Project Number: 040725

Project Title: Impacts of Seafood Waste Discharge in Orca Inlet, PWS

PI's: Drs. Richard E. Thorne and Mary Anne Bishop

Time Period: Aug 16, 2005 to 15 September 2006

Date: September 29, 2006

Work Performed:

The purpose of this three-year project is to examine impacts of seafood waste discharge into Orca Inlet (Fig. 1 and Fig. 2), including evaluation of alternative discharge and disposal methods that could be beneficial to fishermen, the processors and the community. A work plan was developed during the first year, 2004, through workshops and other collaborations. The first field experiment was conducted during summer 2005 after completion of an environmental impact assessment in mid-May 2005, and included dumping of about 125,000 lbs of fish heads and carcasses (Fig. 3). Monitoring showed that the salmon heads and carcasses were rapidly dispersed and efficiently incorporated into the food chain, with no negative consequences. Several of the heads were retrieved in the stomachs of halibut caught in the local sport fishery. This report covers activities during the third and final year of the project.

The lack of apparent negative impacts from 125,000 lbs of waste dumped during the first field experiment led to plans to increase the magnitude during summer 2006. During the first phase, associated with availability of sockeye salmon carcasses in June 2006, we dumped ~138,200 lbs. The increased volume has allowed us to detect short-term accumulations along the bottom, however we observed no pile creation nor did we detect any negative impacts. Again, some fish heads were retrieved in the stomachs of halibut caught in the local sport fishery. Additional dumping is taking place during the second phase of carcass availability during the coho salmon fishery. As of 15 September, ~36,000 lbs of coho salmon heads had been dumped in the vicinity of the sockeye salmon dump site.

During summer 2006 we continued several of the monitoring activities from 2005. We conducted camera (Fig. 4), boat and beach surveys to look for evidence that heads or carcasses were washed ashore or floating away, and to monitor seabird and mammal activity at the experimental site, control site and the historical site. We also initiated two additional methodologies: acoustic tag tracking of selected heads and scavenger traps. We are in the process of tagging and tracking the dispersal of up to 16 salmon heads with Vemco V9 tags (Figs. 5 & 6) at 7 different frequencies, with the tags tied to the opercula bone of the fish (Fig. 7). Scavenger traps are fish heads wrapped in fine mesh, which allow us to evaluate fauna at the dump site, such as amphipods (Fig. 8) and sea stars (Fig. 9), and where ground up fish waste is discharged (Fig. 10).

The logistic operations of acquiring, transporting and dumping these magnitudes of waste have been challenging. The seafood processors in Cordova have been extremely cooperative and have made major efforts to accommodate our needs, at considerable labor cost and distraction during busy times. Vessel availability to transport the seafood waste to the dump site has also been challenging because of the extremely high time demand on vessels and vessel operators during the busy fishing season. On the other hand, public interest in the project has been immense.

Future Work:

Dumping of salmon carcasses and heads, tag tracking, scavenger trapping, camera surveys and beach surveys will be continuing into the early fall (October). Results of measurements will be incorporated into the waste dispersal model after completion of the field season.

Coordination/Collaboration:

This project is a collaborative effort among several entities. The primary institutions are the Prince William Sound Science Center, Alaska Department of Environmental Conservation, and Cordova seafood processors: Norquest, Ocean Beauty, Bear & Wolf and Copper River Seafoods.

Community Involvement/ TEK and Resource Management Applications:

The collaboration noted above has been facilitated by a historic and long-term community interest in fish waste. The Orca Inlet Issues Committee, and more recently, the Prince William Sound Utilization Committee, organized by the Copper River Watershed Project have examined the problem of fish waste around Cordova processing plants. Many of the concerns addressed by the Prince William Sound Utilization Committee run parallel to this project. In addition, members of the Cordova community are participating by providing catch data, especially stomach contents, as detailed above.

Information Transfer:

Project results are being incorporated into the PWSSC website: http://www.pwssc.gen.ak.us/research/seafood_waste. Classified ads have been placed in the Cordova Times and on the televised community scanner advising the public of the project. In February 2006, a presentation was given at a Cordova Community Education Program, sponsored by Prince William Sound Science Center & Alaska Sea Grant Marine Advisory Program. Oral presentations on the project were given at the American Fisheries Society's annual meeting in Lake Placid, NY on September 12 and at the Oceans06 meeting in Boston on September 19, as well as to the Science Center Board of Directors. In addition, the project has been featured in several radio station interviews and public talks.

