multi-disciplinary effort designed to acquire an ecosystem-level understanding of the marine and freshwater processes that interact to constrain levels of pink salmon and herring production in Prince William Sound (PWS). This project collected data needed to test several hypotheses related to predator-prey interactions affecting the mortality of pink salmon (*Oncorhynchus gorbuscha*) in PWS. These hypotheses include the following: (1) predation on juvenile salmon and other age-0 fish is inversely related to the abundance of large calanoid copepods, (2) predation risk is related to the daily foraging times of juvenile salmon, and (3) predation on wild salmon fry is greater when wild fry are mixed with larger hatchery-reared fish. This project was designed to achieve the following objectives: (1) estimate the juvenile salmon consumption rate of fish predators in PWS, (2) estimate the species/size composition of fish predators, and (3) conduct preliminary tests of predator/prey hypotheses. This project also provided logistical support (personnel and equipment) to the SEA herring program.

Our efforts in 1997 focused on estimation of predator abundance, as well as predator behavior and feeding rates in nearshore habitats. Studies were conducted at eight nearshore sites during each of three date periods in PWS during May and June. Four of these sites were located in areas dominated by wild salmon in eastern PWS and four in areas dominated by hatchery salmon in western PWS. Each nearshore study site consisted of an approximately 3000 m long segment of shoreline. Potential predators on juvenile salmon were sampled using variable-mesh gillnets. Sampling was conducted at two stations every 3 hours throughout a 12-hour period spanning the night. Otolith marked juvenile salmon were also recovered at each site to estimate stock composition and test for differences in size and growth of wild and hatchery salmon fry. Relative abundances of gadids (Pacific cod, tomcod, walleye pollock, and black cod), herring and nearshore benthic fishes (rockfish, sculpins, greenlings, etc.) were significantly greater in eastern than western PWS. In addition, relative abundance of gadids increased from May to June in eastern PWS but not in western PWS. Relative abundance of adult salmon and dolly varden trout increased from May to June in both areas sampled. Comparison of relative abundances of fishes between 1996 and 1997 at four western PWS sites indicated greater abundances of gadids, herring and dolly varden trout in 1996. We also used sonic tagging methods to study the diel feeding behavior of age 3+ walleye pollock. Two fish were successfully tagged and tracked for three to four days each. Both fish remained in the upper 50 m of the water column throughout the period of tracking. Swimming speeds were estimated to range from 0.05 to 0.10 m sec^{-1}. Results from field studies conducted since 1994 will be used to construct the SEA pink salmon recruitment model and conduct tests of the SEA predator/prey hypotheses.

Project Number and Title: 98320G - SEA: Plankton Dynamics: Phytoplankton and Nutrients

Principal Investigator: C. Peter McRoy, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks AK 99775 /phone 907-474-7783 /ffcpm@aurora.uaf.edu

Abstract: For the past 4 years we measured the spatial and temporal fields of the major inorganic nutrients (nitrate, nitrite, ammonia, silicate and phosphate), phytoplankton biomass (chlorophyll) and eneumerated taxa to assess the interannual variability in the basis of the food web in Prince William Sound. Through mixing processes, light and nutrients drive the fixation of inorganic carbon into organic matter that is the primary nourishment for herbivorous zooplankton and is transferred to all upper trophic levels. Our results can be used to trace subtleties in circulation, confirm physical models, and drive food web models.

Data collection efforts have been based on the strategy of sampling a single location in detail to determine the time series of events and an extensive shipboard survey of the sound to sample geographic variation at selected intervals from spring through fall. The most complete data set is for 1995, 1996 and 1997 when we based a field team at the AFK Hatchery to sample daily the water column at a nearby location in Elrington Passage. The shipboard data are best for 1995 and 1996 when the SEA project had several vessels collecting samples in the sound.

Our spatial data (using nutrient and chlorophyll fields) indicate that the central sound comprises 2 regions: the inner sound and the outer sound are separated by a physical boundary consistently located about 30 km north of the eastern exit to the Gulf of Alaska (Hinchinbrook Entrance). The inner sound appears to has lower vertical mixing rates, stratifies more easily, and has an early phytoplankton bloom with > 15 mg m^3 that declines within a month as nutrients are depleted. The outer sound has more vertical mixing, probably a result of tides. Increased mixing delays the chlorophyll bloom and reduces its intensity (< 5 mg m^3), but it also introduces more deep nutrients to the surface so the bloom lasts longer. Nitrate concentrations are higher in the outer sound early in the summer, but the inner and outer sound regions are equally depleted by the end of summer, which suggests that annual production in the outer sound is at least as high as annual production in the inner sound. The physical front separating the inner and outer sound becomes an upwelling zone that maintains a moderate level of chlorophyll throughout the summer. Earlier onset of upwelling at the 30km boundary increases the total amount of nitrate utilized by the phytoplankton in the central sound.

Does the amount and nature of the phytoplankton community determine the production of upper trophic levels or is there always enough edible phytoplankton so that it does not matter? Our results indicate that the phytoplankton bloom in the sound in duration, distribution and in composition. The bloom period was shortest in 1995 (29 days) and longest in 1997 (36 days) and while the biomass as measured by chlorophyll was similar in all 3 years, the calculated carbon biomass (based on cell size and number) was much greater in 1996. Such results indicate that 1996 was a better food year than 1994 or 1997, but the test will come from other SEA models and data. While weather and ocean conditions impose year-to-year differences on the sound, the cycle of nutrients and phytoplankton biomass and species composition is similar to other marine systems at comparable latitudes. The sound ecosystem is not disturbed by foreign agents.

