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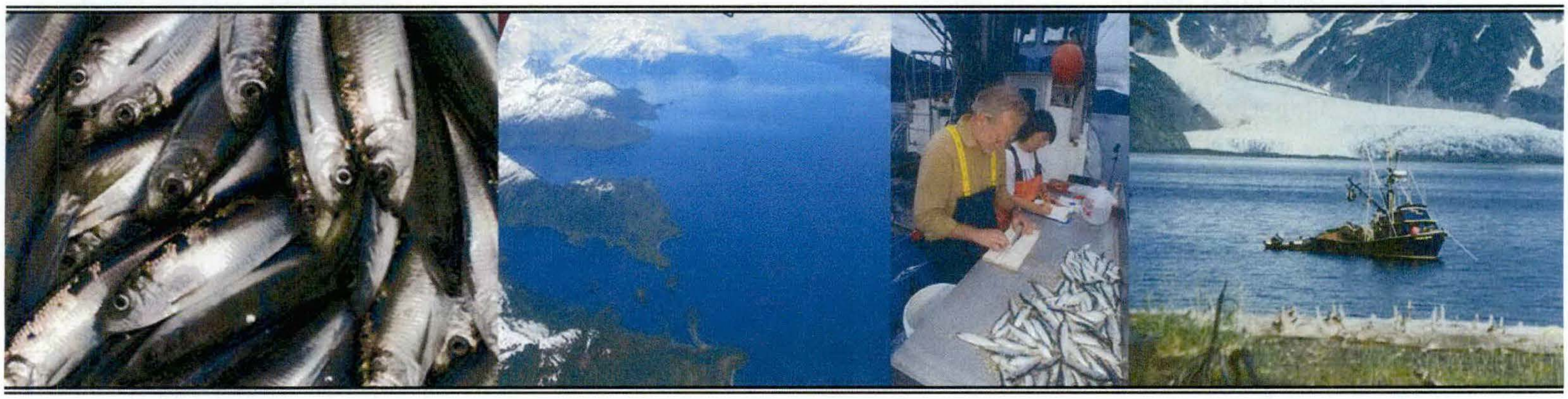
Exxon Valdez Oil Spill Trustee Council

Prince William Sound Integrated Herring Restoration Program



DRAFT – December 31, 2008

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TERMINOLOGY

Recovery – the return of the PWS herring population to some defined level. This can occur naturally or through restoration activities.

Restoration – the recovery of the PWS herring population through human actions.

Intervention –describes the activity that attempts to either increase PWS herring birth rates or reduce PWS herring mortality.

Enhancement – the result of restoring the herring population through intervention in a habitat that is capable of sustaining it.

Integrated program – is an ecosystem-based program organized around common goals and hypotheses determined and implemented through involvement by impacted communities and scientists to develop a teamwork that creates cost-efficiencies, open communication, and inter-related activities that inform each other to achieve the program goals.

Supplemental production – the release of cultured herring to increase the existing herring population.

Intensive aquaculture – the incubation of herring eggs and rearing of herring using traditional hatcheries and artificial environments.

Extensive aquaculture – using natural habitats (bays) to incubate herring eggs or to rear herring.

Recruitment - the process of older juveniles becoming sexually mature and joining the adult population. This definition is specific to Northeast Pacific herring.

Gamete - sperm or unfertilized ova prior to release from adult fish.

Egg – fertilized ovum, adhesive and sessile with developing embryo, and hatching in ~ 3 weeks.

Larva – recently hatched embryo, living off yolk sac (~5 days) and feeding on small (~100 μm) zooplankton, living in surface waters (primarily top 20 m) and part of the zooplankton community, although most abundance in nearshore habitats. In general, larvae are long and thin, with little resemblance to adult forms.

Metamorphic – process of change between larval and juvenile forms (pigmentation beginning, physical change).

Juvenile – the stages between the larvae and sexually mature adult. Young juveniles begin to assume the adult form and develop silvery-colored scales. In general, separate cohorts begin to aggregate together and form schools. The young juvenile stages are retained in nearshore habitats, but may venture into offshore (continental shelf) areas during their second or third years. The duration of the juvenile stages usually ends at age 3 or 4 when the fish are sexually maturing and joining adult schools.

Adult – the sexually mature stage, beginning at age 3 or 4 (36 – 48 months of age). Adults may form sub-populations that may, or may not migrate to shelf waters for summer feeding. In general, adult herring form dense aggregations during winter months and remain relatively immobile and feed opportunistically.

Mass marking – the ability to place a physical or chemical mark on large numbers of fish in order to determine their place of origin.

In-situ – taking place in the original environment; not moved.

Carrying capacity - the maximum population of a particular organism that a given environment can support without detrimental effects.

Otolith - calcareous particles found in the inner ear.

Infection – invasion of host cells or tissues by a pathogenic agent.

Disease - an abnormal condition of a host that impairs normal physiological function. Diseases can be of either infectious or non-infectious etiology.

> *Infectious disease* - a disease caused by a communicable, pathogenic agent. The most common classes of pathogenic agents include viruses, bacteria, fungi, protozoans, multicellular parasites, and prions.
>
> *Non-infectious disease* – a disease caused by factors other than infectious agents. Non-infectious diseases may be caused by environmental factors (e.g. skin cancer), contaminants (e.g. mercury poisioning), genetic disorders (e.g. Parkinson's Disease), etc.

Epizootic – 1) The occurrence of a disease in an animal population, clearly in excess of its normal expectancy, and derived from a common or propagated source; 2) An epidemic among animals; 3) Outbreak (jargon).

Herd immunity – the concept of resistance among a group to a disease to which a large proportion of the members are immune.

Pathology - the study of the essential nature of diseases, and especially of the structural and functional changes produced by them in the host.

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I. Introduction

The *Exxon Valdez* Oil Spill (EVOS) Trustee Council has classified the Prince William Sound (PWS) population of Pacific herring (*Clupea pallasi*) as a resource that has not recovered from the effects of the 1989 oil spill. The PWS herring population was increasing prior to 1989 with record harvests reported just before the spill. The 1989 year class was one of the smallest cohorts of spawning adults recorded and by 1993 the fishery had collapsed with only 25% of the expected adults returning to spawn. The PWS fishery was closed from 1993 – 1996 but reopened in 1997 and 1998 based on an increasing population. Numbers again declined in 1999 and the fishery remains closed today. Reasons for the population collapse and failure to recover remain largely unknown.

The main goal of this plan is to determine what, if anything can be done to successfully recover Pacific herring in PWS from the effects of the *Exxon Valdez* Oil Spill. In order to determine what steps can be taken, this plan will examine the reasons for the continued decline of herring in the Sound, identify and evaluate potential recovery options, and recommend a course of action for achieving restoration.

Recovery Objective: Based on the current information on Pacific herring in Prince William Sound, the Herring Steering Committee recommends the following recovery objective:

Restore the herring population in Prince William Sound (PWS) to a "recovered" (see below) status via a collaborative process between science and impacted communities:

- develop a collaboration between science and impacted communities
- determine the reasons for the lack of recovery of the PWS herring population
- determine the social, economic and ecological feasibility of intervention
- monitor and evaluate the success of restoration efforts
- improve accuracy of population predictions with more reliable information

The population of PWS Pacific herring will be considered recovered when:

1. the spawning biomass has been above 43,000 metric tons for 6 to 8 years;
2. there have been two "strong" recruitments of age 3 fish in those 6 to 8 years, where strong is $\geq$ 220 million fish (or log deviation $\geq$ 5.67);
3. spawning occurs in at least three geographic regions of PWS (e.g. North, East and West).

1. <u>Why Herring, Why Now?</u>

Twenty years have passed by since the Exxon Valdez Oil Spill but herring numbers are too low to sustain a commercial fishery. More importantly, perhaps, is the fact that herring are an integral part of every inshore ecosystem on the northwest coast of North America and the Prince William Sound ecosystem cannot be considered to be recovered from the effects of the oil spill until herring abundance has been restored.

Herring are vital to many different species, humans included. They are an important species for transferring energy from zooplankton to upper level predators such as whales, sea birds and larger fish. It is this vital placement in the food chain and the complex interactions between their food sources, zooplankton, and their predators that makes the examination of herring restoration very challenging. Additionally; population, community, and ecosystem-level resonations of enzootic and epizootic disease cycles contribute to a very dynamic set of conditions that make it difficult to recommend strategies. Each step in the PWS herring population life cycle and the concomitant interaction with either food or predator could be the "bottleneck" point or limiting factor(s) prohibiting their recovery. Herring have not recovered naturally and it is time to make a concentrated and coordinated effort to identify the most likely limiting factors and to identify enhancement opportunities based upon rigorous science.

Scientific research has been conducted on all the injured species in PWS and injured services have also been examined in great detail. Several recovering species have direct links to herring and are a tangible measure of the importance of this keystone species to a full recovery of all species and the ecosystem as a whole. All recovering human services are in some way linked to the recovery of herring with commercial fishing having, perhaps, the most far-reaching implications. The economic effects of commercial fishing losses are felt across entire communities, from the fishes themselves to the related service industries.

There is urgency to examining herring restoration at this point in time while there is still a viable, remnant stock from which to work. Additionally, momentum and a partnership have developed between the scientists and the affected communities to further this effort.

