Planning for the Future of Prince William Sound Resources
Sound Science Review & Planning Team

Science Plan
April, 1999

Mission Statement:
The Sound Science Review Team will review, plan, and recommend research that will provide practical results for user groups of the Prince William Sound fisheries ecosystem.

Goal Statement:
The Sound Science Review Team will focus research on projects that will improve our capacity to predict changes in fish populations. Our initial priority is to optimize the productivity and fitness of salmon resources.

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Executive Summary

The Prince William Sound Regional Salmon Planning Team (RPT), was established under Alaska statute 5AAC 40.300. The RPT was assigned the duty of preparing a regional comprehensive salmon plan to rehabilitate natural stocks and supplement natural production. One of the criteria used by the RPT to determine if a hatchery is compatible with the appropriate regional comprehensive salmon plan is the provision for protection of the naturally occurring stocks from any adverse effects which may originate from the proposed hatchery. The RPT convened a workshop in June of 1998 to identify related issues and research problems. Attendees of the workshop recognized a broad need for an ecosystem-scale perspective
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Planning for the Future of Prince William Sound Resources
Tim Joyce, Chairman

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April 28, 1999

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This letter prefaces the Implementation Plan developed by the Sound Science Review Team. This plan was the result of many hours of meetings and discussions regarding the priority topics of fisheries research in Prince William Sound (PWS). Since the backbone of the PWS fishing industry is salmon, the team decided that the most import issues at this time to study are related to salmon and more specifically the interactions between hatchery and wild salmon.

This team was composed of a diverse group of participants. We tried to include as large a group as possible including the scientific community, fishermen's associations, political subdivisions, native groups, and others who may have a stake in the health of the PWS salmon resources. Not everyone was able to attend every meeting, but most all of the invited groups were able to participate in at least one meeting. It is the diverse and wide spread support for this plan in Cordova that makes it somewhat unique and deserving of your attention.

As you will see from this document, the SSRT does not have funding to support this research. We hope to convince other organizations which fund scientific research to focus on the topics identified in this plan as a priority for this community and PWS. Please take the time to read this plan and consider its ideas when determining projects to fund in the near future.

Sincerely,

[Signature]

Tim Joyce
Chairman, RPT
interdisciplinary study aimed at identifying and understanding processes affecting the biomass, production, and behavior of specific animal populations in the PWS and North Gulf of Alaska ecosystems. SEA is the research and monitoring initiative organized for bioregional implementation by the PWSFERPG, which was presented to the Trustee Council of the Exxon Valdez Oil Spill (EVOS).

The overall goals of SEA were to improve our understanding of ecosystem level processes in PWS and to develop better predictive capabilities to determine the effects of natural and anthropogenic processes on animal abundance and production in the Greater Prince William Sound/North Gulf of Alaska ecosystem. The implementation of the ecosystem level approach to resource assessment developed in the SEA plan was envisioned to provide guidance for developing and improving future efforts of resource restoration, enhancement, and management within the area affected by EVOS.

The SEA studies focused on the "fisheries ecosystem". The fisheries ecosystem as defined includes the predators, competitors and prey associated with specified target species throughout their life history, as well as environmental processes that act to constrain the production of the target species, their predators, competitors and prey. The SEA plan encompassed an approach that sought to examine how physical and biological processes affected fish production along the life history and migratory routes for each species. The SEA plan presented a review of the current knowledge of pink salmon and herring, their life stages, and their roles in the ecosystem. It then presented findings on the probable contributions of each life stage to run failures. In many cases, the findings suggest that the readily accessible, best understood stages have the least likelihood of high mortality events. The plan developed approaches to study life stages in the Sound that have presented significant challenges using traditional methods. New technologies developed since the initiation of SEA, such as otolith thermal marking, have allowed for new approaches to problems that previously required application of assumptions leading to a broad range of plausible answers. Otolith thermal marking enables hatcheries to put an identifying mark on all salmon produced by any hatchery.

In an effort to continue the development of resource restoration, enhancement, and management within the area affected by EVOS, the SSRT has been organized at the request of the RPT, and is supported by a broad local constituency. Regional Planning Teams (RPTs) were established by state statute (SAAC 40.300) for the primary purpose of developing comprehensive salmon plans in various regions of the state. By law, RPTs include three representatives of the Alaska Department of Fish and Game (ADF&G) appointed by the Commissioner, and three members appointed by the board of directors of the appropriate regional aquaculture association. The commissioner may also request the involvement of representatives of federal and state agencies. An approved Comprehensive Salmon Plan (RPT, 1983) for Prince William Sound was established and signed by the Commissioner of ADF&G. This plan describes methods to rehabilitate natural stocks and supplement natural production. The Comprehensive Salmon Plan lists eight key assumptions used in the planning process, one of which was research programs that would be implemented to obtain information needed for optimizing salmon production. The SSRT has prioritized fishery ecosystem research they believe will be important in Prince William Sound.

Initially, the research plan will direct efforts in areas that will benefit salmon management. Interactions between hatchery and wild salmon stocks and monitoring the significant production parameters that were initiated by SEA are of primary importance. Answers to questions on these topics can provide information that will have immediate value to area management and research biologists. The SSRT plan will be dynamic, with implementation involving both short and long-term goals and projects. New technologies and new questions may arise and the SSRT will be expected to deal with those issues as they develop.

Priority Concerns

The Sound Science Review Team considers the interactions between hatchery and wild pink salmon stocks a priority concern, and intends to solicit research that addresses the many questions raised by this issue. If problems are found to exist due to interactions between hatchery and wild stocks, then SSRT research could direct the user groups to possible solutions, including, but not limited to monitoring production techniques and adjusting harvest parameters.

Some senior scientists and managers in the Alaska Department of Fish and Game have asserted that enhanced pink salmon stocks have been responsible for reducing, or even replacing wild pink salmon in Prince William Sound (Eggers et al. 1991). Other scientists and managers have offered dissenting views, claiming that hatchery stocks may not be harming wild stocks (Krohn 1993; Smoker and Linley 1997; Smoker et al in Press). In light of these differing outlooks, and the lack of data that proves either point of view, the SSRT believes that research should be forthcoming that provides practical solutions.
on salmon conservation research, and as such the Sound Science Review Team (SSRT) was formed with the initial purpose to plan research on the interactions between wild and hatchery-produced salmon.

Representatives from a variety of Prince William Sound user groups took part in forming the SSRT:
  Alaska Department of Fish and Game (ADF&G)
  Cordova District Fishermen United (CDFU)
  Native Village of Eyak
  Oil Spill Recovery Institute (OSRI)
  Prince William Sound Aquaculture (PWSAC)
  Prince William Sound/Copper River Regional Planning Team (RPT)
  Prince William Sound Science Center (PWSSC)
  United Salmon Association (USA)
  University of Alaska Fairbanks
  U.S. Forest Service (USFS)

The SSRT invited other Sound groups to participate, including the Villages of Chenega and Tatitlek, the city of Whittier, the city of Cordova, and the Valdez Fisheries Development Association.