(a) Publications:
Thorne, R., G. Thomas, and M.A. Bishop. 2006. Alternative Seafood Waste Disposal Procedures for Alaskan Waters. Richard Thorne, Mary Anne Bishop and Gary Thomas. Proceedings of Oceans06. Boston Mass.

(b) Public Outreach Activities: Radio Interviews & Professional Presentations

February 28, 2006. Radio Interview. James Thorne interviewed by Dan Bross on Public Radio KUAC's Alaska Edition morning program.

February 28, 2006. Oral Presentation. Using Fish Waste to Feed Halibut. Prince William Sound Science Center & Alaska Sea Grant Marine Advisory Program Community Education Program. Cordova, Alaska. Presentation by James Thorne.

April 26, 2006. Radio Interview. Richard Thorne interviewed by Danny Sparrow, on Public Radio KCHU's Coffee Break morning program.

September 12, 2006. Oral presentation. Impacts of Seafood Waste Discharge in Orca Inlet, Prince William Sound, Alaska. Richard Thorne, Mary Anne Bishop and Gary Thomas. American Fisheries Society, Annual Meeting, Lake Placid, N.Y. Public Policy Session. Presentation by Richard Thorne.

September 11, 2006. Oral presentation. Impacts of Seafood Waste Discharge in Orca Inlet. Semi-annual meeting of the Prince William Sound Science Center Board of Directors. Cordova, Alaska. Presentation by Rick Crawford.

September 19, 2006. Oral Presentation. Alternative Seafood Waste Disposal Procedures for Alaskan Waters. Richard Thorne, Mary Anne Bishop and Gary Thomas. Oceans06, Boston Mass. Presentation by Richard Thorne.

Budget:

There are no substantial changes in the budget projections at this stage.

Report prepared by: Drs. Richard Thorne and Mary Anne Bishop

Figures:

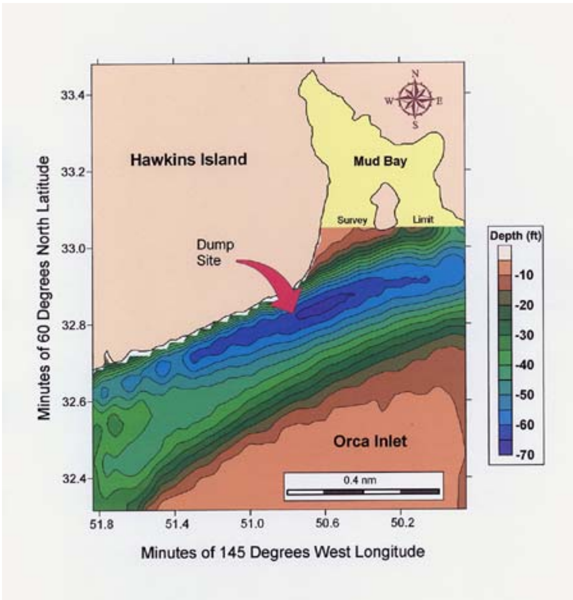


Figure 1. The dump site is a deep area off the SW corner of Mud Bay, Hawkins Island in Orca Inlet.

