FACTORS AFFECTING NEARSHORE SURVIVAL AND PRODUCTION OF JUVENILE SOCKEYE SALMON FROM KVICHAK BAY

Phase I: Important habitat, migration routes and food resources

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PRELIMINARY ABSTRACT (MANUSCRIPT TO BE SUBMITTED TO ALASKA FISHERIES RESEARCH BULLETIN)

Low returns of sockeye salmon to Bristol Bay in 1997 and 1998, and the failure of the peak sockeye salmon run on the Kvichak River in 2000 has generated great concern for the health and continued viability of the Kvichak River stock of sockeye salmon. These events, in turn, have spurred a renewed interest in determining factors that affect survival of sockeye salmon throughout their life cycle, and particularly the early marine phase of that cycle. In this study we provide detailed information on important habitats utilized by juvenile salmon as they migrate from the Kvichak River into and through Kvichak Bay, define their migratory route through Kvichak Bay, and assess food resources available during that migration. In 2001, during the period of sockeye smolt outmigration (mid May to mid June), juvenile sockeye salmon were sampled along several transects from shore up to 50 km offshore. Abundances of sockeye tended to decrease from shallow, nearshore areas with higher temperatures, higher turbidity, and lower salinities to deeper, offshore areas with colder, more saline, and less turbid waters. Bottom depth, temperature, salinity, Secchi depth, and distance from shore are all strongly confounded, thus their potential effects on the distribution of salmon are difficult to separate. Sockeye abundances were not correlated with total zooplankton density or biomass, however, sockeye were correlated with selected zooplankters, such as the calanoid copepods *Eurytemora* and *Epilabidocera*. *Eurytemora* was the most important prey item, in terms of frequency of occurrence and number eaten. Mysid crustaceans dominated the prey in terms of biomass. Nearly 30% of 514 fish examined had stomachs that were empty or with only trace amounts of food. About 37% of the fish from Kvichak Bay had little or no food. The prevalence of empty stomachs suggests that smolts may be food stressed during their migration through near-shore waters.

An investigation into the possible relationship between killer whale (*Orcinus orca*) predation and the continuing decline of the Steller sea lion (*Eumetopias jubatus*) population

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OVERVIEW

The objectives of this research project were twofold: 1) to assess the stable isotope signatures of killer whale (*Orcinus orca*) skin samples to determine the trophic level at which they were feeding and 2) to analyze killer whale blubber samples using fatty acid signature analysis to assess whether killer whales were feeding on Steller sea lions (*Eumetopias jubatus*). Samples were obtained from biopsy sampling of killer whales inhabiting waters from the Bering Sea to Southeast Alaska undertaken by NMML/NMFS in summer 2001.

BACKGROUND INFORMATION

In 1997, the western population of the Steller sea lions was classified as "endangered" and the eastern population as "threatened" under the Endangered Species Act. A number of reasons have been proposed as possible causes of this decline, but most have been eliminated from consideration. The leading hypothesis that is still being considered being a potential change in food availability (e.g., Castellini 1993, Merrick and Calkins 1996), however, despite numerous studies attempting to link the continuing decline in the size of the Steller sea lion population with nutritional stress, there has yet to be a definitive linkage made. An alternate cause for the continuing decline in the sea lion population has recently been proposed.

Barret-Lennard *et al.* (1995) have suggested an alternate cause of the continuing decline in the sea lion population. While predation by killer whales (*Orcinus orca*) is not likely to have caused the Steller sea lion decline, they may now be a contributing factor. The retrieval of 14 sea lion tags from the stomach of a dead killer whale in 1992 is certainly suggestive of the impact that even an individual whale could have on a population (Barret-Lennard *et al.* 1995). Their investigation, cited 492 interactions (10% of them predatory in nature) between killer whales and Steller sea lions showed that the majority of attacks and kills reported were of small adults (n=12) (Barret-Lennard *et al.* 1995). Their research also suggested that only transient whales were likely to be involved, but that this group could account for approximately 18% of sea lions that die annually in western Alaska (Barret-Lennard *et al.* 1995).

Killer whales are classified as top predators in the marine ecosystem with diets that vary regionally and seasonally (Heyning and Dahlheim 1988). Two life-history patterns, involving two forms of killer whales termed resident and transient, have been suggested for whales occupying the waters of Puget Sound, Washington and British Columbia. One criterion used to differentiate the two forms is diet. Resident whales are thought to feed primarily on fish, whereas transients are thought to feed primarily on marine mammals.