Recently, new ecosystem related questions have become the focal point for public interest, primarily the nature and extent of hatchery and wild stock pink salmon interactions (RPT Workshop 1998, NMFS Workshop 1995, PWSSC Workshop 1991). Pink salmon are a dominant species in Prince William Sound (PWS), they are a robust indicator species dependent upon a healthy, dynamic environment. Pink salmon are also a significant source of nutrients from the marine environment to freshwater and terrestrial environments.

Through building on current knowledge from the Sound Ecosystem Assessment (SEA) program and other sources, the SSRT intends to address the interaction of hatchery and wild salmon to improve the conservation of PWS salmon stocks. The new research plan and implementation strategy take a 'fisheries ecosystem' approach to hatchery and wild salmon interactions in the PWS ecosystem that limit the production of fish stocks.

Straying is a natural phenomenon common in all salmon species as a mechanism for survival and colonization. Management and hatchery production practices may modify the extent and effect of salmon strays and the associated impacts. The SSRT categorized hatchery and wild interaction impacts into three areas for research topics. The first category is Conservation, in which genetic diversity between PWS salmon populations is studied. The second category is Ecology, which explores the competitive effects of hatchery and wild salmon both as fry and as spawning adults. The third category is Management, which examines how commercial fishing or hatchery practices will influence the hatchery and wild salmon interactions.

The primary users of the end products of SSRT-directed hatchery/wild interaction research would be the Alaska Department of Fish and Game sections of management and research. The Regional Planning Team would use the results of the research for future decisions. As a result, area fishermen and local communities would benefit from the improved management and predictive capabilities expected to result.

The initial phase of the just-concluded Sound Ecosystem Assessment (SEA) project focused on pink salmon and Pacific herring stocks, due to their major ecological roles in the Sound, as well as their economic importance to the communities. SEA used an ecosystem level approach as it sought to identify critical processes that affect survival of the target species, as well as their predators, competitors and prey, along the migratory routes that the target species utilize within the Sound. The SSRT will reference the SEA work where appropriate to avoid duplication of work, but will look for refinement of the SEA information using new technologies. The information obtained will provide useful tools for management, enhancement, and restoration of fishery resources.

Introduction

In 1993 a bioregional organization known as the Prince William Sound Fisheries Ecosystem Research Planning Group (PWSFERPG) was created on the initiative of concerned citizens in the Sound. Their purpose was to develop an ecosystem research plan directed at understanding natural and anthropogenic factors responsible for changes in the greater Prince William Sound (PWS) ecosystem. The plan, Sound Ecosystem Assessment (SEA), described an applied scientific
While otolith and harvest data need to be collected for in-season management decisions, after its acquisition and use, otolith data becomes a key component in evaluating the success of any predictive models or forecasts for pink salmon. Millions of enhanced and wild pink salmon are harvested in non-terminal locations. A reliable accounting from these significant mixed stock harvests is required. Acquiring a long-term database on the timing, magnitude, and the migratory paths of enhanced salmon entering and migrating through PWS will lend support to a host of future salmon management and resource related decisions.

Supplemental Production Techniques

There has been interest in the effects of hatchery production of salmon in the PWS area throughout most of the history of the fisheries. Recent questions about the effects of hatchery fish on wild fish, and if these effects are indeed negative, have come to the forefront.

Prince William Sound is unique in that one hundred percent of its hatchery-raised pink and chum salmon are marked as fry with distinct otolith (inner ear bone) identification. The more than 600 million marked pink and chum salmon released each year from PWS hatcheries present an invaluable research opportunity.

Survival of pink salmon at sea fluctuates unpredictably between less than 1 percent to more than 10 percent. The resulting uncertainty about allowable harvest causes large economic costs each season for the fishing industry and communities, and hurts the economic viability of the area fisheries. Improving our ability to accurately forecast such changes in survival rates will help to insure the persistence of the regional economy as it remains financially dependent on local fishery resources.

The first large investment of time and energy in salmon enhancement followed the Great Alaska Earthquake, when considerable effort was expended trying to rehabilitate streams where damage had occurred to valuable spawning areas. The Cooperative Fisheries and Oceanography Study instituted by the University of Alaska, area aquaculture associations, and ADF&G responded with enhancement efforts in the Sound. These efforts have resulted in programs to monitor sea surface temperatures as well as phytoplankton and zooplankton abundance. They have also included channel stabilization, construction of fish passes, clearing of fish barriers, and fry transplants.

The beginning of the hatchery era in PWS, the second phase in the development of supplemental pink salmon production, followed decades of poor runs and fishery closures – about one poor run or closure every five years. Collapse of the fishery twice in the 1970’s, associated with severe winters and minimal egg survival, led to the establishment of the hatchery program (Koernig and Noerenberg, 1976).

Hatchery related research has included efforts to determine the best incubation, rearing, feeding, and release strategies for pink salmon fry. Field work has included long term sampling programs to determine temporal and spatial distribution of zooplankton populations utilized by hatchery fish, coded-wire tagging programs and more recently otolith thermal marking to determine the marine survival rates of hatchery fish.

Exxon Valdez

After the Exxon Valdez Oil Spill (EVOS), the search started for links between the spilled oil and population declines in commercially important fish species. Evidence surfaced of damage to early life stages of pink salmon and herring. Precipitous declines of some wild and hatchery pink salmon as well as herring populations occurred in the generations following the spill. There is now evidence that declines in some pink salmon populations were attributable to oil damage.

Because the majority of pink salmon eggs in oiled areas of the Sound were deposited in intertidal portions of streams, they were susceptible to direct contamination from oil. Furthermore, areas of the Sound most heavily oiled following EVOS are also areas utilized most by rearing and migrating juvenile pink salmon from all parts of the Sound. There is evidence that oil contamination reduced the survival of pink salmon eggs, fry, and juveniles in oiled portions of the Sound, and there are some indications that oil related damage might be chronic. Sharr et al. (1993) found lower survival rates in eggs incubating in the intertidal portions of oiled streams than in unoiled streams in 1989 and 1990. Continued damage to incubating eggs was documented in oiled streams after 1990 as well (Bue et al. 1996, 1998). Evidence exists that buried weathered oil leaching into stream channels is more toxic than previously thought and could be a source of continued mortality in developing embryos (Pers. Comm. R. Heinz, NOAA NMFS Auke Bay Laboratory).
Recognizing the major economic and ecological role pink salmon play in the region, the SSRT decided to narrow the scope of this science plan from that of the original SEA plan. It is also expected that a narrower focus will allow more effective interaction with the public during the investigative process. Although initially narrowing our focus to pink salmon, we recognize that other marine life could be investigated in the future. Future investigations could involve other species of salmon: sockeye, chum, chinook, cohos, coastal cutthroat trout; other finfish: halibut, pacific cod, sablefish, walleye pollock, herring, shark, lingcod, rockfishes; and miscellaneous marine organisms: crab, shrimp, octopus, and squid.

