Status of Demersal and Epibenthic Species in the Kodiak Island and Gulf of Alaska Region

Paul J. Anderson
NMFS, Kodiak Fisheries Research Center, Kodiak, Alaska

J.E. Blackburn
Alaska Department of Fish and Game, Kodiak, Alaska

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Trophic Changes

The Gulf of Alaska (GOA) marine ecosystem undergoes extreme changes in trophic structure which have become known as regime shifts (Piatt and Anderson 1996, Anderson and Piatt 1999, Anderson 2000). The extent and degree of these changes are documented and will become important in determining future strategies for management of the marine ecosystem. Analysis of over 50 years of small-mesh trawl data is a first step in gaining an appreciation for the rapid and abrupt changes that have occurred in the marine species complex in the last five decades. The data from small-mesh shrimp trawl cruises provides an opportunity to review changes in the composition of forage species and other epi-benthic fish and invertebrates that occurred through time in the GOA from the early 1950s to the present. Yet the state of scientific knowledge is inadequate to explain the mechanisms at work that drive changes in this system. The following report is a compendium of what the data tells us is important in the demersal and epibenthic portion of the GOA marine ecosystem and offers some possible mechanisms that control trophic structure. Unfortunately the data needed to fully understand the dynamics of this abundant system have not been collected consistently in the past and our hope is that we can make a compelling case for collecting this information in the future.

Historically, there is evidence of major abundance changes in the fish/crustacean community in the western GOA. Fluctuation in Pacific cod availability on a generational scale was reported for coastal Aleutian Native communities. Similarly, landings from the nearshore Shumagin Islands cod fishery showed definite periods of high and low catches with the fishery peaking in late 1870s. King crab commercial catches in the GOA show two major peaks of landings, one in the mid-1960s and another in 1978-1980. All of the area was closed to fishing in response to low population levels in 1983 and has yet to reopen. By the 1960s there was evidence of high pandalid shrimp abundance in these same areas. One of the highest densities of pandalid shrimp known in the world was to spur the development of a major shrimp fishery. By the late 1970s the shrimp population density had declined radically and was accompanied by a closure of the shrimp fishery and the return of cod to inshore areas. Finally, catches of almost all salmon stocks of Alaskan origin suddenly increased to unprecedented levels in the 1980s. These changes, witnessed over the last century, imply dynamic fluctuations in abundance of commercially fished species. Managers, fishermen, and processors should be aware of these dynamics and their impacts on the ecology and economy.

Indicator Species

In a complex natural ecosystem, it is difficult (if not impossible) to measure the complete set of factors that provides a unified picture of the state of the ecosystem. Indicator species may provide a good sense of the ecosystem's status in some global way. Indicator species can either be indicative of some environmental condition or correlated with concurrent changes in other species (Thorson 1957, Dufrêne and Legendre 1997). Pandalid shrimp occupy a central position in the trophic structure of the northeast Pacific where they constitute the main prey of many species and in turn prey on the zooplankton community. They also occupy all depths of the water column from benthos to near surface. Therefore shrimp are good candidates for indicators of possible environmental change because they integrate changes that occur throughout the water column.

The absence of one or more species that were present previously at the same site is more indicative of environmental effect than absence of a single species. It is clearly necessary to know which species should be found at the site or in the system under prevailing environmental regimes.

In the case of the trawl survey data we analyze species group abundance against environmental variables. Canonical correlation analysis was used to measure the association between abundance of three major species groups (pandalid shrimps, gadids including walleye pollock [*Theragra chalcogramma*] and Pacific cod [*Gadus macrocephalus*]), and pleuronectid flatfish and environmental parameters. These groups together represented more than 90% of catch weights from shrimp surveys. The relation of shrimp and environmental parameters was investigated with correlation using Pearson Product Moment Correlation and Spearman's Rank Correlation taking into account any ties.

