CASE STUDY 1

Appendix A: Case Study – Quantifying Drift Invertebrates in River and Estuary Systems

This case study is based on an Innocentive Design Challenge -- Challenge ID: 9933647

Habitat restoration, improvement, and creation in rivers, streams, and estuaries are key elements for the recovery of salmon, trout, and other critical fish species in the North America. Millions of dollars are spent annually on activities such as manipulating flow regimes, adding structural elements such as wood or rock, reconnecting rivers with their floodplains, and restoring wetlands. A critical aspect in evaluating the effectiveness of these habitat manipulations is understanding how they influence the food resources available to critical fish species targeted for recovery and protection. Yet despite its importance, quantification of food resources has proven difficult.

The Bureau of Reclamation, in collaboration with other federal agencies (NOAA-National Marine Fisheries Service, U.S. Geological Survey, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers) is seeking a way to economically detect, count, and identify zooplankton and drift invertebrates in river and estuary systems. Problems identified that prevent the simple transfer of oceanographic techniques to rivers and streams are higher water velocities, turbidity, higher surface/depth ratio, and costs (time and money).

Background

Habitat restoration is considered a key element of fish recovery, and the quality of habitat and food resources available to fish often needs to be evaluated before and after restoration actions. Habitats are often designed to provide increased foraging and rearing habitats at appropriate spatial and temporal scales. Accurate food counts, such as zooplankton and drift invertebrates, are instrumental in fish habitat evaluation and restoration in our rivers and streams. Although technology has been developed for automated detection and identification of zooplankton and drift invertebrates in oceanographic settings, they have not been developed for the unique environmental conditions in rivers and estuaries. High flow rates and turbidity cause problems with automated visual systems used today. The main obstacle in estuaries is turbidity while the main obstacle in river systems is flow velocity. In addition, the horizontal nature of rivers invokes problems not encountered in deep ocean waters (e.g., sunlight effects at the surface of water and the mixing of food sources throughout the water column in rivers due to turbulence as opposed to more stratified food webs in ocean waters). We would like to identify devices/methods that can detect, count, and identify zooplankton and drift invertebrates in an economical way in rivers and estuary systems. Measurements of this type are currently time-intensive and expensive, especially for juvenile salmon in a highly dynamic and complex system such as the Sacramento-San Joaquin Delta (California).

Traditional sampling methods involve the use of towed nets (for slow-moving water) or stationary nets (for fast-moving water) that collect organisms from the water column. Both the field collection of samples and the subsequent sorting and identification of collected invertebrates are time-intensive and expensive, and agencies lacking technical expertise must often rely on outside experts to process samples. Because of the high costs associated with these traditional methods, the spatial and temporal extent of sampling is often inadequate to characterize food availability at scales that are biologically relevant.

In the marine science community, significant advances have been made in plankton monitoring through the use of devices that capture high-resolution images of particles (>100 µm) and invertebrates. These devices produce a catalog of time-stamped images that can be processed to various taxonomic levels with image analysis software, allowing the abundance of organisms in a known volume of water to be quantified.

Analogous technologies for freshwater environments do not exist, but could be developed to continuously monitor the prey abundances and dynamics in key locations for migrating and rearing fishes. Pilot systems have been tested in the freshwater environment, but there have been problems with image capture, leading to poor image quality (blurred) and poor identification (low probability of differentiating target organisms from drift algae, detritus and other materials).

The difficulties during the pilot were likely caused by

- High water velocity
- Low water clarity (turbidity)
- Small target size (1-20 mm)

Another big difference between the marine ocean environment and the freshwater and estuarine environment is that ocean monitoring tends to be vertical (in the water column) and items on the surface are not a large percentage of the whole so they can be ignored. In a stream, items on the surface are a high percentage of the overall water column, and sunlight at the surface affects the imaging equipment considerably. It is difficult to get accurate measurements if targeted items on the surface are ignored.

The Challenge

A device/method is sought that could be deployed to collect data continuously (over hours, preferably days) to capture tidal and day/night variation in prey abundance in rivers and streams. By simultaneously deploying multiple units, scientists could measure important spatial and temporal variation such as depth stratification and source/sink food web dynamics.

The device/method must detect, count, and identify drift invertebrates automatically in a size range of 1 to 20 mm in a cost effective method.

Things to Avoid

1. Equipment made today for oceanographic study – although a good place to start, we are familiar with what exists and our Challenge is to go beyond what exists for our particular problems in freshwater systems.
2. A simple list of equipment without explanation of how they work in concert will not suffice as a description of the system.

Any proposed solution should meet the following specifications:

1. The device/method should be able to:
   a. Detect representative samples of drift invertebrates (1-20 mm). This should include those targeted items floating on the surface to a high degree as well as those in the water column. Representative samples of drift invertebrates in California and other localities are available at the California Department of Fish and Wildlife's Aquatic Bioassessment Laboratory digital reference collections. (http://www.dfg.ca.gov/abl/Lab/referencecollection.asp).
   b. Count the targeted items in samples (sort out debris from targeted zooplankton and invertebrates to minimize false positives)
   c. Identify the number and taxonomic family (or groups of morphologically similar families) of specimens detected (NOTE: exact identification of each species is not as critical as identification of the total amount of food available to fish).
2. This must be accomplished under the following conditions:
   a. Velocities between 0 and 1.5 meters per second.
   b. Turbidity between 0 and 100 NTUs.
   c. Function in shallow water (less than 1 m) and deep water (up to 20 meters).
   d. Function over a long period of continuous deployment (greater than24 hours but preferably many days).
   e. Operate without natural light (at night or dark spaces, provides own light source as needed).
   f. Operate under bright light conditions near the surface in the daytime.
3. If the device is submersible in water, it should be durable enough to be deployable when towed off a boat.
4. If optical, it should be able to capture images without a blur.
5. The device/method should be able to accurately count and identify available drift invertebrates (food) with 95% accuracy.
6. The device/method should be able to measure the size of each target item within 0.5 mm or 10% of item size.

7. The total cost of the equipment should be targeted to not exceed $100K when produced in larger quantities.
8. The proposed system should offer the Seeker client “freedom to practice”. There should be no third party patent art preventing the use of specific equipment and materials for their commercial application.

<u>Nice to have</u>

Include ability to measure flow entering device, such that number of food particles per volume of water is estimable.

Some examples of drift invertebrates are shown below:

These photos show some food sources available to fish in streams: a) mayfly, Ephemeroptera, family Baetidae, b) stonefly, Plecoptera, family Perlidae, and c) caddisfly, Trichoptera family Hydropsychidae.

Photos taken from http://www.dfg.ca.gov/abl/Lab/california_referencecollection.asp