Introduction: The Regional Monitoring Program of the San Francisco Estuary Project carries out pilot projects in order to test concepts and their suitability for long-term contaminant and effects monitoring. The RMP is in the process of identifying measures of contaminant effects in the estuary with studies of benthic communities, sea birds and harbor seals. The SFEI is interested in implementing a monitoring component for contaminant effects in fish. This workplan is for a pilot project to determine some effects contaminants may be having on a common estuarine fish, the shiner surf perch *Cymatogaster aggregata*.

Purpose: The primary objective of this work is to determine if shiner surf perch (*Cymatogaster aggregata;* Embiotocidae) show effects of contamination on some aspect of their fitness, growth or reproduction. A secondary objective is to synthesize the available information and data to develop the framework for understanding the relative contribution of contamination in the well-documented decline of the population in the San Francisco Estuary (Hieb 2000).

Strategy: We will execute a 2-year pilot study that consists of 3 components: a field-based study of growth and reproduction, and a laboratory study of the effects of complex mixtures on growth and fitness, and the accumulation of information sufficient for building population models that clarify the role of contaminants in population dynamics. The ultimate goal of this work is to establish the shiner perch as a model organism for long-term monitoring of the effects of contamination in the estuarine ecosystem. We envision this project as an interdisciplinary backbone onto which additional projects funded from diverse sources may eventually be linked. Hopefully other researchers and other programs will choose the shiner surf perch as a subject for various studies in contaminant effects and population biology so that we can develop a deeper understanding of this species and how it might survive in this highly altered estuarine environment.

Species selection: The weight of evidence suggests that shiner surf perch is an excellent candidate species for study of population effects of contaminants:

1. They accumulate some of the highest concentrations of contaminants of any fish species that has been analyzed in the estuary (Davis et al., 2001).
2. They have high site fidelity (Fritzsche and Collier 2001).
3. They are found in shallows and channels where most of the chemical data have been taken for the last 15 years in the Regional Monitoring Program (RMP) so that there is a historical context for understanding any effects that are found.
4. They are commonly captured by the Interagency Ecology Project (IEP) Bay Study sampling program (Baxter et al. 1999), providing the opportunity for assessing individual health throughout the system as well as providing a historical context for estimating contaminant effects on trends in population abundance.
5. They are also sampled and analyzed by the SFEI sport fish sampling program as well as the Pacific States Marine Recreational Fisheries Statistics Survey (MRFSS) (Karpov et al. 1995), providing additional sources of fishery dependent information.

6. They are a popular recreational fish and are caught in large numbers by urban residents for food, thus are an ideal species for addressing public concerns of estuarine health.
7. Their populations are declining in the estuary and there is concern about their survival (Hieb 2000).
8. They are live-bearers and their entire annual reproductive output (4-36 young annually) can be determined by sampling pregnant females in the late winter and early spring, facilitating economical study of reproductive effects (Fritzsche and Collier 2001).

Hypotheses

HO_1: There is no difference in reproductive success, growth or energy storage in surf perch collected from more and less contaminated environments.

HO_2: There is no difference in contaminant concentrations or biomarkers of exposure and effects in surf perch collected from more and less contaminated environments.

Measurements

Morphometrics and energy storage: The primary measures are those indicators in individual fish that relate to its ability to contribute to the maintenance of the population: fitness growth and reproduction. We will therefore measure age, weight, standard length in adults, juveniles and embryos. It may be difficult to extract or read the ototliths, especially for juveniles and embryos, but we will try. We also have an offer from the NOAA laboratory in Auke Bay, Alaska to measure lipids in embryos, which would give an indication of energy storage in developing offspring. We will use the results of the morphometric and lipid comparisons to guide us in interpretation of contaminant effects that may have population level effects.