One weakness of the SEA program as reviewed was the absence of a formal structure allowing for identification of end user groups, and refinement of the research products to best meet the needs of those groups. Through the integration of public input, it is felt that more effective tools can be crafted from the final research findings. These tools will give greater economic and social value to the plan.

The Alaska Department of Fish and Game would be the primary user group for the end products of this SSRT research plan. The area fishermen and the local communities would benefit from improved management and prediction capabilities. The information gained, and the tools developed, would be applicable to conservation and management in other areas of that state.

The following "Anthropogenic Factors" section discusses the goals of fisheries management in Prince William Sound, the techniques and strategies involved in supplemental (hatchery) production in the area, and the possible damages caused to wild and hatchery stocks by the Exxon Valdez oil spill of 1989.

The "Current Understanding of PWS Pink Salmon Life History and Population Dynamics" section gives an overview of the history and lifecycle of Prince William Sound pink salmon, and discusses their role in the ecosystem. The straying and homing phenomenon are introduced, as well as the differing opinions surrounding that phenomenon.

**Anthropogenic Factors**

**Fishing**

The economic and cultural importance of salmon fishing, in particular commercial fishing, in Prince William Sound calls for efficient management practices that will ensure the fishery continues for generations. The Department of Fish and Game's primary goal is to manage wild pink salmon resources on the sustained yield principal. Managing salmon populations for Maximum Sustained Yield (MSY) requires the consistent attainment of escapement goals (number of spawners) to ensure productive future salmon returns. In PWS, mixed wild stock fisheries have traditionally been managed through time and area restrictions, to provide for wild stock escapement in individual districts. By regulation, the Department of Fish and Game manages for a wild stock priority, i.e. to ensure escapement goals are met for each wild stock.

With the increase of enhanced stocks in PWS, the complexity of managing mixed stock fisheries is multiplied as enhanced (hatchery-produced) stocks have consistently dominated the total return in recent years. Appropriate mixed stock harvest strategies for wild stock conservation may result in reduced quality and under-utilization of enhanced stocks. Under-utilization of enhanced salmon due to conservative management may have the unintended consequence of higher rates of straying, over-escapement, and a poorer quality harvest overall. Currently, commercial fisheries management decisions in PWS attempt to optimize the exploitation of both enhanced and wild stocks. The goal is to simultaneously achieve both wild stock and corporate (hatchery) escapement goals as well as conduct an orderly, high quality harvest.

The Department of Fish and Game has already demonstrated that it is possible to effectively collect and use otolith thermal mark data for in-season management decisions that differentially exploit wild and enhanced populations in non-terminal locations. Recognizing that the commercial harvest is the primary cause of mortality in returning adult salmon, precise and correct management decisions will be required to effectively meet all of the above stated goals. This will require more effective use of otolith data to best structure time and area restrictions on harvest.

Management decisions can dictate the success or failure of the annual escapement of given wild stocks. Management strategies that over-exploit earlier timed wild stocks and under-exploit later timed hatchery stocks have the potential to dramatically alter native adaptive run timing and further complicate management in the future.
straying among streams in the western Sound indicated that straying was likely much more extensive than had been concluded in the past (Sharp et al. 1993, 1994, Pers. Comm., Joyce and Evans, ADF&G Cordova).

Survival from potential egg deposition to outmigration ranges between 0.1 and 22.8% in Alaska (Merrell 1962, Olson and McNeil 1967, Vallion et al. 1981, Taylor 1983). Spawner density can be a significant source of egg loss. Only 17% to 54% of the eggs each female carries may be fertilized and deposited in the stream gravel (Helle et al. 1964). (1) Low intra-gravel dissolved oxygen; (2) extremely high or low stream discharge; and (3) freezing primarily cause mortality during the embryo and alevin stages. Intra-gravel dissolved oxygen is affected by the permeability of sediments, stream discharge, local stream gradient, and temperature (McNeil and Ahnell 1964, McNeil 1966a, McNeil 1966b). Extremely low stream discharge causes mortality by desiccation (Neave 1953). Flooding causes streambed scouring and loss of embryos and alevins from reds (McNeil 1966b). Low air temperatures during periods of light snowpack or stream discharge causes mortality by freezing (McNeil 1966b). Fertilized embryos generally hatch in November, although the range of hatch timing is very broad. From hatching to outmigration, alevins are primarily dependent on the energy stored in their yolk for survival. Fry emerge from stream gravel and migrate to the sea between April and July (Kirkwood 1962).

The timing of the wild fry outmigration appears to be regulated by water temperature, photo period and number of days since fertilization, causing the fish to exit streams over a broad time period. High stream discharge also causes fry to outmigrate (Sharr and Willette 1992). Outmigrations of wild fish occur mostly at night and on ebbing high tides (Kirkwood 1962).

In contrast to the situation in streams, the embryo to fry survival rates in Prince William Sound hatcheries typically exceed 90 percent (PWS Regional Planning Team 1986). The fry are held in saltwater net pens where they are fed and released at a larger size and when the natural zooplankton bloom has peaked in late April or early May (PWS Regional Planning Team 1986).

Upon entry into the marine environment, pink salmon face a gauntlet of predators. Initially, they school near shore in bays and coves adjacent to their natal stream or hatchery (Hoar 1956, Hoar 1958). At this time, they are only 28 to 35 mm in length (Heard 1991), and Pacific herring and walleye pollock sometimes aggregate at stream mouths to feed on them (Thorsteinson 1962, Armstrong and Winslow 1968). In Prince William Sound, fry quickly migrate from bays to adjacent passages to feed, but they remain near shore (Wertheimer et al. 1993). During the first few days of nearshore residence, harpacticoid copepods and calanoid copepods comprise about 70% and 10% of the diet, respectively. As the fish grow, calanoid copepods and other prey comprise up to 80% of the diet (Wertheimer et al. 1993, Willette 1993, 1996). At about 55-65 mm in length, the fish move offshore into coastal bays and passages (LeBrasuer and Parker 1964, Simenstad et al. 1980).