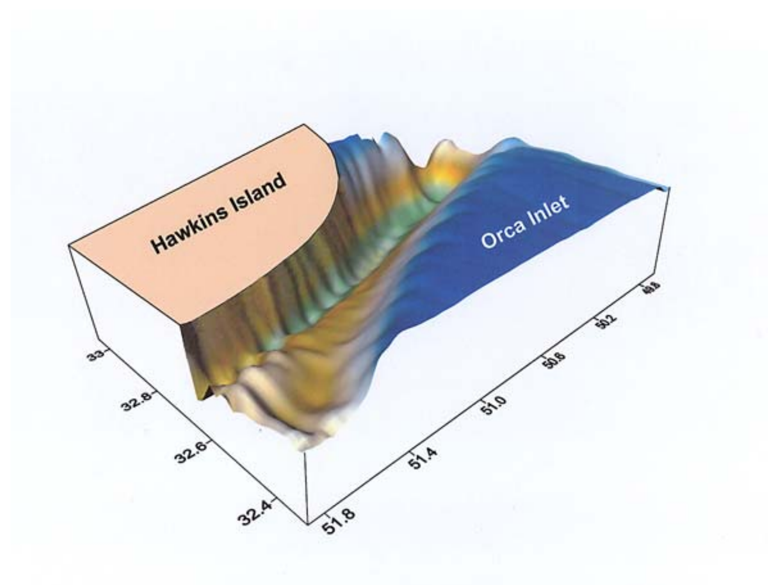
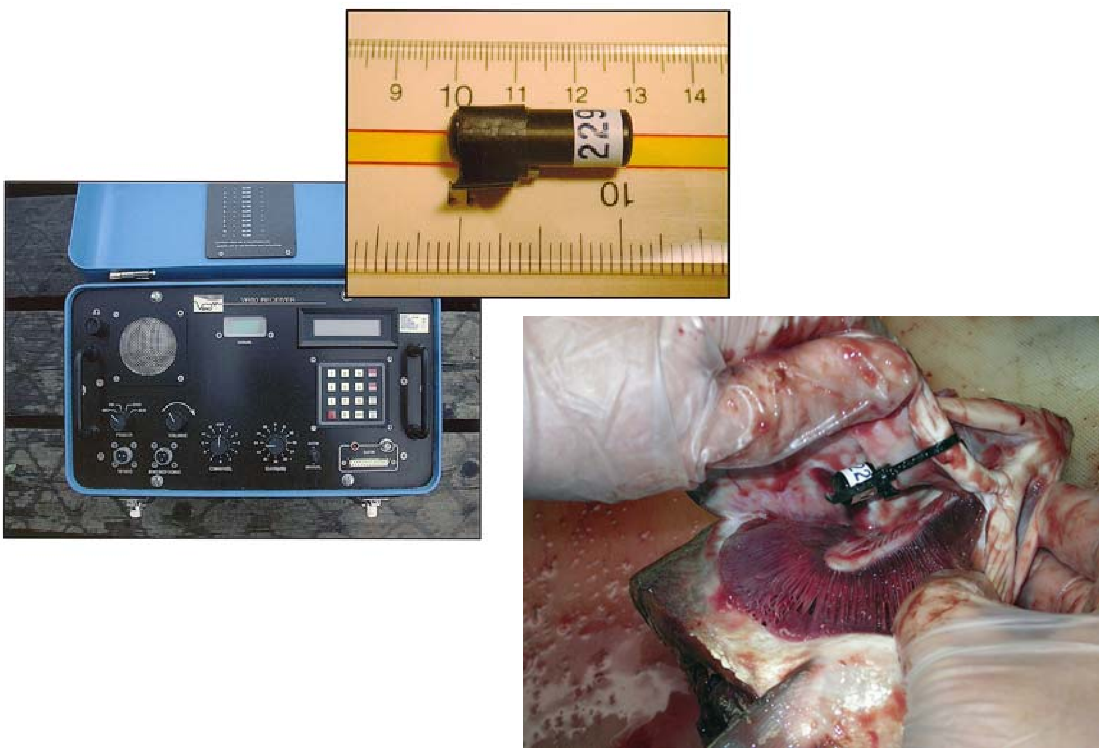


Figure 2. Currents are swift in the dump site trench where the fish waste is dumped.

Figure 3. Fish waste is carried to the dump site in "totes" containing roughly 1100 pounds each and dumped overboard where it is dispersed in the trench by tidal currents.

Figure 4. A special camera sled was constructed to monitor the distribution and decomposition of fish waste in the study area.



Figures 5-7. Electronic tags that emit a trackable coded signal are hidden (left and top center) in the opercular cavity of fish heads (right) for the study of biological and physical dispersion of fish waste dumped in the study area.

Figures 8 & 9. Gammarid amphipods (left) and the sea star Sunflower Star *Pycnopodia helianthoides;* here ~24 inches in diameter) are characteristic of the scavenger community at the dump site, control site and historical site.

Figure 10. The scavenger community where pipes currently discharge ground up fish waste into Orca Inlet is characterized by vermiform fauna (annelid and polychaete worms) and other grazers, such as this 2 mm long nudibranch.

Alternative Seafood Waste Disposal Procedures for Alaskan Waters

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***Abstract*- In 1975 EPA produced effluent discharge guidelines for the seafood processor industry that required wastes to be ground to 1.27 cm (½") in any dimension prior to discharge. Subsequently, several negative impacts were observed around Cordova, Alaska, including noticeable decreases in crab and halibut harvests and a substantial increase in numbers of Glaucous-winged gulls. We hypothesize that the change in discharge guidelines removed a food source for the large bottom oriented animals and increased availability to the surface-oriented gulls. In 2004, we began a three year study to examine impacts of seafood waste discharge into Orca Inlet, including evaluation of alternative discharge and disposal methods that could be beneficial to fishermen, the processors and the community. Preliminary indications are that the heads and carcasses disperse rapidly and are efficiently incorporated into the food chain with no negative consequences, a very favorable contrast to the current EPA-mandated practice.**

I. INTRODUCTION

In 1975 EPA produced effluent discharge guidelines for the seafood processor industry that required wastes to be ground to one-half inch (1.27 cm) in any dimension prior to discharge. The reasons for this requirement were to: a) prevent the wastes from floating by destroying the swim bladder, and b) make waste available to a greater variety of fish species, resulting in greater waste consumption. The size requirement was also based upon a waste particle size commonly achieved by domestic waste water plants at that time.