Contaminants and exposure biomarkers: We will be measuring a variety of organic contaminants and exposure biomarkers. The organic chemical analytes will include: PCB congeners, current use pesticides, polychlorinated biphenyl ethers (PBDEs), and legacy pesticides (DDTs). Polycyclic aromatic hydrocarbon metabolite (hydroxylated PAH and their conjugates) measurements will be attempted in the bile. The ethoxyresorufrin-O-deethylase (EROD) activity assay, a standard measure of p4501A enzyme activity, will be performed on the liver of adults. The enzyme P4501A1 will be measured immunohistochemically in liver of adults and in the selected embryos to determine if there is induction in embryos reflecting the paternal exposure. This enzyme is inducible in endothelial tissues of most fish species by polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCBs). Previously the activity of P4501A1 enzymes in maternal tissues of starry flounder was found to be inversely related to fertilization success and hatching of eggs (Spies et al., 1988). Also, activity of this enzyme was found to be proportional to the time to death in trout that had been challenged by the IHNV virus (Springman, 2005). So, this is an important biomarker with established links to impaired physiological function from contaminant exposure.

Effects biomarkers: We will measure two indicators of sublethal effects of contaminants: histopthological alteration of cells and tissues and induction of egg proteins in male fish. Compromised health and fitness from contaminant effects may be expressed as visible sub-cellular or tissue alterations and may be manifested in impaired physiological processes. Histopathological analyses may find such evidence of impairment.

The alteration of normal reproduction due to exposure to endocrine disrupters is likely in fish from some portions of the estuary; we have chosen the induction of egg protein synthesis in males, a process that normally takes place only in females. The presence of detectable amounts of egg proteins in males indicates an alteration of normal reproductive function not only in males but possibly in females. Estrogenesis in females may lead to alterations of the normal schedule of gamete development and ovulation.

Work Plan For 2005

Objective: Determine if shiner surf perch collected in contaminated and less contaminated environments have differences in measures of fitness, reproductive success and growth and whether such differences, if they exist, affect the population.

Specific goals:

1. Collect 40-60 shiner surf perch from the most contaminated areas portions of SF Bay as determined by analysis of RMP and sport fish survey data (Fairey et al., 1997). We will collect from at least two, and possibly three contaminated sites and hope to be able to collect at three contaminated sites. We will also collect from at least one contaminated site: San Pablo Bay and/or a northern California riverine estuary (e.g., Navarro River in Mendocino County).
2. Determine growth and reproductive output from females (number and size of embryos) and males (size of testes), condition index and lipid storage.
3. Determine sub-lethal biomarkers of contaminant exposure and effects. This would include the EROD activity, histopathology and egg proteins in males and juveniles.
4. Determine contaminant concentrations in tissues.
5. Explore the existing historical data, ecological information, and project data to develop conceptual models as a precursor to quantitative population modeling. This would include developing alternative stage-based matrix model (Caswell 2001) structures to identify key data and information gaps.

Schedule and activities:

In Year 1 of this study, Kathrine Springman will be involved in the collection of the fish from various field efforts at different locations. From these fish, she will dissect and preserve tissues for analysis, as well as determine growth, reproductive output and lipid and glycogen storage. William Bennett will explore the existing historical data, ecological information, and project data to develop conceptual models as a precursor to

quantitative population modeling. This would include developing alternative stage-based matrix model structures to identify key data and information gaps.

Products

A project progress report will be provided by AMS in collaboration with UC Davis January 2006. This report will include a description of sampling and analytical methods and summary of Year 1 project findings. Additionally, all data collected for the project will be provided in electronic format for archiving at SFEI.

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Budget

Fish effects pilot project for SFEI: Budget for Year 1	**Cost ($x1000)**
Personnel	
1. Kathryn Springman, Principal Investigator	$10,000
2. William Bennett, Investigator	$5,000
3. Gary Cherr, Investigator (egg protein assays)	(pro bono)
Supplies	$1000
travel	$750
sub-total	$16,750
Overhead (10%)	$170
Subtotal	
Grand total	$16,870