Project Number and Title: 97320H - SEA: The Role of Zooplankton in the Prince William Sound Ecosystem

Principal Investigator: R. Ted Cooney, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7220, (907)-474-7407

Abstract: I am providing information about the species composition, size, abundance and biomass of net-caught zooplankton as one component of the multi-project Sound Ecosystem Assessment (SEA) program in Prince William Sound. This year, samples were collected (upper 50-m) during a Sound-wide oceanographic survey in May, and from a location adjacent to the AFK pink salmon hatchery on Evans Island in southwestern Prince William Sound from early April through mid June. These collections address continuing questions about the timing and duration of a mid-spring bloom of large copepods which serves as an important forage resource for out-migrating pink salmon fry and for fry pedators like adult and immature walleye pollock and Pacific herring. These collections are also being used to characterize spatial characteristics of upper-layer zooplankton communities in Prince William Sound.

Analyses of these samples and those taken in other years of SEA are revealing an overall seasonal pattern in biomass similar to that reported for the adjacent deep Gulf of Alaska; spring and summer stocks exceed late fall and winter populations by about a factor of 6. A biomass peak associated primarily with the maturing stages of two large calanoid species occurs approximately 20-30 days after the April bloom of phytoplankton each year. When the phytoplankton bloom is early, follow-on zooplankton stocks also peak early.

Cluster analysis techniques are being used to evalaute the spatial distributions of spring-time zooplankton stocks as a means to interpert historical collections of plankton sampled annually by pink salmon hatcheries in the region since the late 1970s. The results from clustering on numerically dominance suggest that the region is partitioned during the spring into two major sub-regions: 1) a portion of the southern, central and eastern Sound intruded by water from the adjacent Gulf of Alaska; and 2) a north and western region that appears to be biologically isolated from the intruding water. These two watermasses exhibit different physical and biological characteristics in late April and early May; the former being somewhat warmer and more saline, while the latter is cooler and fresher. Central and southern water is frequently dominated by juvenile euphausiids, whereas the northern and western water hostes large calanoid populations. In 1996, there was a tendency for calanoid layers to be better defined in the more stratified western and northern watermass.

The results of this SEA project are also being used to create and validate a numerical simulation of the spring phyto and zooplankton blooms in Prince William Sound (with D. Eslinger; 97320-R). This simulation is forced by light and upper-layer mixing to establish the timing, magnitude and duration of plant and animal plankton blooms in Prince William Sound. These results will eventually link to simulations of fish populations with emphasis on prey-predator relationships.

Project Number and Title: 97320I - Sound Ecosystem Assessment: Confirming Fish Food Web Dependencies in the PWS Ecosystem Using Natural Stable Isotope Tracers (SEA-FOOD)

Principal Investigator: Thomas C. Kline, Jr., Ph. D. (Prince William Sound Science Center, P.O. Box 705, Cordova AK 99574; 907-424-5800 (tel), -5820 (fax); tkline@grizzly.pwssc.gen.ak.us)

Abstract: Carbon and Nitrogen Isotopic Composition of Prince William Sound Pelagic Biota Shift on Annual Time Scales: A Tool for Monitoring Changes in Oceanographic Forcing.

Changes in the physical environment that are known to affect phytoplankton and zooplankton production were linked to fish production through carbon and nitrogen stable isotope natural abundance measurements. Stable isotopic analyses of herbivorous copepods and juvenile fishes (salmon, Oncorhynchus spp.; herring, Clupea pallasi; and pollock, Theragra chalcograma) from Prince William Sound and the northern Gulf of Alaska were conducted as part of the Sound Ecosystem Assessment (SEA) project, a comprehensive multi-disciplinary ecosystem study. The advective regime connecting the northern Gulf of Alaska (GOA) with Prince William Sound (PWS) was postulated by SEA to effect recruitment and nutritional processes in juvenile fishes. Herbivorous zooplankton, a proxy for pelagic production sources, had distinctive carbon isotope signatures when sampled in the northern GOA compared to those from PWS. PWS carbon had consistent carbon isotopic signatures during 1994-6 while GOA carbon varied. Nevertheless, PWS carbon was always distinctive from GOA carbon. This variation suggested that inter-annual fluctuations occurring at the food chain base are driven by processes in the Gulf. Analyses of nitrogen isotope ratios and C/N ratios of juvenile fishes were used to make their carbon isotope ratios comparable, enabling determination of their relative affinity for GOA or PWS carbon. The data suggest a large affinity range, changing on annual time scales, consistent with observed oceanographic phenomena. For example, there was a shift to a greater dependency on GOA carbon in 1995 compared with 1994 and 1996. A parallel shift to increased GOA-originating copepods undergoing diapause (resting phase) in 1995 suggesting an influx of GOA zooplankton, provided a second line of evidence. Thus herring and other fishes partially dependent on GOA carbon are subject to vagaries of carbon flow that fall under the domain of physical oceanographic processes connecting the GOA with PWS as well as processes occurring on the GOA continental shelf adjacent to PWS. Time series measurements of natural stable isotope abundance in herring and other fishes in conjunction with fish population indices and physical oceanographic measurements will enable a new understanding of how bottom-up processes affect fish recruitment and interaction.

Project Number and Title 97320J - SEA: Information Systems and Model Development

Principal Investigators V. Patrick[1], J. R. Allen[1], S. Bodnar[1], C. S. Falkenberg[2], D. M. Mason[1,3], R. H. Nochetto[1,4], C. N. K. Mooers[5], J. Wang[5]

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Abstract The Sound Ecosystem Assessment (SEA) Project addresses the processes in Prince William Sound that sustain the economically and ecologically important populations of pink salmon and Pacific herring, with specific focus on processes influencing the first year of life. These are the processes that determine the course of population decline or recovery following an injury to the resource or a disturbance within the ecosystem. Further, they are the means of implementation of any restoration intervention. Clearly, an appropriate implementation depends upon processes so well understood that their function and outcomes are routinely and demonstrably predictable. The SEA objective is to deliver to stakeholders the foregoing understanding in the form of operational models and monitoring schedules whereby targeted species and processes are a) tracked by direct and remote measurements and b) simultaneously tracked by numerical models that in addition provide continuously updated short-term forecasts. Near realtime monitoring and forecast information is delivered to stakeholders via open media such as the World Wide Web. In particular, stakeholders can independently evaluate progress against the stated objective of "routine and demonstrable predictability."