In Cordova, Alaska, processors implemented the one-half inch grind requirement around 1978. Previously, there had been a problem with the fish processing practices in Alaska. The seafood processors dumped the carcasses and trimmings under their docks in a manner that the waste piles would not interfere with unloading operations. The large offal piles were composed primarily of heads, entrails and skeletons. The large offal piles were unsightly, aromatic and, as the carcasses decayed, they often floated down current and contaminated nearby waters and beaches. In most cases, the offal piles were completely dissipated by the next fishing season. It was assumed that many large scavengers, such as halibut, crab, cod and sea lions, fed on the offal piles, which contributed to their complete dispersal by the next spring. When confronted with seafood waste at processing plants, EPA assumed that grinding it would convert it into wastewater and physical dispersion could be used to dilute it.

Several problems were quickly obvious following the implementation of grinding. Many of the processors were located in nearshore protected waters and in harbors. The practice of grinding fish offal before discharge created some noticeable changes in the quality of the nearshore environment, such as the discoloration of the water, foul smells and surface scum, and a build up of large piles of organic matter at the point of discharge. High BOD of the offal piles created anoxic conditions, and methane and hydrogen sulfide eruptions occurred regularly at low tides.

The change in the near-shore animal assemblage was even more devastating to local communities. Prior to the grinding operations, the near-shore assemblage was composed of an abundance of large marine predator-scavengers, such as sea lions, Pacific halibut, Dungeness crab and Pacific cod. Subsequent to grinding, the assemblage became dominated by smaller marine animals, such as sole, flounder, sculpins, Pacific herring and nuisance levels of Glaucus-winged gulls and kittiwakes [1]. Replacing the Dungeness crabs were large numbers of Capitella spp*s* polychaete worms, a well-documented index of environmental stress [2]. Accompanying these changes was a collapse in the local commercial, sport, and subsistence fisheries.

It was obvious that the new fish grinding guidelines were not as effective as the old practices in recycling the seafood waste back into the environment. In 2004, we began a three-year study to examine impacts of seafood waste discharge into Orca Inlet near Cordova. Objectives of the study were to 1) develop a model for fish offal dispersion, 2) design and implement a field experiment to verify the mechanisms of the fish offal dispersion model, and 3) propose changes to existing guidelines that could improve the local environment and quality of life for the communities that were affected by the guidelines. The model and field experiments were developed to compare the dispersion of unground to ground offal. Our primary hypothesis was that the fish offal was more efficiently recycled into the food chain prior to grinding practices due to its utilization by large marine animals, a mechanism that was not considered by the EPA guidelines.

II. METHODS

During the first two years of this project we 1) developed a dispersal model that incorporated both physical and biological transport mechanisms, 2) conducted reconnaissance of the Orca Inlet study area, 3) designed an experimental plan that identified potential disposal sites with favorable hydrographic and circulation characteristics and 4) conducted field observations at experimental sites to verify the model's mechanisms.

In order to develop a model that included biological transport of the offal, we first defined the composition of the local marine animals that would utilize the ground and unground offal. We hypothesized that the assemblage for ground offal was composed of Pacific herring, several species of small flatfish, sculpins, juvenile cods, Glaucus-winged gulls and kittiwakes. Our composition for the unground offal was Steller sea lions, Pacific halibut, adult Pacific cod, walleye pollock, and Dungeness crabs. Average weight, consumption rates and home range for these species were determined from observations and the literature. Since we were only interested in a relative comparison, we did not incorporate the abundance of these animals.

A Sea-Bird CTD and a 600 kHz RD acoustic Doppler current profiler (ADCP) were used to collect temperature, density and salinity by depth and current velocities and direction throughout Orca Inlet. We made continuous measurements of currents on repeated transects and made four CTD drops on each transect to collect temperature and salinity data. These data were used to determine the location for experimental discharges of unground offal. The utilization of unground at the experimental sites was compared to the ground offal utilization at the existing discharge sites.