Discerning the feeding habits of cetaceans can be difficult, however, there are several indirect methods of study available. In recent years a number of investigations have used stable isotopes of carbon and nitrogen to determine trophic relationships of a variety of birds and mammals (e.g., Schell et al. 1989, Hobson and Montevecchi 1991, Kurle and Worthy 2001, Kurle and Worthy 2002). The carbon isotope ratio indicates the source of the diet, while the nitrogen isotope ratio reflects the trophic level of the prey (DeNiro and Epstein 1978, 1981). Isotope ratios are ultimately determined by the food that has been incorporated into the animal over the past several weeks or months, and can provide an overall idea of the average diet. With multiple types of food generally available, isotope ratios can indicate, but cannot prove, that a certain type of food was used; they can however, sometimes prove when a food has not been eaten and assimilated. Isotope data derived from a pilot study on killer whales in Prince William Sound (PWS), AK suggested that some transient killer whales had been feeding at a higher trophic level than resident whales (Worthy and Abend 1998). This could imply that they had been feeding on marine mammals, but based only on isotopic data the possibility that they may have been feeding on piscivorous fish cannot be excluded.

Fatty acid signature analysis has emerged recently as a method that can overcome deficiencies of other techniques (*e.g.*, direct observation, fecal and stomach contents analysis), as well as the limited resolution provided by isotopic ratios. Unlike similar techniques, fatty acid signatures have the resolution to determine individual prey species, sometimes to the extent of separation based upon geographic location and age class (Iverson *et al.* 1997). Fatty acids that originate exclusively from the diet (Fraser et al. 1989, Graeve et al. 1994) were first used as trophic markers in invertebrates and fishes (Fraser et al. 1989, Graeve et al. 1994, Kirsch et al. 1998) and there have been a number of studies suggesting a strong relationship between the fatty acid composition of storage tissues in an animal and the fatty acid composition of its prey (*e.g.*, Fraser *et al.* 1989, Iverson 1993, Graeve *et al.*, 1994, Iverson *et al.* 1997). Recently, Kirsch *et al.* (2000) have demonstrated that the fatty acid composition of harp seal blubber changes to match diet within 30 days of a dietary switch suggesting the possibility that this technique can be used to identify the prey consumed by a predator within the past month.

Marine food webs contain many long chain fatty acids (LCFAs) that are specific to individual prey items, and are generally incorporated into marine mammal blubber with minimal modification (Iverson 1993). By examining the blubber layer, it is possible to use LCFAs as indicators of possible prey items (Iverson 1993). Blubber of cetaceans is known to be heterogeneous, consisting of at least an inner and outer layer in some species (*e.g.* Koopman *et al.* 1996), while in others, a middle layer is also present (*e.g.* Cowan and Worthy 1991, Samuel and Worthy 1999). It has been suggested that each layer is responsible for different functions. Layers with a stable composition, such as the outermost blubber layer, may play a role in structural support, while other layers that are more dynamic (middle and inner blubber layers) may serve as energy storage or insulative sites (Koopman *et al.* 1996, Samuel and Worthy 1999).

The purpose of the present study is to apply both stable isotope signature and fatty acid signature analysis of killer whales from the central Alaskan waters in order to discern both the trophic level at which these whales are feeding as well as their specific feeding habits. It may be possible to use this information to determine if killer whales are feeding on Steller sea lions in this area.

METHODOLOGY

Killer whales were sampled in July –August 2001 from a study area that included a 30-45 nautical mile area around Steller sea lion rookeries and major haul-outs along the central Alaskan coastline from Resurrection Bay to Seguam Pass. Tracklines and sightings of killer whales are shown in Figure 1. Photographs were taken of the dorsal fin and saddle patch on the left side (and right side when possible) of killer whales sighted to identify individual whales. Digital video tape was also collected during each encounter.

Biopsy samples were collected using a regular Barnett crossbow, a Barnett compound crossbow, and a Larson gun using interchangeable 25 or 40 mm dart tips. A small amount of skin and underlying blubber were collected and frozen for stable isotope analysis. Biopsies were obtained for 11 different groups of whales for a total of 17 samples including 11 suspected resident whales (6 groups), four suspected transient whales (4 groups) and 2 suspected offshore animals (1 group).

CURRENT STATUS OF PROJECT

After significant delays in getting promised killer whale biopsy samples transferred from the National Marine Mammal Lab to the Physiological Ecology and Bioenergetics Lab, we are now in possession of the killer whale biopsy samples collected during the 2001 Alaskan cruise.