2. The *Exxon Valdez* Oil Spill and Pacific Herring

The PWS herring population was increasing prior to 1989, with record harvests reported just before the oil spill (Figure 1).

After the oil spill, the 1989 year class of herring was one of the smallest cohorts of spawning adults recorded and by 1993 the fishery had collapsed with only 25% of the expected adults returning to spawn.

The population collapse stopped the commercial fishery, and ignited debate about the cause. Some are convinced that the spill was the cause; others believe it was caused by natural systems (Rice and Carls 2007). Unfortunately, we will never know with certainty what the cause was or when it started, as there is a conflict between data interpretations (Hulson et al. 2008, Thorne and Thomas 2008). Highly virulent pathogens are currently endemic to Pacific herring populations, unhealthy fish were detected at the same time as the crash, and multiple stressors (including exposure to PAH's) can certainly exacerbate some chronic infections to epizootic disease; however, disease surveillances did not occur in the previous years. Hydro-acoustic estimates of over wintering populations were initiated in 1993, after the decline in population was detected, and hence are not available during or prior to the decline or crash. The spill certainly affected the 1989 year class, as eggs and as larvae, resulting in one of the poorest recruitments ever observed. While oil continues to linger on some beaches in PWS, lingering exposures to new year classes is not suspected because there is little or no overlap of present day spawning sites with lingering oil. There is no known mechanism for continued oil exposures to this species. Direct oil effects were no longer detectable after 1990 in herring (Pearson, Elston et al. 1999; Carls, Marty et al. 2002) and strong recruitment of the 1988 year-class (in 1991) suggested that oil effects were restricted to the 1989 year class. No plausible oil-related mechanisms have been developed to explain a delayed response after intervening years of no response. Understanding the cause of the population decline or crash, and when it started, is no longer possible with certainty.

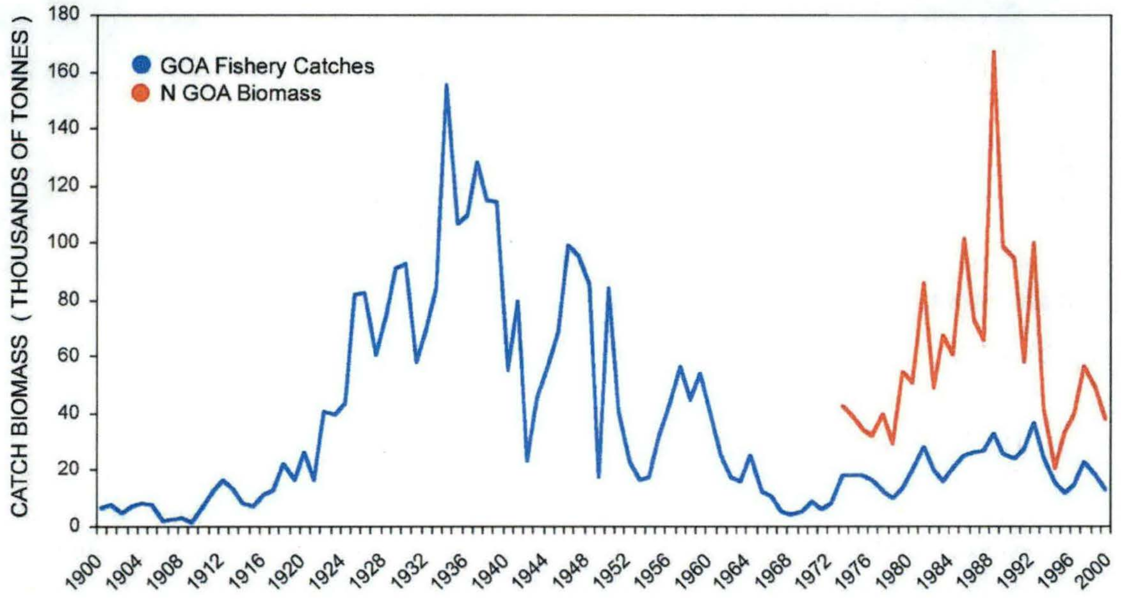


Fig. 1. Pacific herring fishery catches in the Gulf of Alaska (blue line) and estimated annual biomass of herring in PWS (red line) (Brown, 2007).

While oil continues to linger on some beaches in PWS, lingering exposures to new year classes is not suspected because there is little or no overlap of present day spawning sites with lingering oil. There is no known mechanism for continued oil exposures to this species. Direct oil effects were no longer detectable after 1990 in herring (Pearson et al. 1999; Carls et al. 2002) and strong recruitment of the 1988 year-class (in 1991) suggested that oil effects were restricted to the 1989 year-class. No plausible oil-related mechanisms have been developed to explain a delayed response after intervening years of no response. Understanding the cause of the population decline or crash, and when it started, is no longer possible with certainty.

3. <u>Basic Herring Biology</u>

The Pacific herring is one of 180 species of fish classified within the family Clupeidae and the order Clupeiformes. They occur in waters of the continental shelf from northern Baja California to arctic Alaska, westward to Russia and south to Japan and the west coasts of Korea. They also occur along the Arctic Ocean from the White Sea eastward to Ob Inlet (Hay 1985) (Figure 2).

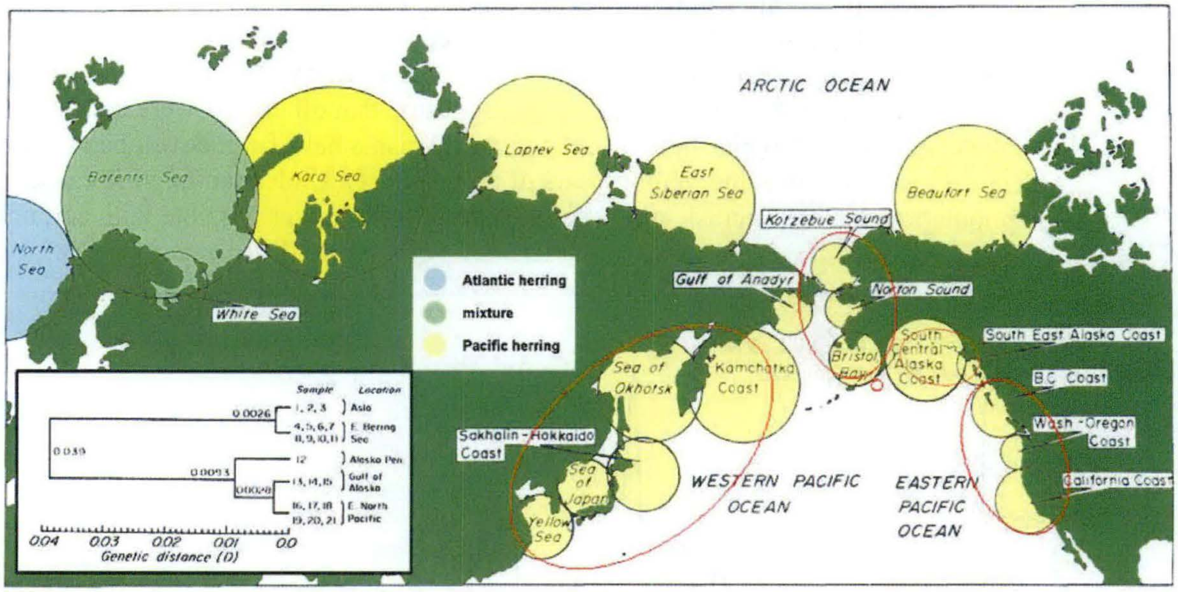


Fig.2. Global distribution of Pacific herring (adapted from Hay 1985)

The four Pacific herring life stages, eggs, larvae, juveniles and adults, are all found in PWS in various seasons and locations (Brown and Carls 1998). Spawning in PWS typically takes place in April and the spawning season varies from five days to three weeks. Pacific herring typically spawn along the same beaches each year, although the volume of eggs and shoreline distances varies (Brown and Carls 1998; Carls et al. 2002). For example, from 1994 to 1997, the annual spawning beach length ranged from 23.3 to 68.5 km (Willette et al. 1998). Figure 3 shows Pacific herring spawning beds located throughout PWS based upon 1973 - 2006 data from the Alaska Department of Fish and Game (Moffitt 2006 pers. comm.)

During spawning, the eggs attach to eelgrass, rockweed (*Fucus* sp), and kelp in shallow subtidal and intertidal areas. The eggs hatch in May, approximately 24 days after spawning depending on temperature (Hart 1973; Brown and Carls 1998). After hatching, the larval herring migrate to the surface, congregate nearshore and continue to grow. Initially, the larvae have yolks that will last a few days, are poor swimmers and currents significantly affect their distribution. The larvae become juveniles in July, about 10 weeks after hatching. In the fall, the juveniles move into deeper water. However, nearshore habitat remains important for at least the first year, and they may spend up to two years in nearshore areas or bays before joining the adult population residing in deeper waters (Brown and Carls 1998).