During the second year, we initiated experiments in remote areas where we dumped approximately 125,000 lbs of salmon heads and carcasses at a single location during June and July. We conducted eight underwater camera surveys with a Splashcam Delta Vision high definition black and white video camera to examine dispersal rates and impacts on surrounding biota. We conducted boat and beach surveys to look for evidence that heads or carcasses were washed ashore or floating away. In addition, we monitored seabird and mammal activity at the experimental site, control site and the historical site. Seabirds and sea lions were monitored by a combination of aerial flights and boat surveys. Finally, we involved local sport fishermen to look for instances of fish with salmon heads in their stomach.

For the third year, we are in the process of dumping 250,000 lbs of heads and carcasses at a single location. The camera and visual surveys are being conducted at 10 day intervals for two months then monthly for three months. Surveys are covering both experimental and control locations. We are again looking for instances of salmon heads in the stomachs of fish taken in the local fisheries. In addition, we are conducting an acoustic tagging program to track the rate and direction of fish head dispersal. We plan to place a total 16 Vemco V9 tags at 7 different frequencies. Tags are tied to the lower jawbone of the fish.

III. RESULTS

A. *Model*

The model of fish offal dispersion or transport from the discharge site (T) that we developed included both physical (P) and biological (B) transport mechanisms.

$$T = f(P+B) \tag{1}$$

P = physical transport of fish waste
B = biological transport of fish waste

Physical transport of fish waste is primarily tidal driven in Orca Inlet. Tides create the largest movement of water in estuaries [3], but since the water movement is in and out of the inlet this effect primarily contributes to mixing and can resuspend ground fish offal. Water can move 10-15 km during a tidal cycle, which is important to determine the transport of ground offal, but the net movement of water depends upon the amount of freshwater runoff into the inlet. Wind and geostrophic forcing also affect physical transport.

Biological transport of fish offal results from animal consumption, growth, digestion/evacuation and migration. The consumption of fish offal is generally considered a function of the body weight of the scavenger. Conversion of fish parts to growth in mariculture operations is about 50%. Thus, large scavengers that move through the discharge areas can consume significant quantities of fish offal and redistribute it in terms of biomass growth and feces over ranges that can exceed physical transport. Also, the distance of species-specific migrations is a function of the size of the animal. Therefore, the size and composition of the animal assemblage is an important aspect to consider for determining the biological transport of fish offal.

$$B = \sum[(r_i)(w_i)/a_i] \tag{2}$$

r_i *= daily ration percent for species i (% body weight)*
w_i *= average weight of species i (kg)*
a_i *= range of movement of species i (km)*

where i is:

1 = decomposers (bacteria, fungi, etc.) (1 m)
2 = small benthic invertebrates (nematodes, polychaetes, starfish, etc.) (10 m)
3 = large benthic marcroinvertibrates (Dungeness and rock crabs, octopus) (<25 km)
4 = small benthic and pelagic fishes (flounder/sole, sculpins, herring, juvenile fishes, etc.) (<30 km)
5 = seabirds (>100 km)
6 = large benthic and pelagic fishes (halibut, sharks, pollock, cod, salmon, etc.) (>100 km)
7 = mammals (sea lions, seals, etc.) (>100 km)

Our initial simulations are shown in Figures 1 and 2. As we suspected, due to their large size, sea lions, adult fish and crabs can assimilate and transport a significant amount of fish offal over a much larger area than physical processes and small animals alone. The fact that the unground fish offal can be utilized by this component of the marine assemblage is a significant oversight by the current guidelines to grind offal. Furthermore, since a large food source will attract and hold high numbers of large animals and enhance their growth at the same time, the process enhances itself as the large animals get habituated.

B *Preliminary Field Observations*

The oceanographic surveys confirmed Mud Bay as the preferred location for the first year's experimental dumping of fish waste (Fig. 3). A location just south of Observation Island was identified as the control site, while the one near Humpback Creek was chosen as a potential second dumpsite.

After preliminary underwater camera surveys for baseline conditions, the project began in earnest with the purchase of waste from local Cordovan seafood processors by Alaska Department of Environmental Conservation and subsequent dumping of about 125,000 lbs of salmon heads and carcasses at

Figure 1. Potential area of fish waste dispersal due to seasonal movements of species consuming fish offal.