This project is responsible for four component objectives: i) models for pink salmon fry survival during marine migration through PWS, and for winter survival of first year Pacific herring; ii) 3-dimensional numerical circulation model for PWS; iii) development and operation of a contemporary data management system serving SEA throughout all phases; and iv) development and operation of web-based solutions for project operations, development of prototypes with resource managers, and for the distribution of project results to stakeholders.

In May 1997 the first prototype for the "Sound Report" web-site was implemented at URL `www.pwssc.gen.ak.us/sea/weather/realtime.html`. Since then the site has continuously provided stakeholders a coordinated, consistent interface to the same near realtime meteorological and satellite monitoring data resources used in SEA for model development: NOAA buoys and C-MAN stations, NWS met stations, UAF-IMS CFOS buoy and AVHRR images (Eslinger 320R), and PWSSC Applegate Rock met station (Bodnar, 320J). EVOS project 320R and this project use the "Report" web site to contribute their near realtime meteorological data to the public domain. The "Report" page has items that in 1998 will move to the "Sound Forecast" page. With regard to project component ii), the "Report" provides an animation sequence of the surface currents for PWS generated by a diagnostic model run with conditions known to occur in early or late summer at neap tide. With regard to component i), the site has animations of model simulations of salmon fry migration and survival in western PWS during spring and of "fasting" first year herring during winter. In these, SEA developments and monitoring are combined with management monitoring data and with hatchery monitoring information from EVOS coded-wire tag projects. For component iii) the SEA database design has realized the design objective of reusability and generic applicability for subArctic coastal-ocean ecosystems: it was selected and used to develop the Shepard Point Road Environmental Impact Assessment Database. This new data resource is accessible via the "Sound Report" web site.

Restoration Workshop posters for these and other project elements will be by computer display and will use the "Sound Report" interface. The poster information will remain on-line until superseded.

Project Number and Title: 97320M - Sound Ecosystem Assessment (SEA) Component M - Decadal Comparisons of Circulation and Transports in Prince William Sound, Alaska

Principal Investigator: Shari L. Vaughan, Prince William Sound Science Center, P. O. Box 705, Cordova, Alaska 99574, (907)424-5800, vaughan@grizzly.pwssc.gen.ak.us

Abstract: The purpose of this study is to identify physical mechanisms that influence the distribution and abundance of stocks of Prince William Sound pink salmon and Pacific herring, either directly or by modulating their food sources. Oceanographic data from cruises in Prince William Sound conducted from 1994 to 1997 are compared to results published by Niebauer et al (1994) from 1976 to 1979. Seawater density was used to calculate dynamic height gradients, which approximate the direction and intensity of the circulation. Dynamic heights in June 1996 show inflow at Hinchenbrook Entrance, and cyclonic (counter-clockwise) curvature in the central Sound similar to that in June 1976. Cyclonic circulation did not exist in June 1994 or in June 1995. A closed cyclonic circulation is evident in the dynamic topography from September of 1994, 1995 and 1996. Magnitudes in September 1995 were similar to September 1978; September 1994 and 1996 values are lower. In December 1996, surface inflow at Hinchenbrook Entrance was indicated. In December 1996 and December 1976, surface outflow at Montague Strait was indicated. Volume transports calculated at Hinchinbrook Entrance in December 1996 from towed acoustic Doppler currrent profiler (ADCP) repeat transect velocities with tides removed (0.1 Sv) were less than those calculated by Niebauer et al from moored current meters (0.3 Sv) in December 1978. Transports in April 1996 (-0.03 Sv) and May 1997 (-0.16 Sv) at Hinchinbrook Entrance were southward, or out of the Sound. In spring of 1978, transports were small (<0.1), but positive. At Montague Strait in June and September 1996, transports were similar to those in 1978 (-0.01 Sv), but May 1997 transports were higher (-0.1 Sv). Future work includes combining these results with phytoplankton, zooplankton, and fish population data from the late 1970s and middle 1990s.

Project Number and Title: 97320N - SEA: Nekton-Plankton Acoustics (SEAFISH)

Principal Investigator and Staff: G.L. Thomas, Jay Kirsch and Geoff Steinhart. Prince William Sound Science Center, P.O. Box 705, Cordova, AK 99574, tele: (907)424-5800, fax: (907)424-5820, email: loon@grizzly.pwssc.gen.ak.us.

Abstract: The inability to forecast the small runs of Prince William Sound (PWS) pink salmon in 1992 and 1993, and the collapse of the herring population in 1993, prompted the EVOS Trustee Council to initiate the Sound Ecosystem Assessment Program (SEA), a coordinated group of ecosystem-level projects, to improve existing predictive tools. Within the SEA program, the purpose of the Nekton-Plankton Acoustics project (SEAFISH) is the evaluation and application of new acoustic measurement technology to collect fine- and large-scale, quasi-continuous information on fish and macrozooplankton distribution and abundance synoptically with physical measurements. This information is used to test the river-lake and prey-switching hypotheses and the development/verification of predictive numerical models.

Annual variability in physical conditions combined with the abundance and distribution of nekton predators and macrozooplankton prey during the spring in PWS, alter the survival of juvenile pink salmon. As a surrogate for direct measurement of the pink salmon, we are measuring the abundance and distribution of key macrozooplankton prey (Calanoid copepods) and predators (pollock and herring) synoptically with physical conditions along the out-migration path of fry to identify and quantify over-spring, pink salmon fry survival mechanisms.