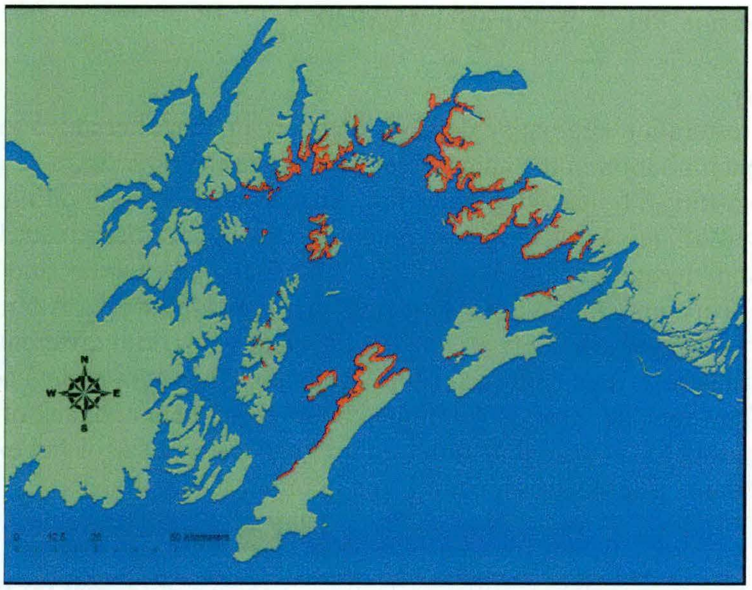


Fig.3 Pacific herring spawning beds located throughout PWS based upon 1973 - 2006 data from the Alaska Department of Fish and Game (Moffitt 2006, pers. comm.)

In PWS, adult Pacific herring rarely spawn before their third year and the average life span of a PWS herring is nine years. After spawning in the spring, adult Pacific herring disperse from the spawning aggregations to multiple schools in deeper waters, presumably close to the entrance of PWS (Brown and Carls 1998). In the fall, adult and two-year old fish return from summer feeding areas and over-winter in central and eastern PWS.

Newly hatched larvae carry a yolk sac that is typically depleted in the first week. The earliest larval stages begin feeding on the eggs of invertebrates and small zooplankton, such as copepods. While the larval Pacific herring grow and congregate nearshore through their first summer, they continue to live primarily on copepods but may also e at other crustaceans, barnacle larvae, mollusk larvae or young fishes (Brown and Carls 1998). As they move into deeper waters, copepods remain an important food for both juvenile and adult pacific herring, but adults also feed on larger crustaceans and small fish. During winter, as temperature and light decrease, food supply becomes limited and both young and adult year classes stop feeding functionally.

Survival of young herring through the winter depends on the amount of food that was available in the preceding summer and their ability to store sufficient lipid reserves to sustain them over the winter. For the older age classes, winter is less limiting on direct survival, but may affect their reproductive condition and spawning capacity in the spring (Carls et al. 2001).

II. Integrated Herring Restoration Plan – Restoration Options

1. Factors Limiting Recovery
The effectiveness of any restoration alternative depends on applying that alternative to bypass or overwhelm some limitation in the natural recovery of the PWS herring population. This leads to asking a fundamental question, what are the factors limiting herring recovery in Prince William Sound? Several potential factors have been identified including disease, predation, oceanographic changes, contaminants in the habitat, and competition. It may also be a combination of these factors that limits recovery. Adding to the complexity, differing life stages are likely affected in different ways or to different degrees by environmental factors. Rice and Carls (2007) provide a thorough review and synthesis of this topic. They conclude that the continued poor recruitment and lack of recovery of PWS herring probably is a combination of more than a single factor but exact explanations remain uncertain. These items are not listed in order of importance.

Disease
Disease prevalence must be monitored, by regular collection of specimens to test for the presence of pathogens. A historical limitation to the integration of population-level disease surveys into fisheries management has involved reactive, rather than proactive disease screening and decision-making process. Once an epizootic is underway, disease kinetics and spatial movement of the epizootic often result in a very difficult situation to manage on a real time basis. Therefore, in addition to monitoring for the prevalence and intensity of key pathogens in PWS herring, molecular and immunological tools must be developed that can that forecast the potential for disease on a population scale. Once these predictive tools are developed, they must be implemented concomitantly with infection, disease, and stock assessment surveys. Tool development should be an iterative process whereby the tools are tested and adjusted on an annual basis; additionally, due to unique characteristics of each of the primary herring diseases in PWS, select tools will be specific to each disease. As well, there must also be some provision to respond to epizootics as they occur: when die-offs are observed, rapid assessments must be done to discover the cause and extent of the outbreak. A preconceived disease action plan, containing multiple contingencies specific to different disease conditions, is essential to mitigating the population-level impacts of an epizootic.

Predation
Previous research has not eliminated predation as a limiting factor in PWS. Herring are of great importance in the PWS ecosystem; as roughly second- or third-order consumers, they transfer energy from zooplankton to a wide variety of consumers including humpback whales, harbor seals, birds, and other fish. Herring may also significantly influence or control the grazing pressure exerted on lower trophic levels (Cole & McGlade 1998). The relationships between herring and multiple predators is complex, but there it is plausible that abundant predator populations could significantly deplete the herring populations and or prevent recovery.

Oceanographic changes
Climatic changes can alter water temperatures thereby affecting the energetics of the fish. Climate changes can also alter the timing and location of productivity important to herring

feeding. Changes in circulation could alter larval dispersal and survival. Biological regime shifts associated with climate change can also alter the predators feeding on herring.

The exact conditions that favor herring survival remain unknown. Brown (2006) found that the Gulf of Alaska populations increased during the positive phase of the Pacific Decadal Oscillation (PDO), when the Aleutian low intensifies and warm water is found along the Alaskan coast, but other investigators concluded that herring do better during the negative phase of the PDO (Anderson and Piatt, 1999). Linking herring survival to a climatic index still does not indicate what aspects of that climatic index enhances herring survival.

Competition
With depressed population levels it may be possible that another species has filled some of the niches in the ecosystem that herring previously occupied. The competition for habitat or food at some life stage may limit the success of herring. Juvenile gadids, such as saffron cod or pollock, are often found in large numbers in the same habitats as juvenile herring. Although the Sound Ecosystem Assessment program found that there was no food competition between age 0 herring and pink salmon smolts (REF) there may be competition between these two species at different life stage or for different resources. At least one recent modeling project suggested that hatchery released salmon smolt are responsible for maintaining the depressed herring populations (Deriso et al. 2008). The roles of competition as a factor that prevents herring recovery remains speculative.

Contaminants in habitat
The waters and majority of the PWS shoreline are among the cleanest habitats in the world. Polynuclear aromatic hydrocarbon loads in the water are very low (Carls et al. 2002). Less than 0.2% of the shoreline has evidence of oil contamination, the current and historical human habitation sites and areas where *Exxon Valdez* oil remains (Boehm et al. 2004; Short et al. 2002 report). Only trace concentrations of persistent organic pollutants (e.g., pesticides and polychlorinated biphenols) are detectable in intertidal areas (Short et al. 2006 report).

While oil continues to linger on some beaches in PWS, lingering exposures of new herring cohorts is not suspected because there is little or no overlap of present day spawning sites with lingering oil. There is no known mechanism for continued oil exposures to this species. Direct oil effects were no longer detectable after 1990 in herring (Pearson, Elston et al. 1999; Carls, Marty et al. 2002) and strong recruitment of the 1988 year-class (in 1991) suggested that oil effects were restricted to the 1989 year class. No plausible oil-related mechanisms have been developed to explain a delayed response after intervening years of no response.

2. <u>Core Data Collection</u>
There is a necessary amount of basic information that is required to know where to focus any restoration activities, and to know whether or not any restoration option has been effective. Foremost, it imperative to have some idea of how many herring there are in PWS and where they occur. Although there is currently an annual stock assessment done

by ADF&G, the data requirements for a (typically conservative) management plan are substantially different from those of the restoration plan outlined here. Supplemental surveys that will improve spatial and temporal estimates of herring population size are required, for both adult and juvenile schools. These supplemental surveys will be most useful if they complement the fall and spring surveys done by ADF&G, but some additional surveys will be required.

It is also important to have some idea of how many new individuals are entering the population. ADF&G currently conducts aerial surveys for spawn extent in the spring. The fate of that spawn may be followed by a combination of focused surveys for larvae, and estimates of larval drift from hydrographic models (which are currently being developed by the AOOS project). That knowledge will then inform the abovementioned surveys, and further strengthen estimates of how many herring there are in PWS.
Finally, it is critical to address several questions posed by the prior section on factors that are currently limiting recovery:

Disease: Disease prevalence must be monitored, by regular collection of specimens to test for the presence of pathogens. As well, there must also be some provision to respond to epizootics as they occur: when die-offs are observed, rapid assessments must be done to discover the cause and extent of the outbreak.

Predation: It is required to have some idea of how many individuals are being removed from the population. Surveys to determine the abundance and distribution of key herring predators are necessary.

Oceanographic conditions: Environmental conditions set up the growth environment for herring: temperature plays a role in metabolic and therefore growth rates, and nutrient availability controls primary production, which ultimately determines how much zooplankton food are available each year. Moreover, the amount of transfer between PWS and the Gulf of Alaska (in terms of both water properties and plankton) can impact the ecosystem within the sound (Cooney et al. 2001). The environmental and food climate within PWS thus must be monitored with targeted surveys.