Instantaneous daily growth during the initial 40 days of marine residence in PWS ranges between 0.030 and 0.052 percent body weight per day (Willette 1993, 1996). During this same period, the instantaneous mortality of pink salmon from the Bella Coola River, British Columbia ranges between -0.069 and -0.119 (Parker 1968). Mortality appears to be greater for slow-growing fish, because predators select the smaller salmon fry (Parker 1971, Healey 1982). In PWS, growth during the early marine period is related to survival to adult, but the parameters of the relationship change from year to year (Willette 1993, 1996).

Most juveniles appear to emigrate from the Sound in a counter clockwise direction, leaving through the southwestern passes (Willette 1993, 1996). Some juveniles that originate from the eastern and southeastern portions of PWS likely exit through Hinchinbrook Entrance. At about 100-125 mm in length, pink salmon leave coastal bays and passages and enter the coastal zone adjacent to the open ocean (Royce et al. 1968). The earliest movement of juveniles out of PWS probably begins in mid-June and continues into August.

Upon entering the open ocean, juvenile pink salmon from PWS occupy a 20-mile wide band and move southwest with the prevailing Alaska Coastal Current (Dodimead et al. 1963, Royce et al. 1968, Hartt and Dell 1979). Growth during this period is lower than earlier in the life history (LeBrasuer and Parker 1964). Mortality is also lower during the oceanic life stage compared with the initial 40 days (Parker 1968). By October or November, the fish have grown to 200-250 mm in length, and they begin moving from the coastal zone into the open Gulf of Alaska. Between January and March, pink salmon are found in a band between 40° and 56° N in the northeast Pacific (Takagi et al. 1981). A slow northward movement begins along a broad front in April, but inshore migration is not apparent until June (Takagi et al. 1981).

The diet is comprised largely of squids, euphausiids, and amphipods during this life stage, with squids dominating in the diet between 45° and 52° N (Pearcy et al. 1988). Considerable diet overlap occurs among immature Pacific salmon in the North Pacific; although, chum salmon feed on somewhat different prey than other salmonids (Pearcy et al. 1988, Welch and
In 1991 and 1992 these differences persisted despite the gradual disappearance of oil and were also observed in upstream areas outside the oiled zone. Willette (1993, 1996) observed diminished growth and survival for fry rearing in oiled areas in 1989 and Wertheimer (1993) has identified ingestion as a possible source of oil contamination for those fry.

Most effects observed in the early life stages disappeared, or could no longer be detected as oil dissipated. However, the persistent differences in egg mortalities between oiled and unoiled streams observed by Sharr et al. remained troubling. The chronic nature of these differences, their spread into unoiled areas, and preliminary results from continuing research by NOAA NMFS on intergenerational effects of oiling on fitness (Pers. Comm. R. Heinz, NOAA NMFS Auke Bay Laboratory) may be indicative of a lethal genetic effect. This lethal effect may now have spanned generations, and could be illustrated by recent evidence of large scale straying of both hatchery and wild salmon. The chronic damage to these pink salmon populations is somewhat localized and is declining and as a result the EVOS Trustee Council has listed pink salmon as recovering.

The negative departures from mean abundance of wild pink salmon populations in recent years are not outside the range of those observed historically nor do they fall outside the range of population levels predicted from current forecast models. There is naturally a large range in populations, and also imprecision in the existing models that predict population changes. Any departure from the mean or predicted numbers of unperturbed natural populations would also have to be huge to point to a demonstrable population level effect from a man-induced perturbation such as the EVOS.

Current Understanding of PWS Pink Salmon Life History and Population Dynamics

History and Lifecycle of Prince William Sound Pink Salmon

Pink salmon likely populated the streams of PWS following the last retreat of large continental glaciers. Each year, millions of wild pink salmon return to spawn in streams around the Sound. During the past twenty years, wild pink salmon returns ranged between 1,767,000 and 21,200000. Since maximum hatchery production was attained in 1988, estimates of hatchery produced pink salmon have ranged between 4.8 and 32.0 million adults (Morstad, et al. 1998).

Pink salmon have a virtually fixed two-year life cycle (Reviewed by Heard 1991). This characteristic causes greater interannual fluctuations in population size compared with other salmon species, because interannual survival variability is not buffered by variable age at maturity. The fixed two-year life cycle also results in genetic isolation between fish spawning in odd- and even-numbered years (Aspinwall 1974). Odd- and even-broodline pinks utilize somewhat different spawning habitats in PWS. Seventy-four percent of the even-broodline fish spawn in the intertidal portion of streams; whereas, only 46% of the odd-broodline fish spawn intertidally (Noerenberg 1953, Helle 1970).

Pink salmon spawn in over 800 streams in the PWS region between July and September. Most of these streams are less than 5 km long exhibiting widely fluctuating discharge in response to local precipitation. Early investigators distinguished pink salmon populations in the Sound based upon migratory timing and geographic distribution of spawning (Noerenberg, 1955, Kirkwood 1962, Pirtle 1961). Spawning streams in eastern PWS are generally longer and egg deposition occurs early in the season. Spawning along the remainder of the northern and western mainland shore occurs during the middle of the run and the latest spawning occurs on the large southern and southwestern islands. Of the three brood lines used at the four large pink salmon hatcheries in the Sound, one spawns in July, and the other two spawn in early September.

Genetic analysis of both odd and even year PWS pink salmon suggests strongly that there are, in addition to profound odd/even year differences, regional genetic differences. These differences are particularly detectable between collections from southwestern and eastern PWS streams, if not detectable stream-to-stream. There are also some significant genetic differences between upstream and intertidal populations (Seeb et al 1997; Habicht et al 1998). There may also be genetic differences related to run timing in PWS pink salmon as there are in other pink salmon (McGregor et al 1998). These analyses of regional pink salmon populations are consistent with analyses of pink salmon populations over broad geographical regions that indicate a balance of considerable gene migration (straying) and local population isolation (homing) within regions (Gharrett et al all 1988; Olsen et al 1998).

Indeed, evidence from tagging experiments in PWS suggests that straying among populations may be common (Sharp et al 1993, 1994; Pers. Comm T. Joyce, D. Evans ADF&G Cordova). Later qualitative investigations of pink salmon
Pink Salmon Interaction Hypotheses

The SSRT has identified seven initial questions about the interactions between hatchery pink salmon and wild pink salmon in Prince William Sound. These questions are intended as a starting point from which to focus research. They are phrased here as null hypotheses, accessible to testing.

1. Straying among PWS pink salmon populations is a natural phenomenon. Management and production practices do not modify the extent and effect of straying.
2. Straying rates are not influenced by density, hydrology, geography and habitat preference (inter tidal vs. upstream).
3. Straying hatchery produced pink salmon do not limit the production of naturally reproducing populations.
4. Temporal separations of returning hatchery and naturally reproducing stocks do not limit the effect of straying.
5. Current levels of hatchery and naturally reproducing pink salmon fry production do not force density dependent growth during early marine residence.
6. Predictions based on fry survival and condition indices of hatchery and wild salmon adult returns are independent of each other.
7. Hatchery rearing and release strategies can not mitigate the effects of predation and a limited forage base.