To develop new methods to make representative measurements of the macrozooplankton prey, a zooplankton survey was conducted in PWS in May 1996, using a 420 kHz digital sonar and a MOCNESS net. Data from the catch supplied us with zooplankton species, size, and absolute density, which were applied to scattering models, which allowed us to predict volume backscatter. A matrix equation is formulated that solves for the reflection coefficient of each taxa by adjusting these predicted backscatter values so they agree with the measured acoustic backscatter. This allowed us to determine target strength (TS) for each taxa in each area of the Sound. By equating the net and acoustic information, the acoustics can be used to extrapolate the absolute density and species composition provided by the nets into high-resolution, wide-coverage information.

We examined the prey switching hypothesis with the most abundant fry predator in the Sound, walleye pollock (Theragra chalcogramma) on surveys between 1994-1996 in the Sound. In all years, pollock were observed to switch from their primary food sources, fish and macro-invertebrates, to macrozooplankton when plankton densities are high in the spring. In 1995, we made acoustic simultaneous observations of pollock and zooplankton in the pelagic surface waters throughout the Sound. We found patches of plankton 50 m to 5 km long in the top 50 m of water. Net tows showed that these patches were over 90% calanoid copepods. Walleye pollock abundance was positively correlated with zooplankton abundance (r^2=0.26). Furthermore, the copepods observed dominated the diet of pollock at this time. These results showed that walleye pollock were feeding on, and were attracted to macrozooplankton patches in PWS. Environmental conditions that result in low macrozooplankton densities, or prohibit the formation of dense plankton patches could reduce feeding opportunities for pollock. When macrozooplankton are not abundant, adult pollock may switch their diet to include more juvenile fish, which could reduce the survival of many important fish species.

Since the goal of model development is to predict population change in pink salmon and herring, there is a need to have accurate assessments of the adult and juvenile population wherever possible to serve as a

starting (initiation) and ending (verification) points for predictions. Currently, we depend upon Prince William Sound Aquaculture Corporation for the numbers of pink salmon fry released, and the Alaska Department of Fish & Game (ADF&G) for the numbers of returning adult pink salmon, but both of these assessment techniques could use error assessment and improvement. We have developed assessment methods for adult herring and have attempted to find matching funds from ADF&G and the fishing industry for fall and spring assessments.

Some management and public information spinoffs have occurred from the SEA Nekton and Plankton Assessment Project. Acoustic measurement and estimation of the size of the dominant predator populations in the Sound, adult walleye pollock and adult Pacific herring, have contributed to establishing commercial harvest guidelines. The tracking of the size of these populations is very popular public information since these fisheries have significant economic impact on the region. With new, rapid, cost-effective stock assessment techniques management becomes more affordable and less risky. Also, as the quality of the data on commercial stocks improve, alternate management practices such as in-season measurement and multiple species approaches become feasible.

One of the unique aspects of the acoustic stock assessment measurements is that the surveys have been shown to be repeatable. This may be a first in fisheries science. Given this development, there maybe a more significant application of the technology. On a global scale, marine fisheries management has and still relies primarily on preseason forecasting of fish biomass to establish harvestable quotas. This practice has a dismal record for conserving fish stocks worldwide. A recent trend in marine fish management has been to include more in-season information to update managers on the status of the harvestable stocks. In PWS, acoustic surveys of prespawning aggregations of herring pollock have been conducted with the speed and repeatability that the in-season biomass estimates could be used to open and close the fisheries. There is no reason that such techniques cannot be applied to other pelagic and semi-pelagic marine fishes that aggregate prior to spawning. Use of the in-season acoustic estimates of biomass to regulate fisheries would change the current fishery management practices form a passive, inaccurate preseason guessing game to a proactive, in-season measurement program that would conserve spawners and sustain healthy fisheries.

Three posters on these results will be presented.

Project Number and Title: 97320R - SEA: Trophodynamic Modeling and Validation Through Remote Sensing

Principal Investigator: David L. Eslinger, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Alaska, 99775 (Phone 907-474-7797)

Abstract: Coupled biological and physical models developed in prior years were improved in 1997 with the addition of increasingly realistic dynamics for zooplankton and the addition of a planktonic larval herring component. These models were run for all available years, including 1997. Forcing data were collected using the C-LAB buoy, located near Naked Island.

Springtime zooplankton populations in Prince William Sound, Alaska, are dominated by a number of species of calanoid copepods. These species can be loosely grouped into two categories: large Neocalanus-type copepods, which reproduce at depth; and smaller Pseudocalanus-type copepods, which reproduce at the surface, after feeding. The Neocalanus-type copepods are an important food source for pink salmon, pollock, and other fish species in early spring. The Pseudocalanus-type copepods are an important food source throughout the spring, summer and fall, for larval and juvenile Pacific herring. Larval herring feed only on the smaller life stages of the Pseudocalanus-type copepods.

We have developed a coupled biophysical model of plankton dynamics for Prince William Sound, Alaska. The model includes three potentially limiting nutrients: nitrate, ammonium, and silicon; two phytoplankton types: diatoms and flagellates; and three zooplankton types: large Neocalanus-type of copepods, smaller Pseudocalanus-type copepod, and a euphausiid group. We present a comparison of the results of the model using two different formulations for the Pseudocalanus-type copepod. The first formulation combined all life stages in one variable, which simulated total Pseudocalanus biomass. For the second formulation, all stages of Pseudocalanus development were simulated. This formulation requires sixteen different variables, and results in a considerably more complicated model. Information on the biomass of different life stages is important in simulating the proportion of total biomass available as food to Pacific herring. The different model formulations are presented and the results compared.