Competitors: As with predators, there is a requirement to have some idéa of the abundance and distribution of important competitors to herring, in order to know if they have been displaced within the ecosystem of PWS. This may also be determined by surveys.

In summary, there are basic information needs about the state of both herring and the PWS ecosystem, that are required for the continual development of the IHRP so that restoration activities may be assessed and modified as necessary. Herring are an integral part of the PWS ecosystem, and an integrated ecosystem monitoring program will help draw the various programs within the IHRP together.

1. ADFG stock assessment program
2. Stock assessment program supplement

   a. increased spatial and temporal scale of overwintering (fall & spring) surveys
   b. evaluation of stock assessment techniques, especially spawn data input
   c. evaluation of age at maturity (monitor gonad size & weight)
   d. identification of stock structure (otolith chemistry, tags)
   e. Juvenile surveys (summer, fall, spring)
   f. establish distribution
   g. use tags or otoliths to determine spatial contribution
3. Tracking survival and recruitment
   a. impacts of seabird, marine mammal and fish predators and disease
   b. evaluation of interspecific food competition of herring with pink salmon, sand lance and juvenile Pollock
   c. evaluate interrelationship among predation, prey availability, competition, and disease
   d. evaluate food limitation and key food/energy sources (outside or inside PWS) at juvenile and adult stages

3. <u>Overview of Restoration Options</u>

It may be possible to restore herring populations in Prince William Sound through the use of direct restoration or intervention methods such as the moving of fertilized eggs to habitats more favorable for survival or the release of juveniles reared in hatcheries. However, the efficacy of these or other direct restoration methods need to be proven and may remain technically infeasible or too costly. Furthermore, the use of direct restoration activities may cause unintended adverse environmental outcomes such as the increase in incidence of disease to herring or other fishes. Well-designed pilot projects can be used to test the efficacy and provide an experimental platform with which to better understand the factors limiting herring recovery, which must be accounted for in the implementation of full scale restoration activities.

The issue of restoration through intervention and particularly enhancement of marine fish populations is controversial. There is part of the fisheries science community, mainly from the ecological side, that is steadfastly opposed to the concept of marine finfish enhancement. There is another component who are comfortable with the concept. However, even the detractors of the concept suggest that the activity may be warranted when all other conventional management procedures fail. Even then there are reservations about the efficacy of the approach if density-dependent factors regulating recruitment occur after the release of cultured fish.

A decision to investigate the feasibility of a particular intervention alternative does not necessarily mean that the EVOS Trustee Council is committed to implementation of a large-scale intervention program. Instead, the intention is to examine the implications of the concept, as it applies to herring in Prince William Sound. Full scale intervention activities would require several years of preparation, mainly to develop and determine some technological issues, such as mass marking of fish. Mass marking and other technological activities are fundamental pre-requisites of intervention activity. Therefore, because the development of these technological issues will take time, it is important that some investigations begin immediately. It also is important to understand that these investigations also could result in a definitive conclusion that the restoration activities are impractical or far too expensive.

The Integrated Herring Restoration Plan Steering Committee discussed and prioritized several restoration alternatives. The alternatives are presented in the order that they were rated by the group by possibility of success. Each alternative has advantages and disadvantages that should be considered when designing pilot and full scale programs. Because it is not clear what is the limiting factor to herring recovery it is not possible to predict the efficacy of any alternative so a plan to test the efficacy is essential to the development of that restoration approach.

Regardless of which intervention alternatives are developed, monitoring and research will play an important role in the restoration process. Monitoring will be required as part of any active restoration program to evaluate the efficacy of various active restoration methods, the status of recovery, and the potential occurrence of unintended adverse impacts. Research will be needed to support the particular activity and to identify if limiting factors elsewhere in the herring life cycle will prevent the restoration activity from being effective.

4. Restoration Options

   a. **Supplemental Production**

   Supplemental production is an enhancement activity designed to release cultured herring to supplement natural recruitment to assist recovery or restoration of the population to historical levels. Depending on the specific approach, supplementation can bypass early life stage mortality caused by larval drift, food availability, habitat competition, predation, and disease. For example, although juvenile herring could be released into nursery habitats after a few months, maintenance through the first winter would allow continued feeding and avoid winter starvation, a factor that may be limiting the population. The cost of any supplemental program depends on the length of time that the herring are maintained. All fish released must be marked to allow the efficacy of the program to be determined. Fundamental questions regarding the factors limiting recovery may be addressed with a well designed mark-recapture programs. There is also the potential for controlling the release site environment in a manner that can inform the efficacy of other restoration alternatives.

   Supplemental production will be attempted only if the guiding principals are fulfilled (do no harm, base all activities on science, and be economically responsible) and the PWS herring biomass does not rebound naturally. To avoid harm, fundamental questions concerning the potential of introducing disease or exacerbating it in PWS herring will be addressed before any supplemental activities. This is the subject of ongoing research. Science-based tools, such as mass marking tools will be developed, authenticated, and peer reviewed before enhancement activities are considered. Mass marking is the subject of a pending workshop. A 'core' monitoring program to measure natural impacts on the PWS herring population must be fully operational before enhancement activity is considered. Furthermore, supplemental production will only be considered only if estimated probabilities of success are reasonable. Costs will be estimated and discussed; no plan will advance if funding mechanisms are inadequate or cost-benefits are inappropriate.

To understand the implications of a supplemental program, one or more supplemental designs must be proposed for the purposes of cost analysis, regulatory implications, and consideration of potential positive and negative impacts on the herring population and the PWS ecosystem. In addition, a well designed supplemental program would also provide the information needed for developing a full scale in situ herring rearing program. These are the purposes of the supplemental proposal that follows.

The proposed supplemental program presumes juvenile herring will be released in spring, avoiding winter starvation conditions and that it will begin as a pilot program. Advantages of this alternative include that it directly adds fish to the ecosystem, technology exists for rearing hearing, large numbers of juveniles can be raised past one or more potential limiting factors, and the degree of manipulation should permit marking of all fish. Disadvantages include the higher costs associated with the length of time herring must be cared for and the potential for the release of diseased or inferior stock.

- **Action Steps**
  1. Pilot project
     a. Create a project plan
        i. Estimate total pilot project costs by phase
        ii. Create a collaboration plan with potential partners
        iii. Determine population enhancement objectives
     b. Design an operational plan including:
        i. Egg acquisition methods
        ii. staffing/observation schedules
        iii. release timelines
        iv. disease control protocols
        v. caging/netting/tank structure
        vi. feeding protocols (if necessary)
        vii. Permitting (EIS requirements)
        viii. lessons learned from salmon enhancement
        ix. equipment required (Ships, nets, divers, etc.)
        x. program for evaluating outcomes
     c. Develop disease surveillance program in and around the vicinity of the supplementation facility.
     d. Develop safe and effective biosecurity procedures including:
        i. Disease prevention procedures in the supplementation facility.
        ii. Methods to prevent the spread of pathogens from the rearing facility to wild fishes.
        iii. Standard Operating Procedures (SOP's) to implement in the event of disease outbreaks in the rearing facility / locality.
     e. Develop procedures to prevent exacerbation of disease resulting from comingling of released fish with wild cohorts.

2. Based on results of pilot project, if it is decided to proceed
    a. Create a project plan
        i. Estimate total project costs by phase
        ii. Create a collaboration plan with potential partners
        iii. Evaluate population enhancement objectives
    b. Design an operational plan including:
        i. Egg acquisition methods
        ii. staffing/observation schedules
        iii. release timelines
        iv. disease control protocols
        v. caging/netting/tank structure
        vi. feeding protocols (if necessary)
        vii. Permitting (EIS requirements)
        viii. lessons learned from salmon enhancement
        ix. equipment required (Ships, nets, divers, etc.)
        x. program for evaluating outcomes

- **Science Necessary**

1. Year 1 Steps
    a. Supplementation hypotheses, objectives, & strategies (intensive vs. extensive)
        i. Cost/Benefit Scale Study
    b. Evaluate the feasibility of marking and recapture technologies
        i. Mark/recapture detectability threshold & interpretation
        ii. Maintain the mark/recapture program
    c. Design a program for disease evaluation/control
        i. Evaluate the effect of stress on disease outbreaks
        ii. Maintain disease control program
    d. Identify potential egg acquisition, rearing, & release locations
    e. Evaluate the carrying capacity/natural food availability in each candidate bay
    f. Evaluate the grow out age/release condition
        i. bio-energetic model
    g. Evaluate the survival, condition, & distribution of post-release juveniles
        i. within nursery area
        ii. outside nursery area
    h. Evaluate the effect of juveniles released on natural populations
    i. Evaluate the optimal release cycles
    j. Basic understanding of disease kinetics and exacerbation factors including effects of rearing density, temperature, and nutritional status.
    k. Adaptive management strategies intended to mitigate disease.
    l. Expanded diagnostic tools for rapid diagnosis of pathogens and diseases
    m. Efficacious, long lasting, and safe vaccines that can be easily administered to reared herring.
    n. Develop required permitting.