Implementation

This implementation plan was developed to build on our current understanding of the natural and anthropogenic factors contributing to the interaction between hatchery and wild salmon stocks. This section defines the objectives of the implementation plan in terms of each of the major hypothesis, and describes the strategies with which the field and modeling studies will be undertaken. General scientific and logistic problems are discussed and available technologies are described. A timetable for plan implementation is also presented.

The SSRT has divided the Implementation Plan into three areas of concern: Conservation, Ecology, and Management.

Conservation

...of locally adaptive diversity between PWS salmon populations

Conservation Hypotheses Statement:

(1) Modern theories assert that Prince William Sound pink salmon have evolved genetically discrete, ecologically specialized populations, which respond differently to physical and biological processes effecting mortality. The degree of local adaptation is limited by gene flow (straying and interbreeding) among wild pink salmon populations and could be affected by gene flow from hatchery pink salmon to wild pink salmon.

Research Objective List:

1.1 Estimate the extent and causes of migration (straying and interbreeding) between PWS salmon local populations.
1.2 Describe microclimate environmental differences and connection to genetic differences.

Maturing pink salmon appear in the southwestern entrances to PWS in mid June. The migration continues through August with fish generally moving in a clockwise direction toward their natal streams. Fish may require as long as 25 to 41 days to migrate from the southwest entrances to spawning riffles (Noerenberg and Savoie 1964). However, a portion of that time may be spent milling in front of the spawning streams and the actual travel time from the southwestern entrances to the stream mouths may be considerably shorter (Sharr and Sharp 1991, Fried et al. 1998). In some years, a portion of the run may also enter the Sound through Hinchinbrook Entrance (Noerenberg and Savoie 1964).

**Pink Salmon in the Marine Ecosystem**

Juvenile pink salmon are fed upon by numerous bird and fish species including gulls, kittiwakes, loons, terns, cormorants, auklets, puffins and kingfishers, cod, pollock, herring, sablefish, sculpin, salmon, and rockfish. Returning adult salmon are preyed upon by numerous marine mammal species including killer whales, porpoises, sea lions and harbor seals. Adult salmon are an important food resource for salmon sharks. A number of terrestrial mammals also prey on adult salmon as they enter their spawning streams. The decomposing carcasses of adult pink salmon are an important food resource not only for the decomposers, but for fish, crab, shrimp, mussels and other invertebrate species.

While both juvenile and adult pink salmon contribute to the productivity of the marine ecosystem they are dependent on that same system for survival. Changes in predator abundance, prey density, and large scale climatic events have a profound impact on pink salmon survival. At present our ability to predict such changes in the ecosystem is limited.

**Straying and Homing of Hatchery and Wild Pink Salmon**

Nearly all salmon return reliably to their natal stream to reproduce. Homing is a striking and well-known feature of their biology; through it local populations are genetically isolated and able to adapt to local environments. Straying, by which a small portion of salmon return to spawn in a stream different from their natal stream, also occurs. Through straying local populations are in genetic communication and are able to maintain genetic diversity. A long-term balance between homing and straying is important to the fitness of salmon populations and metapopulations (e.g. several papers in Heggberget, 1994).

Patterns of straying vary between species and among populations, and are not well understood. It is technically difficult to study straying, and requires observations of tagged or marked fish; most data come from observations of artificially cultured salmon (Quinn 1993). Straying is often thought to be greater in pink salmon than in other species, but evidence of this species difference is not strong (Quinn 1993). Straying from hatchery populations poses a particular risk to wild salmon populations because, if it results in interbreeding, maladaptive genes from hatchery populations can be introduced into wild populations and adaptive gene complexes in wild populations can be disrupted (Gharrett 1994, Reisenbichler 1997).

The extent of this risk is not well understood or documented (Quinn 1993; Campton 1995), but the policy in PWS and in Alaska has been to minimize the risk by restriction on stock transfers (ADF&G 1985). Straying away from pink salmon hatcheries in PWS and straying between wild pink salmon populations in PWS both may be more frequent than generally assumed (Sharp et al 1993).

Because straying and homing between species and populations of salmon is neither well understood nor documented, and because the risks, if any, of straying could pose important questions for fishery and hatchery managers and end users, the SSRT has identified this initial list of Pink Salmon Interaction Hypotheses. These questions reflect the current priority concerns of the SSRT: namely, to identify and define the interactions between hatchery and wild pink salmon stocks, and to seek out effective measures to be taken, should any be needed, by fishery and hatchery managers.
the effects of interbreeding on local populations, i.e. on run timing, fry survival, fry emigration, etc., including both wild and hatchery populations in the design.

1.3 Evaluate hatchery management and fish cultural effects on straying.

This will involve determining the relative effects on straying of alternative hatchery management and culture practices such as on site and off site releases, early small and late large releases, selection of early or late returning stocks, selection of a stock with a lower propensity to stray and selection of a stock that maintains commercial value for longer periods of time than current stocks.

1.4 Determine extent of outbreeding depression by appropriate controlled experimentation.

This will involve controlled experiments in which outbreeding is modeled by artificial hybridizations between populations and in which resulting offspring are observed throughout their life cycle for two generations. Relative survival between succeeding life stages and other indications of outbreeding depression (e.g. fluctuating asymmetry) should be observed in these experiments with all practical experimental power.

**Ecology**

...aspects of wild-hatchery salmon interactions

*Ecology Hypotheses Statements:*

(2) Hatchery-produced and wild pink salmon fry compete for food. Other species of salmon produced at hatcheries prey on pink salmon fry and compete with the pink salmon for food. Current levels of hatchery salmon and wild salmon force density dependent growth during marine residence. Growth rate is not generally density dependent, but rather more generally dependent on physical environmental factors - temperature, circulation patterns, and forage availability.

*Research Objective List, Growth Hypotheses (2):*

2.1 Determine distribution and abundance of prey, prey species composition, and ocean temperature along the migratory pathway.

2.2 Estimate growth rate of the early life stages of pink salmon.

2.3 Monitor bioenergetic model of growth and describe changes in optimal growth conditions over time.

2.4 Monitor atmospheric and oceanic conditions that constrain cross-shelf transport in the Gulf of Alaska, with particular emphasis on conditions that result in influxes of shelf-derived waters and associated zooplankton assemblages into Prince William Sound.

2.5 Monitor the temporal and spatial extent of cross-shelf transport of water masses and ocean-derived macrozooplankton from the Gulf of Alaska into PWS. Understand interannual and decadal scale variability in cross-shelf transport and associated zooplankton biomass.