Growth and survival of larval Pacific herring, *Clupea pallasi*, are simulated for 1993 through 1997 using a larval dynamics model linked to the phytoplankton-zooplankton The herring model is forced by physical variables and zooplankton results and is used to examine the influence of oceanographic processes on the growth and survival of Pacific herring larvae. Small changes in mixed layer temperature and zooplankton concentrations during the larval period lead to substantial differences in the larval stage duration. Larval herring are modeled from hatching, through metamorphosis, to the juvenile stage. The herring model includes feeding, growth, metabolic costs, starvation and predation components. The model is initialized with hatch date estimates, and results are compared with juvenile herring characteristics. We have examined the response of Prince William Sound larval herring to environmental variability and different forcing scenarios.

Project Number and Title: 97320T-SEA-Juvenile Pacific Herring Growth and Habitat

Principal Investigators: Brenda L. Norcross, Associate Investigators: Kevin D. E. Stokesbury, Evelyn D. Brown, Robert J Foy, Institute of Marine Science, University of Alaska - Fairbanks, P.O. Box 757220, Fairbanks, Alaska, 99775 (phone 907/474-7938)

Abstract: This project is a component of the Herring Recruitment group of SEA, initiated to provide information on the herring population in Prince William Sound and restoration measures required after the *Exxon Valdez* oil spill. The Herring Recruitment group is examining the physical and biological mechanisms affecting the survival of juvenile Pacific herring (*Clupea pallasi*) and providing indices of recruitment into the fishing stock. To do this a conceptual model addressing three objectives: 1.) overwintering survival model, 2.) summer habitat model, 3.) monitoring strategy, has been created The Growth and Habitat project is determining: 1.) horizontal and vertical distributions of juvenile herring, using hydroacoustic and aerial surveys, and the underlying biological (predator distribution, prey distribution) and physical variables (oceanographic conditions, substrata) influencing these distributions, 2.) survival rate of juvenile herring based on densities and yearclass distribution, 3.) summer growth rates in different areas, 4.) habitat quality, based on oceanographic conditions, energetics, growth rates and prey availability, 5) larval drift based on the SEA oceanographic model, 6.) an overwintering survival model.

In 1997 we completed 5 diel surveys, sampling Eaglek, Whale, Ziakof, and Simpson Bays in March, May, July, August and October. During all but the latter survey four or five vessels were employed: an acoustic vessel, a trawler, a seiner, a processing boat which also supported the inshore fry skiff, and an oceanographic vessel. Aerial surveys were completed in June and July. One vessel was used during the October survey and focused on developing a cost-effective monitoring strategy combining hydroacoustic, zooplankton and fish collections with oceanographic measurements. As our field sampling effort decreased, our focus shifted to data analysis. Presently, the majority of acoustic survey data has been combined with fish collection data to extrapolate estimates of spatial distributions for pollock and herring. Diet composition of juvenile herring and prey availability within the 4 bays has been determined for 1995 and 1996, and work continues on the 1997 data.

The Prince William Sound Pacific herring population is made up of 3 size modes representing young of the year, juvenile (1-2 year old) and adult (sexually mature) herring. Herring of each size mode are contagiously distributed on different spatial scales. Cohorts (age/size) of herring are spatially segregated. Juvenile herring aggregate in Bays for the first 2 years of their life. They congregate in surface waters during June and July. Prey availability and herring prey selection vary spatially and temporally.

These spatial distributions define the area where the physical and biological variables occur determining Pacific herring life history and population size in Prince William Sound. The present lack of information of these variables confounded the identification of damage caused by the *Exxon Valdez* oil spill and estimates of the population's recovery time Our future work will focus on determining these variables.

Project Number and Title: 97320T(supplement) - SEA: Local and Traditional Knowledge of Herring and Other Forage Fish

Principal Investigator: Jody Seitz, UAF Herring Program, P.O. Box 881, Cordova, AK 99574 (907) 424-5916.

Study History: The project was initiated in 1997. The project was designed to document the historical distribution of forage fish such as juvenile herring, sandlance, capelin, and eulachon through qualitative interviews with key respondents in several communities. The information will be mapped and indexed by subject and provided to the Alaska Predator Ecosystem Experiment (APEX) and Sound Ecosystem Assessment (SEA) researchers. It is designed to provide researchers with population and habitat use information over a longer period and broader area than can be known through existing records and current data collection efforts.

Abstract: The researchers used a combination of key respondent interviews and mapping to document the locations of juvenile herring, herring of unknown age (unknown herring), mixed adult and juvenile herring (mixed herring), herring spawn, unidentified small fish (small fish), capelin, sand lance, eulachon and pollock. Researchers concentrated on recording information about juvenile herring and small fishes other than juvenile herring, such as sand lance and capelin. A total of thirty-nine respondents were interviewed in thirty-seven interviews (two couples were interviewed jointly). Ten interviews were carried out in Homer; twenty-six interviews were conducted in Cordova; and three interviews were carried out in Tatitlek. Most interviews were tape recorded. Respondents and researchers marked locations of fish schools on charts overlaid with mylar. Fish schools were color-coded by species for later reference. Maps of juvenile herring distribution in Prince William Sound were produced using the computer mapping programs GMT and ARC Info for this report.

Project Number and Title: 97320U - SEA: Fish Energetics

Principal Investigator: Dr. A. J. Paul, University of Alaska, Seward Marine Center, POB 730, Seward, AK 99664 (Phone 907-224-5261)

Abstract: This project describes the interannual and seasonal whole body energy content (WBEC) of juvenile herring and walleye pollock in Prince William Sound. Calorimetric measurements of their summer, fall and spring nutritional status are used to quantify the energy content of these forage fishes available to predators. This study is also determining if starvation during the over-winter period is important in regulating recruitment of age 0 herring.

During the fall, the WBEC of Pacific herring exhibited a wide range of values relative to length or age. In the fall young of the year recruits had an average WBEC of 5.7 kJ/g wet wt vs 8.0 for age 1 and 9.4-10.2 kJ/g for fish of ages 2 to 7. The fall measures of WBEC showed that the age 0 and age 1 fish stored markedly less energy to over-winter than older herring. Thus, energetically the recruiting year class, and those entering their second winter, are the most at risk of over-winter mortality since all year classes depend on stored energy to over-winter.