- **Technologies Required**
    1. Mass marking and recapture techniques
        a. sub-group batch multiple marking
    2. Feeding methodologies
    3. Food production/composition
    4. Containment systems (nets, pens, etc.)
    5. Survey techniques

b. Predator Management

The goal of predator management is to reduce mortality by controlling the level of predation on herring. Herring are a common prey item of fish, birds, and mammals, and predation is therefore a likely factor limiting recovery of herring in PWS. Predator management can be accomplished by altering the behavior of a predator (known as "hazing"), or by outright removal of the predator.

Clearly, there are a number of herring predators whose abundance and behavior cannot be manipulated, on legal and moral grounds: two major mammal predators in PWS (humpback whales and Steller sea lions) are currently listed as endangered species. Moreover, the recovery of herring populations is partly because they are prey to avian predators still listed as not recovered from EVOS. However, there are a number of significant fish predators on herring, including groundfish (walleye pollock, cod and halibut) and salmon; behavioral modification of fish predators is not possible, but they may be removed by targeted fisheries. Walleye Pollock in particular has been identified as a potentially major predator (and competitor) of herring during the winter period, and a targeted fishery for that species is the most feasible restoration option.

- **Action Steps**
    1. Removing/hazing/barring predators

- **Science Necessary**
    1. Determine the predators that need to be included
        a. seabirds
        b. pollock
        c. marine mammals
        d. flatfish
    2. Complete overwintering density surveys at:
        a. entry to bay system (beginning of summer)
        b. leaving bay system (late summer)
        c. joining adult schools (fall)
        d. recruitment
    3. Determine energetics models for predators/prey
    4. Complete census of predator/prey fields
    5. Determine time varying age structure of herring (maybe predators also)
    6. Determine time varying distribution of predator/prey movement pathways

7. Surveys to determine success

- **Technologies Required**
  1. Active acoustic detection and alarm technologies
  2. Mass marking and recapture techniques
  3. Accurate census of juveniles

c. Altering carrying capacity by over-winter feeding

Food may be a limiting factor for at least part of the herring life cycle. During winter, as temperature and light decrease, food supply diminishes and could become limiting, especially for young year classes. Survival of young herring through the winter depends on the amount of food available in the preceding summer and the amount herring store as lipid reserves to sustain them over the winter (Blaxter and Holliday 1963; Hay, Brett et al. 1988; Paul, Paul et al.1998, Vollenweider 2007). For older age classes, winter is less limiting on direct survival, but may affect their reproductive condition and spawning capacity in the spring (Carls et al. 2001). Therefore the food environment experienced by herring prior to and during winter may influence year class strength and reproductive capacity. These observations indicate that multiple restoration measures might be taken.

It has been observed that herring will feed in the winter when food is available, and that winter feeding improves their condition (Rice, 2007). Overwintering starvation (or predation on nutritionally stressed individuals) is a potentially large source of mortality for herring, particularly for juveniles, so supplying supplemental food to young herring during the winter may lead to improved year-class strength. There is a wide variety of marine feeds that have been developed for aquaculture that could be used towards this end, some manufactured (pellet food and the like), some more natural than others (e.g. Artemia eggs and nauplii); each have some advantages and drawbacks in terms of price, simplicity, and nutritional value.

It may also be possible to increase productivity in an area of the Sound by adding additional nutrients: adding inorganic nutrients to increase fish production has been done successfully in lakes for many years (Hyatt et al., 2004). Fertilization has not been attempted in the coastal ocean, mainly due to problems of residence time (i.e. dilution by tidal flushing) and scale (the vast amount of nutrients required). Even in well constrained lakes, nutrient additions have usually been of a single, limiting nutrient, and unbalanced nutrient ratios have often lead to unintended consequences (blooms of algae types that are grazer resistant, for instance). Rather than adding allochthonous nutrients (i.e. nutrients that are brought in from an external source), it is also possible to enhance the movement of autochthonous (i.e. local) nutrients by moving deep water to the surface. Deep water is generally nutrient enriched (by the degradation of sinking organic matter); nutrient levels in the deep waters of the North Pacific are among the highest in the world ocean (Reid, 1961).

Nutrients are usually prevented from being mixed to the surface by temperature or salinity gradients. Such gradients are especially pronounced in in PWS, where the large amount of fresh water input every spring and summer create a relatively fresh surface layer overlying deeper, nutrient rich water. However, it is possible to move deep water to the surface, which will increase nutrient concentrations and enhance production; the technology has been used for many years for shellfish aquaculture. A series of simple calculations suggest that artificial upwelling may enhance growth in fish stocks (Kirke, 2003), though those calculations were done for a low latitude reef ecosystem.

The surface waters of PWS are usually stratified in summer (Vaghan et al. 2001), which tends to reduce nutrient fluxes to the surface. Most primary production occurs in April and May (Eslinger et al., 2001) Mechanical "upwellers" could be used to enhance late-summer production: the technique has been recently demonstrated in the open ocean (Grabowski et al. 2008). Age-0 and -1 schools are generally found in inshore areas by late-July (Norcross et al., 2001), and locally enhanced production and increased food availability could then be expected to result in increased energetic reserves in young herring, which could be expected to cause a concomitant reduction in overwintering mortality.

There are numerous questions that need to be addressed prior to initiating an overwintering feeding or nutrient enrichment program. Within overwintering bays, it is important to have some understanding of the current winter carrying capacity. . Measurements of how much food is available to overwintering herring can be assessed by plankton surveys. It is also important to understand the bioenergetic requirements of herring during winter, in order to determine how much food is required. However, the bioenergetics of herring are fairly well known (Megrey et al., 2007). Finally, surveys to enumerate herring and their competitors are needed, in order to determine how much food would be required.

To assess the effectiveness of an overwintering feeding program, it would be important to monitor winter survival as well as the energetic condition of the fish. A comparative approach, where one bay is manipulated and one is not would permit testing whether or not food additions improved overwintering survival, and by how much. A potential test of the effectivenss of feeding supplementation could be based on fatty acid (FA) profiles. If the FA composition of manipulated bays were different than the profies of non-affected bays, then this would be reflected in the FA of herring that consume the food. Therefore FA testing, combined with other tests, could determine if manipulation led to increased feeding of herring, and if the effects of the manipulation were limited to local areas, or whether the possible movements of herring among different bays, obscured any local effects.

Similarly, to assess the effectiveness of a late summer nutrient enrichment, it would be important to also monitor the effectiveness of the upwelling system (with measurements of nutrients and productivity), as well as to follow survival and energetic condition of the fish. Again, a bay to bay comparison would be required to determine if nutrient additions were effective.

The technology requirements for a feeding program are fairly modest. There would need to be some development of the method used to deliver the food, and the nutritive composition. Aquaculture nutrition is a mature science, and there are many aquaculture feeds currently available that might be used for herring. Similarly, a late summer nutrient enrichment program could use existing upweller technology. Some upwellers are powered by waves, others by mechanical pumps, it is likely that an enclosed bay (which receives less wave action) would require the use of the latter. Both of these restoration options would need to be informed by synoptic, broad scale surveys of overwintering bays in PWS, high-speed cost-effective survey methodologies (optical and acoustic) are required to collect the data required at the appropriate scale, and at a reasonable cost.

- **Action Steps**
  1. Provide food
  2. Fertilize

- **Science Necessary**
  1. Determine what equipment is needed
  2. Determine the appropriate artificial/natural feed
  3. Determine required permitting
  4. Determine bays where juveniles are overwintering
  5. Evaluate overwintering Energetics
  6. Determine the natural survival level in each bay
  7. Determine the predation rates in each bay
  8. Compare herring results with competitor fish
  9. Evaluate efficacy of process
  10. Determine in-situ food availability
  11. Determine oceanographic conditions in each bay

- **Technologies Needed**
  1. Feeding methodologies
  2. Food production/composition

d. Disease Mitigation

Traditional disease management strategies involve an integration of infection prevalence and intensity monitoring with mitigation strategies including prevention with prophylactics, treatment with appropriate therapeutics, and adaptive disease management practices that are evaluated by continued disease monitoring. Although this proven process typically process works extremely well in hatchery situations, where fish are monitored and manipulated under semi-controlled conditions, the traditional disease management process is not appropriate in situations involving populations of wild marine fish, including Pacific herring in Prince William Sound. For example, administration of prophylactics and therapeutics to populations of wild marine fish are complicated by issues involving ecosystem scale and fish community dynamics, and are typically not considered appropriate for populations of wild fishes. These complications have historically prevented the advancement of disease management in populations of wild fish; however, the field of disease ecology has recently emerged and is offering creative ways to mitigate and manage diseases in wild populations.

A disease ecology approach is similar to that employed by the World Health Organization (WHO) and Centers for Disease Control (CDC), and involves a three tiered process involving:

1. Establishment and continuation of infection prevalence and intensity monitoring and surveillances. This component is required to monitor changes that signal the emergence of future epizootics and to evaluate the efficacy of future disease management strategies.
2. Incorporation of empirical studies intended to determine the basic epidemiological relationships between environmental and biological factors influencing infection / disease prevalence.
3. Development of predictive tools, based on known epidemiological relationships, which will be useful in forecasting the potential for future disease epidemics.