2.6 Monitor spatial and temporal components of primary production within PWS, and patterns of zooplankton abundance in relation to patches of primary producers. From this, estimate amount of zooplankton crop derived from primary production in the Sound.

2.7 Monitor and compare the predation on 0-class hatchery and wild pink salmon during periods of both low and high macrozooplankton abundance within Prince William Sound. Test predation models focused on how predation pressure varies with abundance of alternative prey.
1.3 Evaluate hatchery management and fish cultural effects on straying.

1.4 Determine extent of outbreeding depression by appropriate controlled experimentation.

PWS Salmon Conservation Background:

Salmon in PWS spawn and their offspring develop in different kinds of places and different times of year, for instance short steep streams of the west and long flat streams of the east, intertidal and upstream gravels, early and late season streams. The number of eggs or alevins or fry that die is determined (apart from the effect of reed superimposition in generations of high spawner numbers) by the different microclimate conditions in those places, for instance temperature, flow, scouring, freezing. Because salmon tend to spawn in their own natal stream there is usually little interbreeding between local populations. These attributes of salmon biology have been observed in PWS or in other salmon habitats but are poorly known.

The outcome of these mortality forces totaled over all streams is a large part of the lifetime mortality that determines the eventual number of salmon to be safely harvested. If these mortality forces could be understood it would not only contribute to understanding of the locally adapted genetic structure of PWS salmon, it would also contribute to forecasting run strength, an important short term economic problem.

Because of this separate breeding, and because the vitally important physical conditions tend to be different from stream to stream, biological theory predicts that local populations are genetically different from one another, a phenomenon called local adaptation. Theory further predicts that disruption of the genetic differences by unnatural gene flow (straying and interbreeding) would lead to less survival and fewer surviving fry in each local population, a phenomenon called outbreeding depression. Theory predicts this loss would be exacerbated in the case of gene flow from hatchery populations because of their adaptation to an unnatural environment and their loss of natural mating behavior.

The first prediction, of genetic differences between local populations, has been generally supported by (EVOS-ADFG) genetic observations at the physical/chemical level. They have demonstrated broad scale differences between PWS populations over broad distances if not between adjacent local populations. The further prediction that unnatural gene flow will lead to loss of fitness in local populations (outbreeding depression) remains largely theoretical, supported by few observations. But because the consequences of unnatural gene flow could be significant in the long term and irreversible, we must take these predictions seriously. Determining the degree of wild stock straying and the resulting gene flow should be a top priority. This would provide a biological context for evaluating the degree of hatchery straying. Once hatchery straying has been evaluated, and if it is found to reduce fitness in local populations, policies and procedures could be implemented to reduce hatchery stock impacts. Harvest management policies that prevent unnatural straying could be identified and used. Hatchery management procedures that diminish straying and its effects could be identified and used. Production policies that conserve locally adaptive genetic differences could be further identified and used.

Conservation Research Objectives and Implementation Ideas:

1.1 Estimate the extent and causes of migration (straying and interbreeding) between PWS salmon local populations.

This will mean observing salmon, identifiable by natural or artificial tags, as they migrate into spawning grounds and spawn. It will mean observing both hatchery and wild populations. A number of techniques have been suggested (otolith thermal marks, genetic tags or markers, physical or chemical tags). Some are unproven and only genetic tags can demonstrate inherited effects. This will mean observing more than one generation (several to many) so that the relationships between straying and interbreeding with geographic difference and with run timing difference can be described.

1.2 Describe microclimate environmental differences and connection to genetic differences.

This will mean observing microclimate differences between stream habitats, upstream and intertidal, east side and west side, etc., including temperature and flow. These observations should be connected to controlled experimental estimations of
2.3 Monitor bioenergetic model of growth and describe changes in optimal growth conditions over time.

The degree of match or mismatch of outmigration and hatch timing to optimal growth conditions will be evaluated through a combination of field studies and modeling. Temporal and spatial changes in growth conditions in Prince William Sound will be evaluated with shipboard surveys. Zooplankton will be collected with ring nets, and temperature and salinity will be measured to 20 meters. Prey density and temperature data will be used to model the distribution of growth potential in Prince William Sound. Results from outmigration and hatch timing models will be used to estimate the proportion of the population that encountered optimal growth conditions.

2.4 Monitor atmospheric and oceanic conditions that constrain cross-shelf transport in the Gulf of Alaska, with particular emphasis on conditions that result in influxes of shelf-derived waters and associated zooplankton assemblages into Prince William Sound.

Employ numerical modeling studies that quantify the relative contributions of forcing functions driving cross-shelf transport processes. Focus interannual and decadal scale variations from the models on the principal forcing functions and the associated variability in cross-shelf transport and zooplankton biomass in the Gulf of Alaska.

2.5 Monitor the temporal and spatial extent of cross-shelf transport of water masses and ocean-derived macrozooplankton from the Gulf of Alaska into Prince William Sound. Understand interannual and decadal scale variability in cross-shelf transport and associated zooplankton biomass.

Conduct shipboard surveys on the shelf of the Gulf of Alaska as well as in the main entrances to Prince William Sound. By these surveys, determine physical, biological and chemical properties of shelf-derived water masses, and the extent to which these waters intrude into Prince William Sound. Sampling gear will include CTD, ADCP, net gear for horizontal and vertical sampling, and seawater collection and analysis equipment for the determination of shelf-derived water mass chemical properties (i.e. nutrients, silicates, other geochemical tracers). Natural stable isotope abundance has been shown to be useful in the Prince William Sound research context (Kline, multiple citations).

2.6 Monitor spatial and temporal components of primary production within PWS, and patterns of zooplankton abundance in relation to patches of primary producers. From this, estimate amount of zooplankton crop derived from primary production in the Sound.

Moored instrumentation (one or more C-Lab buoys), shipboard surveys employing C14 incubations, fluorometers, and remote sensing from either satellite or airborne sensors (such as SeaWiffs) will determine the spatial and temporal variability of primary production within Prince William Sound.

2.7 Monitor and compare the predation on 0-class hatchery and wild pink salmon during periods of low and high macrozooplankton abundance in Prince William Sound. Test predation models that focus on how predation pressure varies with abundance of alternative prey.

Researchers will monitor how large releases of hatchery fish compete with wild pink salmon for food. The data from these field studies will be applied to an existing model. Prey energy content, handling times, and reactive distance will be estimated for the principal prey species. Prey density and composition will be measured in areas with high and low pink salmon density.