At the present time, stable isotope analysis of the skin samples is being undertaken. Fatty acid signature analysis will soon be initiated; however, the biopsy samples include only small quantities of superficial blubber. This component of the blubber layer is not especially conducive to FASA since it contains very few LCFAs. These fatty acids are critical for the interpretation of prey species.

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Figure 1. Cruise track lines for 2001 (derived from Dahlheim *et al.* 2001).

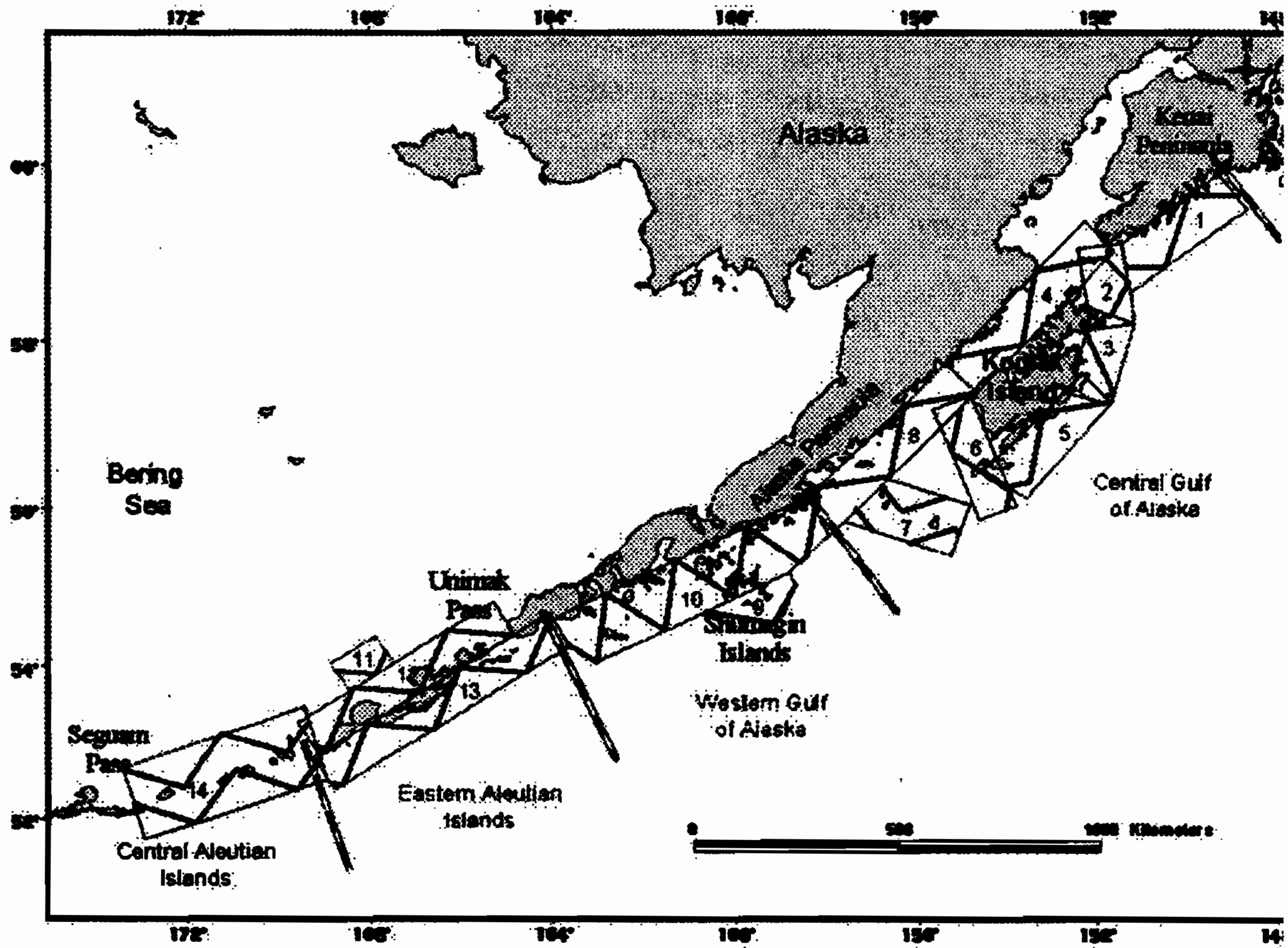

Figure 1. Survey design with proposed tracklines within survey strata (Table 1). Dashed lines show the boundaries of Steller sea lion subareas within the killer whale study area.