Combined, this three-tiered approach will provide the basic epidemiological information necessary to develop and validate adaptive disease management strategies intended to mitigate the effects of future herring disease outbreaks in PWS; these adaptive management strategies can then be evaluated and adjusted through continued monitoring for infection prevalence and intensity. A very clear advantage of this approach over that employed by the WHO and CDC involves utilization of the natural host (Pacific herring), rather than mammalian surrogates for humans, in empirical manipulation studies.

- **Action Steps**
    1. Develop harvest management strategies to mitigate disease
        a. Culling the population before or during an epizootic
        b. Curtailing fishing
    2. Maintain population herd immunity

- **Science Necessary**
    1. Basic understanding of disease kinetics and exacerbation factors
    2. Predictive tools that forecast disease potential
        a. Genetic / molecular tools
    3. Bank of herring immune response genes
    4. Immunological tools
        a. In vitro tools
        b. Serological tools
    5. Epidemiological tools
        a. Processes involved in ickthophonus
    6. Evaluate success of the tools and harvest management strategies
    7. Annual monitoring
        a. Infection prevalence and intensity monitoring

   b. Monitoring for susceptibility and disease potential
   c. Evaluate epizootics
8. Determine cause through sampling
9. Develop vaccines and determine efficacy
10. Develop required permitting

Disease principles, relationships, and adaptive management strategies addressed in he Disease Mitigation option are also critical and intimately tied to the success of restoration Option: Supplemental Production. Disease is a natural phenomenon inherent to populations of both wild and hatchery fishes, with both groups of fish sharing similar causes, exacerbating factors, and principles of disease. For example, viral hemorrhagic septicemia causes large epizootics among populations of wild Pacific herring (Traxler and Kieser 1994, Meyers and Winton 1995, Meyers et al. 1999, Hedrick et al. 2003), and often causes epizootics in impounded herring used for the closed pound spawn-on-kelp (SOK) fishery that has occurred in Prince William Sound (Hershberger et al 1999). As a result of extremely large quantities of infective virus shed into the water during active epizootics (Kocan et al 1997, Hershberger et al 1999, and Hershberger et al *In Preparation*), some have questioned the impacts of the closed pound SOK fishery on initiating epizootics and deleterious population-level effects to wild, un-impounded herring.

e. Managing Competition (habitat (space) & food source)

There are several species of fish that occasionally compete with herring for food resources, and competition may thus be partly responsible for the lack of recovery of herring stocks. Recent work (Deriso et al. 2008) suggests that competition (and predation) from juvenile salmon released from hatcheries in PWS may be limiting the recovery of herring. However, the importance of salmon hatcheries in the local economy precludes limiting their output.

Juvenile walleye pollock (Theragra chalcogramma) is also a significant competitor to herring in PWS (Sturdevant et al., 2001). Juvenile pollock inhabit the same nursery bays as juvenile herring, and it has been observed that the energetic content of pollock tends to increase over the winter, while that of herring declines (Paul et al. 1998; Kline 2008). This suggests that herring may be out-competed by pollock during the winter, which would add to overwintering mortality (pollock is also a predator of herring, and predator control is dealt with in another section). If pollock is a significant competitor of herring, removal of that competition has the potential to reduce overwintering mortality.

The removal of pollock may be accomplished by a selective fishery specifically targeting that species. In practice it may not be possible to specifically target juvenile pollock, because it often co-occurs with herring. A selective fishery for adult pollock could be accomplished more easily, and would result in a concomitant reduction in the number of juvenile pollock the following year (as well as removing a major predator of herring in PWS).

In order for this option to be successful, some basic knowledge of the biology of pollock in PWS would be required, including estimates of stock size, age structure and distributions. As well, there would not need to be any specific fishing gear technologies developed for this option, pre-existing gear and methods could be employed.

- **Action Steps**
  1. Determine required permitting
  2. Remove competitors

- **Science Necessary**
  1. Distribution and abundance of competitors
  2. Distribution and abundance of overwintering juveniles
  3. Evaluate overwintering energetics
  4. Estimate the natural survival in each bay
  5. Estimate the predation rates in each bay
  6. Determine in-situ food availability
  7. Determine oceanographic conditions in each bay

- **Technologies Needed**
  1. Selective fishing gear

f. Improved Management Strategies

The recovery goal outlined in this plan requires a biomass above that currently used to open the fisheries. Therefore, changes to harvest strategies may be needed to allow full rebuilding of the stock. Such changes may include protecting spawning areas from staging and anchoring boats to reduce disturbance to the eggs, changing the fishery threshold, and restricting practices that tend to induce disease. Advantages of the approach include low costs to implement and potentially improved sustainability of the fishery. The disadvantages include not being able to implement until the fishery is reopened and no direct measure of how the changes affect the population.

- **Action Steps**
  1. Restrict or eliminate fishery gear types that tend to induce disease
  2. Increase or revisit fishery threshold
  3. Improve accuracy of stock assessment/ASA to minimize risk of over-fishing
  4. Create protected area for spawning

- **Science Necessary**
  1. Develop predictive tools to forecast future abundance
  2. Maintain existing stock assessment
  3. Strengthen stock assessment monitoring to evaluate effectiveness including egg deposition and GSI (gonad somatic index) & LSI (liver somatic index)
  4. Understand the role of spatial integrity in stock management
  5. Identify characteristics of productive spawning beds
  6. Model reproductive energetics and efficiency

7. Determine larval drift
8. Establish/verify predator prey relationships
9. Establish disease relationships
10. Determine if immunity can be introduced in-situ
11. Determine carrying capacity

- **Technologies Needed**
  1. Otolith chemistry for stock identification

g. Relocation of Stranded Eggs

Egg relocation involves moving eggs stranded on the shore back into the water to improve their viability or moving them to another location believed to be more favorable for survival. This approach attempts to reduce mortality at the egg and through the larval drift stages of life. Advantages of the approach are that the manipulation of eggs may allow them to be marked, and the cost is relatively low since handling is minimized. Disadvantages include potential harm to existing eggs during the collection process, the low likelihood of being able to manipulate enough eggs to detect an effect in the population, and it bypasses very few potential bottlenecks in herring recovery so it has a lower likelihood of success.

- **Action Steps**
  1. Return windrow eggs to the water
  2. Relocation of naturally spawned eggs, on natural or artificial substrate, to more favorable nursery bays

- **Science Necessary**
  1. Create operational plan for moving/gathering eggs
  2. Create a monitoring plan for moved eggs to determine success
  3. Survey to determine windrow egg quantity (variable in space and inter-annually)
  4. Determine the mortality rate of moving eggs
  5. Determine permitting requirements
  6. Determine hatching success on artificial and natural substrates
  7. Determine effects (if any) of stress on eggs
  8. Determine spatially diverse egg destinations using a larval drift analysis (probability map)
  9. Determine larval carrying capacity/natural food availability
  10. Determine the affect on natural populations
  11. Identify ideal nursery habitats
  12. Determine the larval disease prevalence/exposure

- **Technologies Needed**
  1. Technology for marking & recapture for evaluation
  2. Circulation model for larval drift analysis

h. No action – Allow Natural Recovery

If direct restoration activities are found to be impractical, too costly, or too risky, then monitoring and research may be the only viable means of understanding the natural recovery of the herring populations, or the mechanisms that prevent natural recovery. For example, monitoring and research might lead to a better understanding of the role of disease, predictability of disease outbreaks, and disease management practices that reduce disease impacts. Monitoring of herring populations and critical life-history attributes might also allow for the development of better predictive models of herring stocks, more protective fisheries management practices, and longer-term sustainability of the stock. Furthermore, monitoring and research might reveal unknown sources of human-induced impacts on herring that, if identified, could be ameliorated and removed as an impediment to natural recovery. The tools and understanding developed by monitoring and research would be expected to provide fisheries managers with better predictions of herring populations allowing for more adaptive management practices that will be needed even if active intervention is implemented. The greatest advantage is that no ecological manipulation is required. The disadvantage is that it does nothing to restore herring populations.

5. Recommendations

A number of restoration options may be dismissed for logistical, financial, and permitting reasons; the IHRP working group recommends that the restoration options that are most likely to be successful are:

- Supplemental production
- Carrying capacity supplementation
- Predator management (specifically the selective removal of Pollock)
- Competitor management (specifically the selective removal of Pollock)

An intensive field program (addressed in "core data collection") is also required, and should be initiated as soon as possible to provide the baseline data that will be needed by all restoration activities.

A precautionary approach is recommended for all the restoration options. Before any supplemental production activities begin, it is recommended that two workshops be held in FY2009, to investigate the feasibility of applying current marking technologies and to review the state-of-the-art in culturing technologies. White papers resulting from those workshops will then be used to plan pilot supplemental production activities in FY2010. All other restoration options should begin in FY2009 with small pilot studies to demonstrate feasibility and assess scalability.

Herring has an annual life cycle, so changes in the herring population will take several years to assess. It is thus important that the Trustee council recognize that a multiyear commitment to herring research is required, particularly support for the monitoring that will provide the critical data necessary to update and modify the plan as necessary. A long-term commitment is not incompatible with an annual funding cycle, for the various restoration options, and the IHRP has been designed to be flexible and to allow changes to be made to the plan based on the status of the herring population on a year-to-year basis.