Changes in WBEC of captive age 0 Pacific herring forced to fast during winter was measured and compared to cohorts collected in the field. Fish that died during fasts had WBEC values ranging from 2.8 to 3.6 kJ/g wet wt. During March recruits in Prince William Sound often have WBEC $\leq$ 3.6 kJ/g wet wt and those nutritionally stressed fish are in danger of starvation.

Somatic energy content of age 0 walleye pollock was examined in the fall and spring during two years. In the fall of one year few recruits under 70 mm standard length (SL) were collected and the mean WBEC was 3.6 kJ/g wet wt. In the fall of the next year age 0 pollock had an average WBEC of 3.6 kJ/g, but smaller 60-70 mm fish were common. In both years recruits were generally able to either maintain or improve their WBEC over the winter. There was marked variation in WBEC for fish at different capture sites.

Pollock and herring are a major prey of many species injured by the oil spill. Our energetic measures will be useful in estimating fish and bird consumption rates when these forage fishes are prey. The information gathered by this project is being related to SEA zooplankton surveys, habitat studies, prey selection studies and trophic isotopic studies through the SEA modeling effort. The energetic data is also available to APEX and other EVOS trophic studies.

Project Number and Title: 97320Z - SEA: Synthesis and Integration

Principal Investigator: R. Ted Cooney, Institute of Marine Science, University of Alaska Fairbanks, Fairbanks, Alaska 99775-7220, (907)-474-7407

Abstract: Project 320-Z provides funding for SEA investigators to meet annually for planning and science exchange purposes, and for covering costs of submitting an integrated SEA annual report and DPD.

The annual meeting of all SEA investigators was held in Valdez, September 28, 1997 following the AAAS Arctic Science Conference. The meeting developed plans for the SEA synthesis volume to be published as a special issue of the journal Fisheries Oceanography in FY99. Titles and authorship for manuscripts were determined at the meeting. SEA principal investigators also discussed plans for the January review of the program, and a format for the 30-minute public presentation was agreed upon.

Project 320-Z assisted in the preparation and submission of the FY98 DPD and the FY96 Sea Annual Report. These documents were submitted and reviewed according to the procedures of the EVOS Trustee Council in April and May, 1997.

Project Number and Title: 97427 - Recovery monitoring of harlequin ducks in Prince William Sound, Alaska.

Principal Investigator: Daniel H. Rosenberg and Michael J. Petrula, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska 99518 (Phone 907/267-2453).

Abstract: We conducted shoreline surveys of harlequin ducks *(Histrionicus histrionicus)* inhabiting areas in western Prince William Sound oiled by the *T/V Exxon Valdez* oil spill and in non-oiled areas in eastern Prince William Sound. We used the number of breeding pairs, age and sex composition, chronology of molt, the number of broods, and trends in abundance to determine whether harlequin ducks in western and eastern Prince William Sound exhibit similar demographic characteristics. Variation between regions in these parameters would indicate that harlequin ducks in western and eastern Prince William Sound are being subjected to different extrinsic influences. Similar trends in numbers between regions would be evidence for recovery by harlequin ducks in western Prince William Sound. Surveys were conducted simultaneously in both regions during 3 spring and 3 fall surveys in 1995, 1996, and 1997. Spring surveys were timed to monitor harlequin ducks during the breeding season, while fall surveys coincided with molting and brood-rearing. A winter survey was also conducted in March 1997.

The number and composition of harlequin ducks in Prince William Sound varied among survey periods because of seasonal movements by ducks in and out of the study area. The number of ducks declined during the spring as pairs moved from coastal areas up breeding streams to nest. The large decline in breeding pairs suggests that a large proportion of the breeding population leaves the coast; probably to nest on larger, inland drainages. Consequently, productivity by the relatively small number of pairs that remain on the study area contributes less to overall recruitment. Annual variation in the number of breeding pairs counted during our first spring survey indicates that annual variability exists in breeding chronology. During the fall, numbers progressively increased as males, followed by females, returned to the coast to molt.

The general pattern of seasonal movements by harlequin ducks was similar between regions. However, we observed differences in the magnitude and timing of these movements that may indicate geographic variation in population structure and potential differences in productivity. A lower proportion of paired females in western Prince William Sound combined with a greater proportion of flightless females early in the fall indicates to us that breeding propensity of female harlequin ducks is lower in western than eastern Prince William Sound. However, the presence of a relatively large number of sub-adults in western Prince William Sound suggests that the lack of breeding activity by females in that region may be the result of females not attaining breeding age, and not because they have failed to attain breeding condition. Ten, 14, and 12 harlequin broods were observed in eastern Prince William Sound in 1995, 1996, and 1997, respectively, while no harlequin broods were observed in western Prince William Sound. We suspect relatively little breeding habitat exists in Prince William Sound, but relatively more is available in eastern Prince William Sound. A negative trend in harlequin abundance in western Prince William Sound and a positive trend in eastern Prince William Sound suggests that harlequin numbers in western Prince William Sound are still declining, however, repeated winter surveys may provide a more accurate measure of annual variability in numbers.

Project Number and Title: 98252 - Investigations of Genetically Important Conservation Units of Species Inhabiting the EVOS Area

Principal Investigators: James E. Seeb, Lisa W. Seeb, and Susan E. Merkouris, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, Alaska 99518.

Abstract:

The commercial fishing industry in the Gulf of Alaska (GOA) spill area underwent radical alterations from the impacts following the 1989 *Exxon Valdez* oil spill (EVOS). Area closures, species closures, and price fluctuations cumulatively affected both the industry and the target species. This study was designed to address discrete stock concerns through (1) identification of the stock structure of marine species most affected by fishery alterations including walleye pollock (*Theragra chalcogramma)* and rockfish (*Sebastes sp.);* and (2) conduct experimental matings at the Alaska SeaLife Center (ASLC).