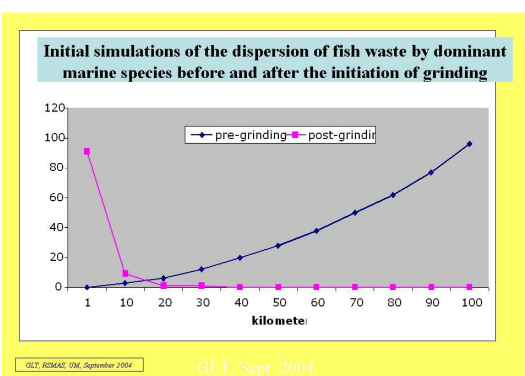

Figure 2. Potential area of fish waste dispersal due to seasonal movements of species consuming fish offal.

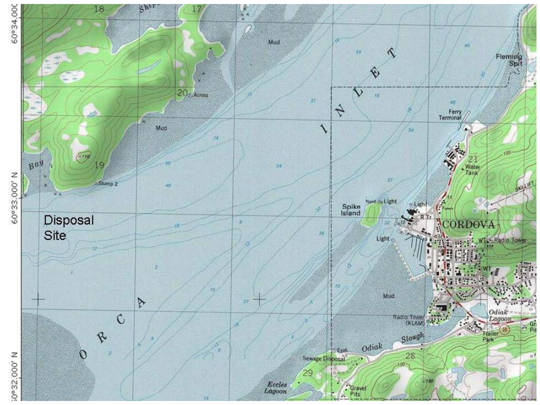

Figure 3. Location of disposal site off Mud Bay, across from Cordova.

Mud Bay during June and July 2005. Post disposal surveys did not find any floating or beached salmon heads or carcasses. Gull surveys reported large numbers of gulls in the vicinity of the current outfalls (Fig 4), attracted to the ground waste particles. Gulls were rare in the vicinity of the head and carcass disposal.

The underwater camera surveys showed a substantial population of halibut, flounders and starfish at the Mud Bay site (Fig. 5). The camera surveys did not locate any concentrations or piles of heads or carcasses despite single dump events of up to 50,000 lbs. Currents and scavengers appeared to disperse the heads and carcasses very rapidly. The public reported three halibut catches with salmon heads, for which we were the only source.

IV. DISCUSSION

The lack of negative impacts in 2005 led to the decision to double the amount of heads and carcasses in the 2006 field trials. As of July 1, over 140,000 lbs had been dumped within a one-month period. The increased volume has allowed us to detect short-term accumulations along the bottom, but still no pile creation, and no apparent negative impacts. On-going acoustic tag tracking will allow us to better understand the dispersal rate, while the on-going camera surveys and direct capture/stomach analysis will aid our understanding of ultimate impacts.

Figure 4. Gulls attracted to current disposal site

The field results to date are in accordance with expectations from the conceptual model. The model implies that waste dispersal is greatly enhanced when utilized by larger and more mobile organisms. Initial simulations from the model provide an explanation for how this mechanism works. In 2006, we will run simulations on an expanded number of species and we will attempt to introduce density as a variable to determine its affect on potential loading rates at dispersal sites.

The timing of the commencement of fish offal grinding by Alaskan processors has an eerie relationship to the collapse of the western stock of Steller sea lions [4,5]. We have observed that Steller sea lions appear to be one of the first scavengers to associate with fish offal discharges, from newly erected sportfish cleaning stations to our experimental sites where we discharge the unground fish offal. The processors in Alaska were processing about a billion pounds of fish in the late 1970s, which was all disappearing or was assimilated into the food web by the end of winter. The implementation of grinding immediately removed 500,000,000 pounds from the scavengers' food supply. This by itself would account for a reduction in 125,000 tons of growth in the larger animals. A perturbation of this magnitude should have produced some major responses in the scavenger populations, which is a current topic of our 2006 investigations.

V. CONCLUSIONS

All indications are that the salmon heads and carcasses were rapidly dispersed and efficiently incorporated into the food chain, with no negative consequences, which contrasts very favorably with the current EPA-mandated practice.

The 1975 change in disposal practices may have had several unintended consequences. In addition to noticeable deterioration of water and habitat quality, there was a loss of forage for larger and more mobile animals, such as Dungeness crab and Pacific halibut, that have high value to the local fishery-based communities. These detriments, combined with a potential health hazard from excessive bird feces during a period when bird flu is considered a potential major pandemic, suggest that new guidelines are needed that reduce negative impacts on the processors and coastal communities that depend upon productive fisheries and a healthy environment.

Figure 5. Flatfish seen by underwater video camera at experimental site.

ACKNOWLEDGMENTS

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