III. Integrated Herring Restoration Program – Programmatic Issues

1. Introduction
This section of the Integrated Herring Restoration Program (IHRP) addresses the administrative and programmatic issues relating to maintaining the program. It discusses how the Herring Steering Committee will communicate with the Trustee Council, Restoration office, researchers and project leaders, agency personnel, and the public.

2. Integrated Herring Restoration Program Steering Committee
The Herring Steering Committee ("Committee") consists of scientists, agency representatives, commercial fishermen, and members of the public. The Committee has been tasked with the creation and implementation of the IHRP and is responsible for making recommendations to the Executive Director on project proposals, progress reports, and final deliverables. The Committee currently consists of 10 members and meets on a bi-annual basis. Two temporary sub-committees have been formed for topic-specific experts to address issues and perform specific tasks, including writing the IHRP and evaluating current marking technologies that may be applicable to PWS herring. Temporary sub-committees will be formed as needed to address topics and members will be selected from both the Committee at large and from national experts on specific topics. The main tasks of the Committee will be to:

- write and update the IHRP;
- make recommendations to the Executive Director on project proposals, progress reports, and final deliverables;
- identify the need for sub-committees to address specific topics; and
- ensure open communication and data sharing between funded projects.
- ensures communication with impacted communities and input from impacted communities is incorporated into the IHRP.

   a. *Organization*
   The Committee will provide guidance to the Executive Director and will work closely with the EVOSTC Restoration office and agency project managers to meet its identified goals.

   b. *Decision Making*
   The Committee functions on a majority vote basis and makes recommendations as a group. Any dissention in the group on a topic is provided along with the majority recommendation to ensure that all information is available to the Executive Director and the Trustee Council prior to making any decisions. The Committee will have two standing meetings scheduled each year.

c. *Internal Review and Reporting*
This section addresses the internal review and reporting structure of the Committee, the reporting required of each PI to the Committee, and how the committee will report to the Executive Director and Trustee Council.
Internal reporting – The Committee will communicate between meetings through email, teleconferences, and a web-based forum. Two standing meetings will be scheduled during each fiscal year and other meetings will be scheduled as needed to address specific topics.

Project Proposals – Upon receipt of project proposals, the Committee will to review and make recommendations on each proposal. Confidentiality and non-disclosure agreements will be signed prior to distributing the full proposals to the Committee members. They will also receive any anonymous peer reviews received for each proposal. Proposals that are received from a Committee member's agency, institution, or co-worker will not be shared with that Committee member and they must recuse themselves from any discussion or recommendation on that specific proposal(s).

After reviewing and discussing each proposal, the Committee will make recommendations to the Executive Director for each proposal based on its scientific merit, ability to answer questions identified by the Committee in the request for proposal, and how well the project will integrate with existing efforts. A majority vote will determine if a project is recommended for funding.

Project Progress Reports – Project progress toward identified objectives will be reviewed by the Committee at its bi-annual meetings. Each principal investigator (PI) will be responsible for providing a detailed report on the project's progress to both the Committee and to the assigned agency project manager 30 days prior to the identified Committee meeting date. PIs may attend the meeting either in person or via telephone to aid in the discussion of the project's progress. The Committee will make recommendations, if necessary, to the PI, Executive Director, and agency project manager for suggested changes in scope, schedule, or level of integration. The Committee will inform the Executive Director of any projects that are not meeting their identified goals or are not working as part of the integrated team.

Principal Investigator Reporting – Each PI will be expected to provide an in-depth review of their project's progress 30 days prior to each of the two Committee meetings. The review will be provided to their assigned agency project manager who will forward it to the EVOSTC Restoration Specialist for distribution to the Committee. The report will detail each of the project's objectives and what work has been accomplished to date on each, an update of the project's schedule, and a summary of how local communities have participated in or been made aware of their progress.

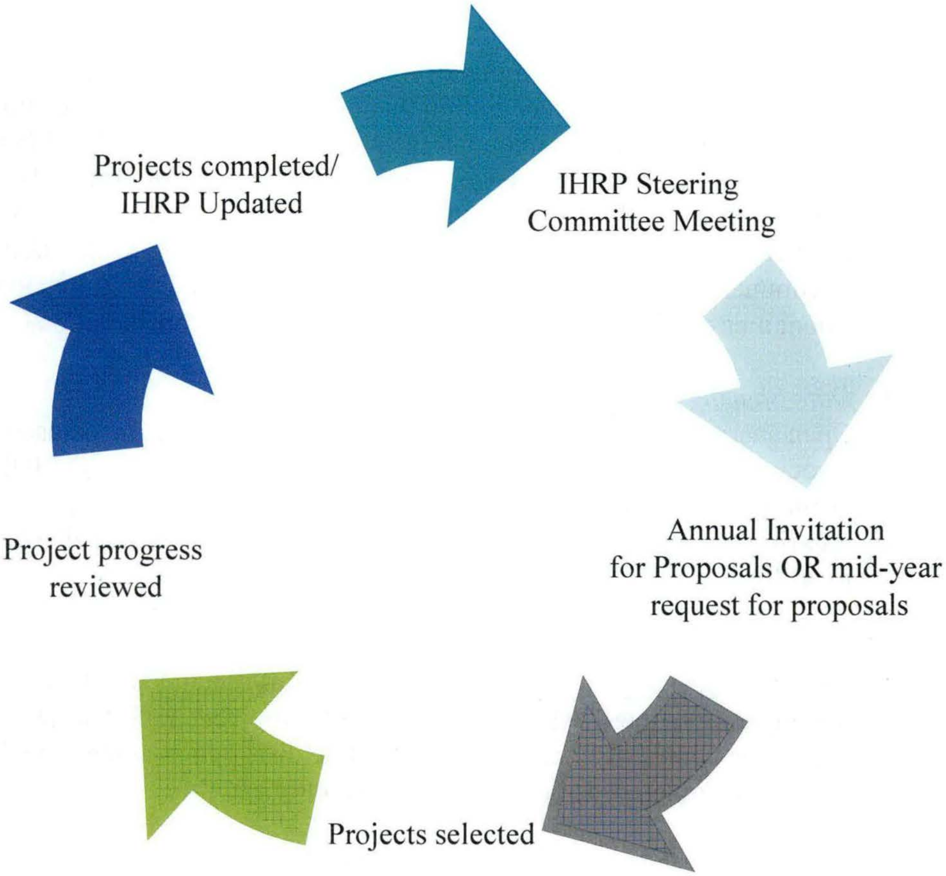
Reporting to the Executive Director – The Steering Committee will provide a written summary of each meeting to the Executive Director within 14 days of the end of the meeting. The summary will provide details of the discussion, recommendations of the committee based on the items reviewed, and a timeline for items that need action prior to the next meeting.
Project Final Reports/Deliverables – The Committee will review all final reports and deliverables for each project to ensure that the information gained is incorporated into the IHRP. The Committee will provide feedback to the EVOSTC office staff that will be added to independent peer reviews and addressed into each final report/deliverable.

d. *Recommended Herring Coordinator*
A full-time herring coordinator position has been recommended by the group to assist with logistics, internal and external communication, and to coordinate the efforts of the Steering Committee. The recommendation is for the herring coordinator to be housed at the EVOSTC restoration office in Anchorage, Alaska and to report directly to the Executive Director. The proposed tasks of this full-time position would include:

- coordination of all project logistics including vessel time, laboratory time (if appropriate), data transfer, and information sharing between the PI's;
- communication of the PI's and Steering Committee's progress to the Executive Director and the Trustee Council;
- scheduling the bi-annual workshops and any necessary meetings throughout the fiscal year;
- updating the Integrated Herring Restoration Program document under the guidance of the Steering Committee; and
- updating the herring information webpage on the EVOSTC website.

e. *Adaptive Management Cycle*
The restoration program for PWS herring can be managed adaptively where the problem evaluation, policy decisions, research, monitoring and outcomes are all related in a way that leads to logical decision making and provides order and context for the various program activities.

Flexibility will be key in determining the course of decisions for each fiscal year and the chart below illustrates the management cycle. At any point in the process, the Committee can make the decision to start over at the beginning of the cycle if necessary. An example of how the program can be adapted to meet particular goals would be if a project's progress is reviewed and it is determined that additional scope is needed or if a question has been raised in the research that requires a separate study. The Committee can then elect to meet again and begin the request for proposals cycle at any point in the year.