To address stock questions of inner vs. outer GOA walleye pollock, we are comparing genetic variation observed in collections from within Prince William Sound (PWS) to that observed in collections from the outer GOA waters of Shelikof Strait. A walleye pollock population from Bogoslof Island area of the Bering Sea was collected for an outside comparison. We are using three methods of gene detection: (1) allozyme analysis of 34 loci, (2) RFLP analysis of five regions of the mtDNA molecule, and (3) analysis of four microsatellite loci. Since microsatellite primers for walleye pollock have not been developed, existing Atlantic cod (*Gadus mohua*) primers were first tested on walleye pollock larvae from known crosses. We used these crosses to verify the mode of inheritance of each microsatellite locus and to determine the presence of null alleles. Results showed that the microsatellites *Gmo1, Gmo2, Gmo9,* and *Gmo132* may be useful for our population study.

Currently, we are developing genetic markers to test gene flow among black rockfish (*Sebastes melanops*) populations inhabiting the greater oil spill area. To determine gene flow, we are analyzing genetic variation of black rockfish from four sample locations: 1) PWS, 2) Resurrection Bay, 3) Outer Kenai Coast, and 4) Kodiak Island. Genetic variation is being analyzed at five mtDNA regions and at five microsatellite loci.

Finally, a plan for implementing experimental runs of pink salmon (*Onchorhynchus gorbuscha*) fish at the ASLC is being developed within the guidelines of State of Alaska regulations and policy. Our initial efforts will focus on determining Mendelian inheritance of genetic markers so they can be properly used in discrete stock studies.

Project Number and Title: 98330 - Toward a Mass-balance Model of Trophic Fluxes in Prince William Sound

Principal Investigators: Daniel Pauly, Fisheries Centre, University of British Columbia, 2204 Main Mall, Vancouver, BC V6T 1Z4, Canada, (604) 822-1201

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Abstract: The steps toward construction of trophic mass-balance models are documented through a preliminary ECOPATH model of Prince William Sound (PWS) covering the pre-EVOS decade from 1980 to 1989, constructed from published data.

The mass-balance model thus constructed allows for a number of inferences on the functioning of the PWS ecosystem, but more importantly, it allows identification of information gaps which subsequent work following the EVOS have filled to some extent.

Two examples in the present effort illustrate the usefulness of mass balance models: the first is a cross validation of trophic level (TL) estimates (the correlation between ECOPATH-derived TL values and stable isotope-derived TL values = 0.945); the second is a run of ECOSIM, which turns ECOPATH files into a set of differential equations that can be integrated over time, and which can be used to elucidate functional responses to ecosystem perturbations.

A brief outline of a proposed collaborative approach is presented within the context of the Trustee-supported project, "A mass balance model of trophic fluxes in Prince William Sound". This collaborative approach incorporates direct contributions of PWS researchers in the construction and verification of improved models (increased precision and resolution, explicit consideration of uncertainties) covering the post-EVOS period for both PWS and the area south of the Kenai Peninsula. This work is supported by the Exxon Valdez Oil Spill Trustee Council (Project 98330-BAA).

Project Number and Title: 98347 Fatty Acid Profile and Lipid Class Analysis for Estimating Diet Composition and Quality at Different Trophic Levels

Principal Investigators: Ron Heintz and Marie Larsen, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Hwy, Juneau, AK 99801, 907-789-6058 (office), 907-789-6094 (fax), ron.heintz@noaa.gov, marie.larsen@noaa.gov.

Abstract: Examination of the relative abundance of lipid classes and the determination of fatty acid profiles in predators and their prey provides researchers with a means to evaluate the energy transfer between trophic levels. Lipid classification analysis will provide a measure of an animal's nutritional condition which is based primarily on the amount of stored energy, or triglyceride, in the total lipid. The fatty acid profile of this triglyceride store will change as the animal forages and takes on the characteristics of the prey thus providing a "fingerprint" of its diet. Several studies have used this concept in foraging and dietary studies but the sources and scales of variation need further examination. This study supplements energetic analyses undertaken by APEX investigators by sampling herring and sandlance in separate locations of Prince William Sound and identifying the spatial variability in the fatty acid profiles and relate the differences to nutritional condition. Secondly, we will relate the fatty acid profiles observed in herring and sandlance to the energy content and fatty acid profile of concurrently sampled zooplankton. Samples will be processed by traditional methods for extraction and esterification processes, but will employ analytical instruments not typically used by lipid analysts. A high performance liquid chromatograph (HPLC) equipped with an evaporative light scattering detector (ELSD) will be used to separate and quantitate lipid classes and a gas chromatograph equipped with a mass selective detector (GC-MSD) will be used to quantitate individual fatty acids.

PROJECT NUMBER AND TITLE: 98348 - RESPONSES OF RIVER OTTERS TO OIL CONTAMINATION: A CONTROLLED STUDY OF BIOLOGICAL STRESS MARKERS, DIVING PHYSIOLOGY, AND FORAGING SUCCESS

Principal Investigators: Merav Ben-David, R. Terry Bowyer, and Larry K. Duffy, Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK 99775

Abstract: Investigations in Prince William Sound following the *Exxon Valdez* oil spill revealed that river otters (*Lutra canadensis*) on oiled shores had lower body mass and elevated levels of bioindicators, than did otters living on nonoiled shores. In addition, otters from oiled areas selected different habitat characters, had larger home ranges, and less diverse diets than those in nonoiled areas. These observed differences between river otters from oiled shores and those from nonoiled areas strongly suggest that oil contamination had an effect on physiological and behavioral processes in otters.