Samples of zooplankton and epibenthic invertebrate prey will be collected with ring nets and pumps. Hydroacoustic surveys will be conducted to estimate the density of pink salmon in each area. Quantifying fish captured with a small-mesh purse seine will define acoustic targets. Ocean temperature and fish stomach contents weight will be measured in areas of high and low fish density. Analysis of variance will be employed to test for differences in prey density, prey composition, and stomach fullness between areas of high and low fish density. Foraging model estimates of the effect of fish density on prey density and prey composition will be compared with empirical results. A bioenergetic model will be used to estimate growth in each area, and analysis of variance will test for differences in predicted growth between areas.
(3) Hatchery rearing and release strategies can mitigate negative effects of predation and a limited forage base. Any mitigating effects of hatchery/wild pink salmon stock interactions by rearing and release strategies need to be found.

Research Objective List, Predation Hypotheses (3):

3.1 Monitor predation models focused on how predator distribution responds to localized, short-term aggregations of vulnerable prey (e.g. hatchery releases).

3.2 Monitor the effect of pink salmon production on regional predator population size.

PWS Salmon Ecological Background:

Artificially propagated salmon or hatchery salmon interact with wild salmon, as well as with other fishes through bottom-up and top-down processes, as well as interactions between bottom-up and top-down ecological processes.

Bottom-up processes are those affecting the common plankton food supply of hatchery and other fishes, while top-down processes are those involving predators common to hatchery salmon and other fishes. Bottom-up processes can affect the nature of salmon predators, thus the bottom-up processes can modulate top-down control. Bottom-up processes, i.e., regulation of the salmon food supply, are driven by the physical environment. Environmental control varies spatially, among the habitats used by salmon and their interacting species, and temporally, on a large range of time scales. Important time scales include diel (24-hour), fortnightly (tidal amplitude), seasonal (annual production cycle), inter-annual (variations among production cycles), decadal and inter-decadal (climatic forcing on a planetary scale).

Recent evidence confirms that both bottom-up and top-down processes are important factors for Prince William Sound fisheries, specifically in salmon and herring production. Process interactions provide an important population regulatory mechanism, since a dominant pink salmon predator, walleye pollock, is also a planktivore (Willette et al. F.O. paper). The size of pink salmon fry determines their vulnerability to predators when the availability of plankton induces pollock to switch from plankton to salmon fry feeding. These complex interactions have been modeled successfully (Patrick et al. F.O. paper), enabling predictability of hatchery salmon runs.

Each year, 600 million hatchery fry are released in Prince William Sound, each carrying its home hatchery's specific otolith mark. These identification marks allow for absolute certainties when sampling to determine which salmon are wild and which are hatchery-reared. Hatchery salmon can be tracked into the Gulf of Alaska and Bering Sea at which point they are mixed with unmarked as well as marked hatchery salmon from places other than Prince William Sound, as well as with wild salmon (Helle et al.). Otolith marking in Prince William Sound hatcheries will permit studies of interactions between hatchery and wild salmon that were not possible before.

Ecology Research Objectives and Implementation Ideas:

Growth Hypotheses (2):

2.1 Determine distribution and abundance of prey, prey species composition, and ocean temperature along the migratory pathway.

Prey density, prey species composition, and ocean temperature will be monitored in the area where fry are rearing. Stomach contents analysis will be conducted to test the prey selection component of the model. To insure that a range of environmental conditions is encountered, field validation studies will be conducted from April through July.

2.2 Estimate growth rate of the early life stages of pink salmon.

The bioenergetic model for pink salmon will be used at various times during the fry outmigration. Recovery of otolith marked fish will be used to compare growths rate of hatchery and wild pink salmon fry. Studies will be conducted in Knight Island Passage as the juveniles can be captured after the near shore rearing stage and prior to migration from Prince William Sound.
Harvesting pink salmon in the PWS commercial fisheries became more complicated as hatchery production increased. The wild stock populations could not sustain themselves at the same exploitation rates that could be applied to hatchery stocks. The ability to distinguish the hatchery and wild stocks in a particular fishery became essential for proper harvest management. Coded wire tags were applied to a portion of the release starting in 1987 in a large-scale effort to differentiate the hatchery stocks from the wild stocks. Major assumptions used in the coded wire tag program, and the slow turn around time limited the effectiveness of that program. Otolith thermal marking was started in 1995, with adult returns starting in 1997. These thermal marks allowed for absolute certainties in identifying the stock composition of a harvest. Small sample sizes allowed a limited test fishery to occur in questioned areas, providing information on the stock composition of the pink salmon prior to a full-scale fishery. Selective harvest or protection could be accomplished by utilizing the otolith information obtained.

Recent information collected from some selected streams in the southwestern portion of PWS indicated that a large percentage of pink salmon escapements were composed of hatchery produced salmon that had strayed from their natal release site (Pers. Comm. Joyce & Evans, ADF&G Cordova). The ability of the hatchery strays to produce viable offspring, and what effect they might have on the local wild stocks is a topic of speculation, and further complicates managing commercial harvests to achieve escapement goals in these streams. The otolith thermal marks provide the ability to monitor stream escapements both spatially and temporally.

Management Research Objectives and Implementation Ideas:

4.1 Identify and characterize the effects of harvest management on hatchery and wild populations.

Time and area regulate common property fishery harvests. Specific areas are known to contain high percentages of hatchery produced pink salmon, and are harvested more frequently than areas containing mixed stocks. Areas of mixed stock fisheries are managed based on information on the stock composition and by the observed stream escapement levels from aerial surveys.

If stream escapement levels are below the expected for a large area, then fishing will not be allowed on the mixed stock. Rather, fishing will be confined to a small terminal area around the local hatchery where much higher levels of the hatchery stock will be located. By the same token, if local stream escapements are at or above expected levels, then harvest will be allowed in known mixed stock areas. The percentage of hatchery produced pink salmon will determine the extent of the allowable harvest in the mixed stock areas.

4.2 Identify locations outside of hatchery terminal areas that will exploit hatchery populations with low exploitations of wild stocks.

Because of the 100% marking rate in hatchery stocks, otolith thermal marks provide precise estimates of the stock composition. Extracting samples from areas where large concentrations of pink salmon have developed could provide stock information heretofore unavailable. This information could allow the management biologist to harvest high quality pink salmon and remove that portion of a hatchery population prior to maturation and potential straying. One such area was discovered in Hidden Bay in 1997. Several hundred thousand hatchery-produced pink salmon were harvested which had previously been protected because of the unknown stock composition. Other areas, away from terminal areas where harvest of hatchery stocks could occur, might exist, but they need to be documented.