3. <u>Administrative Procedures</u>
   a. *Semi-Annual Meetings*
   In order for the Committee to make recommendations in a timely manner, two meetings per fiscal year will be scheduled as standing meetings and will include all members of the Committee. The meetings will last approximately three-four days and will be held in Anchorage or Cordova, Alaska. Sub-committee and full Committee meetings may be called throughout the year as needed and will be publicly advertised. All meetings will be open to the general public. The bi-annual workshops will serve to discuss proposals, project progress reports, and final reports and deliverables. The group will also discuss updates to the IHRP document and determine if any corrective action is needed.

   b. *Logistics coordination*
   Prior to the potential appointment of a herring coordinator, the funded PIs will be expected to prepare a detailed schedule of any necessary vessel or laboratory time, required samples, and community involvement activities as part of their original proposal. At the first workshop of the fiscal year, this information will be shared with the group to assist in the sharing of necessary resources to minimize overall cost. As part of any project's progress report or final report, it must detail the coordination that has taken place with other funded projects.

c. *Funding cycle*

While the Committee recommends the continued use of the annual invitation for proposal cycle, there is recognition that projects may be identified throughout the fiscal year as required to maintain the momentum of the IHRP. When these projects are identified by the Committee, an invitation for proposals related to that specific project will be generated and reviewed by the Executive Director, Trustee Council, legal counsel, and agency liaisons prior to being made public. Recommendations for funding will be provided by the Committee to the Trustee Council based on the proposals received for funding consideration.

d. *Data Sharing Program*

Open sharing of information, particularly collected scientific datasets and their associated metadata, between projects is a vital component of the IHRP. Timely availability of collected datasets allows for helpful crosschecks, comparisons, and improved accuracy of research results for each project. It can also generate new ideas for needed research that are not currently anticipated.

The Trustee Council's Data Policy (revised March 17, 2008 and available at http://www.evostc.state.ak.us/Policies/data.cfm) remains in effect for all projects participating in the IHRP. Like all EVOSTC projects, IHRP projects are required to provide copies of final datasets for public distribution at the time the final report is completed, as outlined in the Data Policy.

In addition to the requirements of the Data Policy, principal investigators participating in the IHRP are required to make collected and processed datasets available to other IHRP projects within 60 days of collection. Consistent with the Data Policy, such datasets will not be made publically available until the final report is completed.

Beginning in the FY09 funding cycle, and in future fiscal years, proposals for IHRP projects must include a detailed schedule showing projected data collection and processing timeframes for each proposed year of the project. The 60-day dataset availability requirement will be based upon the date of collection. For projects that began in previous fiscal years and are continuing into FY09, the principal investigator must provide a detailed schedule of projected data collection and processing timeframes to the EVOSTC Data Manager by November 30, 2008.

It is the responsibility of each PI to meet their data sharing obligations to other investigators, as outlined in this section, by making datasets available in a timely manner. PIs should inform the Data Manager as soon as possible if the 60-day requirement cannot be met so that an alternate delivery date can be arranged. The EVOSTC Data Manager will inform the EVOSTC Executive Director of projects consistently failing to provide datasets in a timely manner and future funding for such projects may be denied.

Datasets are shared using the web-based ProjectView application provided by the Trustee Council office. ProjectView provides a secure method for sharing datasets and metadata between IHRP projects without making them available to the general public. Investigators may upload datasets (and associated metadata) to ProjectView directly and share them with other IHRP projects, or provide them to the EVOSTC Data Manager by email, CD, or other agreeable method for uploading and sharing.

To reduce the probability of errors and preserve scientific integrity, it is recommended that only processed datasets be shared. Unprocessed (raw) datasets may also be shared, at the discretion of the PI responsible for collecting the data, if requested by investigators from other projects. Any unprocessed datasets that are shared should be clearly marked as such in their description, and to distinguish them from other datasets, which are assumed to have been processed unless otherwise noted.

e. *Use of Technology for Communication*

Constructive communications between the parties involved is critical to the success of this Program. Participants are encouraged to use the discussion forum located at http://www.evostc.state.ak.us/forum to discuss projects or ideas and comment on important documents. The forum software preserves the comments made for future reference and makes them available to all participants immediately. Forums are available for members of the Committee. Threaded discussions, document attachment, and email subscription capabilities are available to all participants.

f. *Intellectual Capital*

The open discussion of project ideas and proposals is of some concern to the Committee. In order to ensure that these discussions are as open as possible, each member of the Steering Committee will sign a non-disclosure and confidentiality statement at the beginning of the fiscal year.

g. *Communication Plan*

Recognizing the importance of this work to spill-affected communities and the public at large, the Committee will provide for meaningful public involvement and regular updates on the development and implementation of an Integrated Herring Restoration Program in PWS. This includes, but is not limited to:

- Providing routine advance notification of meetings and ensuring meetings are open to the public, accessible in person or by teleconference with scheduled time for participation (as needed).
- Providing periodic updates to citizens (especially to spill-affected local communities, native villages and corporations), PAC, TC, liaisons and Committee.
- Hosting community forums to report on progress and solicit input.

- Briefing TC members regularly. Arrange to brief elected officials with TC members and steering group members at key milestones.

h. *Role of the EVOS Trustee Council Restoration Office*
The EVOSTC restoration office will lead this effort and will be the primary point of contact for the PIs, Committee, and agency project managers. Since the Committee is not a Federal Advisory Committee Act group, they will make recommendations to the Executive Director. Prior to potentially acquiring a herring coordinator, the Restoration Specialist will serve as the central point of contact and will be responsible for the coordination of the Committee. The Restoration Specialist will work closely with the Executive Director, Environmental Program Specialist, Data Manager, and agency liaisons to ensure that the IHRP continues to serve the goals of the Trustee Council and to communicate its progress regularly.

i. *Role of Agency Project Managers*
The agency project managers will be responsible for keeping the Committee updated on the progress of projects funded as part of the IHRP. The project managers currently use a quarterly update process, which is publicly available, to communicate scope and schedule progress. The agency project managers will also be required to alert the Committee if a project is not meeting its identified goals and objectives.

4. <u>Community Involvement</u>
Meaningful community involvement is defined as a substantive role for individuals, communities, and community-based organizations in the design and conduct of research, monitoring, general restoration activities, in the analysis and application of the results, and in information-sharing in ways that ensure the information is both timely and easily understood.

The Trustee Council has determined that the IHRP will be community-based and will provide this meaningful participation by the local communities that continue to be injured from the loss of herring in the Sound. Community involvement can take many forms and can range from utilizing local vessel charters and guides to utilizing local citizens in the collection and analysis of project data.

Each proposal received as part of the IHRP will be reviewed for its level of community involvement prior to funding, during the course of the project, and in communicating its final deliverables. Assistance will be available to PI's and the Steering Committee through the Communication and Outreach Coordinator at the EVOSTC restoration office.

5. <u>Opportunities for Partnering</u>
There are many state and federal agencies and non-governmental organizations currently funding research and restoration projects in Prince William Sound. Opportunities for partnering are numerous and would be mutually beneficial both financially and in the

exchange of information. The following organizations are currently funding herring research and would be good candidates for partnering:

- Oil Spill Research Institute (OSRI)
- North Pacific Research Board (NPRB)
- Prince William Sound Science Center (PWSSC)
- Prince William Sound Regional Citizens Advisory Council (PWSRCAC)
- Alaska Ocean Observing System (AOOS)
- University of Alaska, Fairbanks (UAF)
- University of Alaska, Southeast (UASE)
- Alaska SeaLife Center (ASLC)

Each group will be contacted by the Executive Director to determine if a partnership will be beneficial and to determine the form of any potential partnerships. A memorandum of agreement will be signed between the Trustee Council and any interested groups that will detail the level of information and cost sharing. The Steering Committee may invite partners to any of its public meetings to discuss projects or upcoming opportunities.

IV. Integrated Herring Restoration Plan

1. Year 1
   a. Administrative needs:
      i. Herring Coordinator position
      ii. Two Herring Steering Committee meetings
      iii. Ad-hoc sub-committee meetings as needed

   b. Recommended projects:
      i. Host a "marking/tagging technologies workshop and produce a white paper.
      ii. Host a "strategies and technologies for supplemental production" workshop and produce a white paper.
      iii. Select 4 – 5 new projects, one of which is community based that would fill important identified data gaps.
      iv. Augment ongoing ADF&G survey work. The current surveys are not comprehensive and key information could be missed.
      v. Investigate geospatial and habitat features of bays for potential restoration activities. (Bays with historic herring spawning and larval rearing, oceanographic and geographic features that support retention, etc)
      vi. Validate larval drift models through cooperative investigations. (AOOS)
      vii. Complete disease, predation, oceanographic, competitor, and larval herring surveys.
      viii. Investigate dedicated fishery for pollock to reduce competition.
      ix. Begin investigation of carrying capacity enhancement. (Experimental foods/fertilization.)

x. Identify and begin a community-based project. (E.g. Pilot scale juvenile feeding experiment.)
xi. Begin an acoustic survey of distribution of Pollock to compare herring and pollock.
xii. Investigate regulatory permits that would be required for supplemental production.
xiii. Begin core monitoring program
    1. Stock assessment program supplement
        a. increased spatial and temporal scale of overwintering (fall & spring) surveys
        b. evaluation of stock assessment techniques, especially spawn data input
        c. evaluation of age at maturity (monitor gonad size & weight)
        d. identification of stock structure (otolith chemistry, tags)
        e. Juvenile surveys (summer, fall, spring)
        f. establish distribution
        g. use tags or otoliths to determine spatial contribution
    2. Tracking survival and recruitment
        a. impacts of seabird, marine mammal and fish predators and disease
        b. evaluation of interspecific food competition of herring with pink salmon, sand lance and juvenile Pollock
        c. evaluate interrelationship among predation, prey availability, competition, and disease
        d. evaluate food limitation and key food/energy sources (outside or inside PWS) at juvenile and adult stages
xiv. Develop an epizootic response plan.

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