This project is designed to explore experimentally the effects of oil contamination on physiological and behavioral responses in river otters (*Lutra canadensis*). Fifteen wild-caught otters will be exposed to two levels of oil contamination under controlled conditions in captivity. Samples of blood, tissues and feces will be collected for analysis of biomarkers, and immunological examinations. In addition, behavioral observations on diving and foraging will be conducted to explore the effects of oil contamination on diving physiology and foraging success.

Project Number and Title: TM6A - Influence of Oil Hydrocarbons in Mink (*Mustela vison*): Digestibility and Rate of Food Passage.

Principal Investigators: R.G. White, J.E. Blake, J.E. Rowell and M. Sousa. Institute of Arctic Biology, University of Alaska Fairbanks, P.O. Box 757000, Fairbanks, AK 99775. (907) 474 7648. e-mail: ffrgw@uaf.edu.

Abstract: Following the Exxon Valdez oil spill we initiated a study to evaluate potential toxic effects of consuming known low doses of weathered Prudhoe Bay crude oil (wPBCO) in a mustelid. Mink are natural carnivores in the Prince William Sound region, they should typify physiological responses of carnivorous mammals and they have known sensitivity responses to trace amounts of environmental toxicants.

Objectives of this phase of the study were to a) determine the effect of ingestion of wPBCO on food intake, digestion and rate of passage and b) determine the dietary dose of wPBCO that could be tolerated nutritionally while assessing the impact on reproduction. Assumptions of the study were that wPBCO might act as:
a) a nutrient - whereby increasing consumption of wPBCO should result in increased intake, absorption and/or body weight maintenance.
b) a non-nutrient, bulk diluent - whereby increasing dietary intake should stimulate appetite and feces output.
c) a toxicant - whereby increasing consumption should lower appetite, digestive function and health status.

Studies were made in the Vivarium of the Institute of Arctic Biology. Mink were fed daily 225 g of high quality commercial mink ration containing 0 (control), 1, 10, 100, 1000 ppm WPBCO. The diet was fed for a 3-d pre-experimental period and then for a period when food intake, digestion and rate of passage were determined. Rate of passage of the oil-lipid phase of the diet was determined using tritiated glycerol-triether (H-GTE) and the aqueous-protein phase with Cr-EDTA.

Mink maintained body weight, appetite and digestion at exposures of 1 to 100 ppm. At 1000 ppm intake was slightly suppressed and rate of passage of food highly accelerated. At 100 ppm oil hydrocarbons were consistently detectable in the bile and liver. We concluded that consumption of crude oil at 100 ppm would not precipitate nutritional deficiency in reproductively active female mink.

Given the highly accelerated rate of passage of both the lipid and protein phases, accompanied by a lowered alimentary fill, we conclude the increasing intake of wPBCO is acting as a non-nutrient bulk diluent. No toxic effects were noted through pathology in the tenure of this study. Although no evidence for a nutrient limitation was found when mink were fed a diet highly fortified with carbohydrates and minerals, the results have import for the nutrition of carnivores consuming highly oil-contaminated foods in the wild. Negative effects would be greatest for nutrients likely to be limiting in the diet (e.g. carbohydrates and Ca), or those nutrients not absorbed by active transport mechanisms.

Project Number and Title: TM6B - Influence of Oil Hydrocarbons in Mink (*Mustela vison*): Effects on Reproduction.

Principal Investigators: John E. Blake, Janice E. Rowell, Marsha Sousa, and Robert G. White. Institute of Arctic Biology, PO Box 757000, University of Alaska Fairbanks, AK 99775-7000 (907) 474-5188, ffjeb@uaf.edu

Abstract: Our primary objective was to study the impact of consuming a low concentration of weathered Prudhoe Bay Crude Oil (wPBCO) on the reproduction of mink (*Mustela vison*). Mink have a well-recognized sensitivity to environmental pollutants, particularly PCBs. Oil used in this experiment was obtained from the Exxon Valdez and laboratory weathered to eliminate all hydrocarbons smaller than n-C_{10}. This approximated 2 weeks of natural weathering. Animals used were standard dark mink housed in outdoor cages with nest boxes.

Initially, we conducted a dose-response experiment to identify the lowest contamination level of wPBCO that would provide detectable hydrocarbons in the bile of mink without producing obvious clinical illness or significantly reduce palatability. Twenty-five mink were divided into 5 groups and offered feed contaminated with wPBCO at 0, 1, 10, 100, and 1000ppm for 5 days. The mink readily ate the diets and there was no significant decline in food digestibility or palatability. The 100ppm diet was the lowest level of contamination producing significantly ($p<0.05$) elevated levels of bile and liver hydrocarbons. In a concurrent trial, mink offered a choice did not discriminate between contaminated (100ppm) or uncontaminated feed.

In the main study, female mink (n=120) were randomly assigned to a control and 5 treatment groups. One treatment group was offered contaminated feed (100ppm) for 120-days beginning pre-estrus. The other 4 treatment groups were fed the same contaminated diet for 7-days during a specific stage of reproduction (pre-estrus, diapause, pregnancy, or lactation).

No significant effect was found on reproductive performance as measured by: successful breeding, gestation length, whelping success, total number of kits per litter, number of live kits per litter, mean litter birth weight, number of kits surviving to weaning, and kit growth rate from birth to weaning. The only significant anatomic or clinical pathological difference was found in the group fed wPBCO for 7-days during lactation. This group differed from controls ($p<0.05$) in mean total red blood cells, mean hematocrit, and mean hemoglobin.

This study shows that mink willingly consume feed contaminated with up to 1000ppm wPBCO and that consumption of feed contaminated with 100ppm wPBCO at specific critical times or continuously throughout the breeding cycle does not alter mink reproductive success as defined here. Additional studies are needed to evaluate the health and reproductive capacity of future generations. Caution should be taken in extending these results to conditions where the feed is not highly fortified or where food intake is limited below *ad libitum*.