4.3 Determine geographic areas that are affected by straying.

Pink salmon do not always return to their natal areas to spawn. Salmon straying is a natural occurrence in the wild as a means of colonization of new habitats and as a survival mechanism. Hatchery salmon also stray, but by their sheer numbers straying hatchery pink salmon become significant. Some areas of PWS lie in a migration corridor for returning hatchery pink salmon, and streams along that corridor have been found, in a recent examination of otoliths from spawned carcasses, to contain a large number of stray hatchery salmon. Other areas in PWS have not been examined, and as such it is unknown if straying hatchery pink salmon is a localized occurrence or if it is Sound-wide.
Predation Hypotheses (3):

3.1 Monitor predation models focused on how predator distribution responds to localized, short-term aggregations of vulnerable prey (e.g. hatchery releases).

Predation levels will be assessed by estimating the distribution of pink salmon and that of their predators. Models of prey choice will predict diet as a function of zooplankton availability, and will be tested against diet composition estimates from stomach samples and field observations.

3.2 Monitor the effect of pink salmon production on regional predator population size.

The degree of coupling between predator population size and pink salmon will be estimated from effects on the reproductive success of the predator. This component of the program cannot be tested without long-term monitoring of the factors affecting recruitment of predator species.

For each hatchery in PWS, control study sites with similar habitat characteristics will be selected to test for the influence of large releases of hatchery salmon on local predator abundance, predator feeding rate and diet (measured before, during, and after releases). Hydroacoustic surveys will be conducted at each hatchery and at each of the corresponding study sites to estimate abundance and size composition of predators. Surveys will be conducted at each site before, during, and after fish are released from hatcheries.

Bottom and mid-water trawls and purse seines will be used to identify acoustic targets and collect samples for stomach analysis and to determine the ratio of hatchery salmon to wild salmon at each location. Researchers will measure the length and weight of the predators, and the weight of their stomach contents. Prey composition will be estimated from the analysis of stomach contents. Importantly, this collection will also determine the ratio of hatchery salmon to wild salmon. Bioenergetic models will be used to estimate feeding rates of predators using stomach fullness and water temperature data. Analysis of variance will be used to test for differences in predator abundance, feeding rates, and prey composition between hatcheries and corresponding study sites, and between time periods.

Management

...of Prince William Sound hatchery and wild pink salmon interactions.

Management Hypotheses Statement:

(4) Harvest Management can affect hatchery straying by targeting hatchery populations.

Research Objective List, Hypotheses (4):

4.1 Identify and characterize the affects of harvest management on hatchery and wild populations.

4.2 Identify locations outside of hatchery terminal areas that will exploit hatchery populations with low exploitations of wild stocks.

4.3 Determine geographic areas that are affected by straying.

4.4 Determine the relationship of run entry timing and straying potential of hatchery stocks.

4.5 Improve precision and accuracy of forecast methods to identify run strengths of individual hatcheries.

PWS Salmon Management Background:

Pink salmon hatchery production has been ongoing in PWS for 25 years. Initially, one hatchery (AFK), located in the southwestern area was the only hatchery releasing pink salmon. By 1986, four hatcheries were producing pink salmon in PWS with combined releases approaching 500 million fry.
Scientific peer review would be accomplished by the individual funding agencies so that the projects undergo accepted scientific scrutiny prior to submission of the end products to the SSRT. The final results, including all models produced, would be supplied to the project coordinator for incorporation into new management tools for the end users and for local archiving.

The SSRT anticipates a need for a project coordinator to successfully maintain group focus between the various researchers, and funding organizations and to insure the final study results are delivered in useable form to the public. This position would be funded in a yet-to-be-determined manner.

The project coordinator would report to the Regional Planning Team, and would participate in formulating any future science plan drafts. This would help insure continuity between current and future research efforts.

One suggestion is that the coordinator position could evolve into a science coordinator located at the Prince William Sound Science Center, but funded independently from the Center. Locating the individual at the Science Center would make them accessible to the public and researchers alike. Maintaining a management structure would improve the long-term success of multi-disciplinary ecosystem studies. By maintaining continuity in research programs, scientists could continue their programs without long interruptions for finding more funding, and the user groups would have information packaged for them, ready to use.

This person would coordinate two workshops per year. One workshop would be a formal presentation to the public highlighting the on-going research and presenting the results. The second workshop would involve the Principal Investigators, representatives from the funding agencies, and members of the SSRT, who would meet in round table discussions. By facilitating such meetings, the SSRT hopes to solve common problems, coordinate complimentary research in an effort to prevent overlapping work, and insure that all projects are accomplishing SSRT goals.

Literature Cited

ADF&G (Alaska Department of Fish & Game) 1985. Genetic Policy. Alaska Department of Fish & Game, Juneau.


4.4 Determine the relationship of run entry timing and straying potential of hatchery stocks.

Substantial numbers of hatchery strays were found in the southwest district in 1997 by Joyce and Evans. Those strays were found to be a higher percentage of the total stream escapement the closer the stream was to the hatchery and the later in the spawning run. It is not known if the pink salmon that stranded had staged at the hatchery of their origin prior to straying, or if they strayed along the way to their natal hatchery. Knowledge of the mechanisms of straying could provide opportunities in the management strategy to harvest hatchery pink salmon before they stray.

4.5 Improve precision and accuracy of forecast methods to identify run strengths of individual hatcheries.

Forecasting hatchery and wild salmon returns reliably and accurately would improve the management of the fishery through advanced warning of the need to protect or harvest wild stocks. Models based on an ecosystem approach developed through the SEA project hold promise for forecasting some of the hatchery components of the pink salmon returns. Forecasting the wild stock returns has been problematic, but otolith marks on all hatchery releases allow sampling to take place in areas of mixing of juveniles that could allow for computing a contribution to the total emigration. Combining the hatchery forecast with an estimate of the wild contribution to the emigration would allow the computation of the expected wild return. Generating and testing the models to provide accurate forecasts need to occur before these tools can be utilized by management.

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**Time Table**

February: Final draft of plan goes out to peer review.

April: RPT review of the plan.

April: Identify funding for administrator position.

April: Recruit an administrator to coordinate research efforts, meeting schedules, and presentations to the public.

April: Solicit research proposals that support the plan.

May: RPT incorporation of plan into the Regional Salmon Plan.

Ongoing: Review research proposals and solicit letters of support for said proposals.

March and September, Ongoing: Hold semi-annual review sessions. Present research results to the public in a spring meeting (coordinated with PWSAC’s spring board meeting and the spring RPT meeting). Investigators would meet to share information and refine research goals in the fall.

Ongoing: Deliver new tools and information to end users, and make available on a permanent basis through the PWSSC.

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**Project Administration and Final Reporting**

The SSRT is not a funding agency, but is a representative group of PWS community organizations that recognizes a need for research and information on PWS fisheries issues. In return for this information the SSRT is willing to provide a letter of community-based support for research projects which fall within the implementation plan guidelines. The SSRT will not peer review project proposals, but will judge them based upon the usefulness of the proposed end product.


Prince William Sound Aquaculture Program, 1975, Salmon Culture Program.