The abundance of the three species groups and the set of environment variables were correlated at 95%, as indicated by the first canonical variate. The correlation was slightly improved (96%) when the species were lagged: shrimp and flatfish at one year, gadids at three years. In the canonical correlation, gadids were almost as important as shrimp, perhaps yielding this species as another indicator. The correlations for shrimp abundance relative to water column temperature are significantly different ($P < 0.001$) from zero, indicating that there is a trend between the variables. The correlation of shrimp catch per unit effort (CPUE) and water column temperature anomaly (GAK250) was $r = -0.71$. The correlation between proportion of shrimp in survey catches and water column temperature anomaly was $r = -0.72$. That is, as water temperature increased, shrimp abundance and the proportion of the catch composed of shrimp tended to decline.

The results reported in this study suggest that shrimp react very quickly to warming climate trends and are a useful indicator of impending changes in the ecosystem that require longer time periods to fully manifest themselves. When the climate reverts to colder temperatures the low shrimp population may not react as quickly due to its low reproductive potential. In the case of near extinctions such as *P. goniurus*, rebuilding may take a considerable amount of time. The present high biomass of fish in the GOA probably precludes rapid rebuilding of shrimp stocks.

It is noteworthy that the GOA and the northeast Pacific are predicted to soon revert to the cold regime. Pandalid shrimp appear to be useful as indicators of a cold to warm regime changes, so it is unlikely that shrimp population changes will reflect this latest cooling trend for some time. However, there is some evidence that Pacific cod have the ability to react quickly to nearshore cooling of the water column. Recent data analysis suggest that cod are redistributing away from nearshore bay habitat in the Kodiak region. Cod are probably good indicators when reverting to cold from warm regime conditions.

In addition to the main indicator species of cod and shrimp, several noncommercial species of different orders were apparently impacted by the environmental changes. Among noncommercial species the most significant change since the early 1970s has been the decline of *Lumpenella longirostris*, long-snout prickleback. Catches of pricklebacks averaged 2 to 3 kg km^{-1} in the early 1970s. However, since 1981 catches have remained at relatively low levels averaging substantially less than 1 kg km^{-1}. All pricklebacks combined averaged 0.9 kg km^{-1} in the period 1972-1999, and have remained stable at 0.3 kg km^{-1} in the 1994-1999 period. *Eumicrotremus orbis*, spiny lumpsucker, has completely disappeared from catches in recent years. In the early 1970s this fish was locally abundant in some of the bays along the Alaska Peninsula. This species, while relatively low in total biomass during the early 1970s, is now almost extinct in the nearshore region of the GOA. Highest catch rates of spiny lumpsucker occurred in 1963 and 1964; no records of this species in this trawl series has been recorded since 1988. Clearly there is some concern that this species may now be functionally extinct in our survey area.

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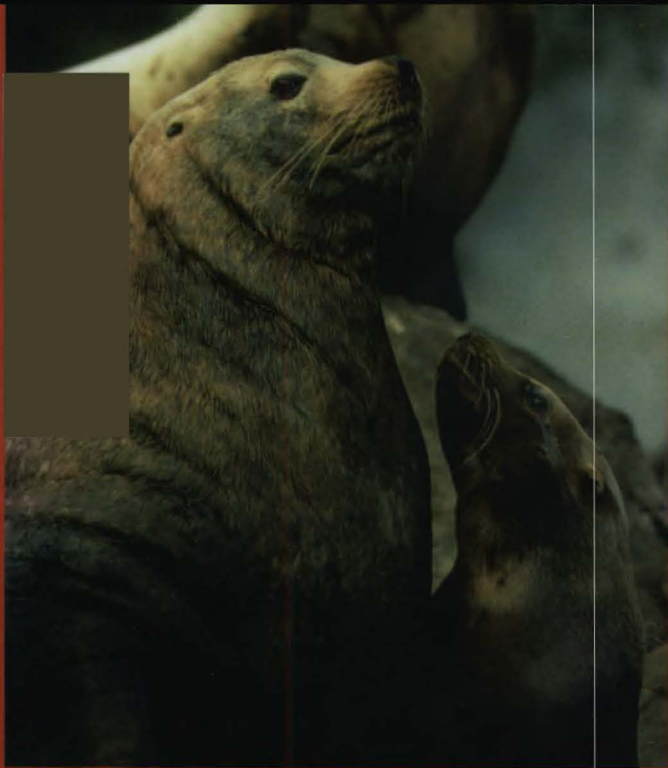

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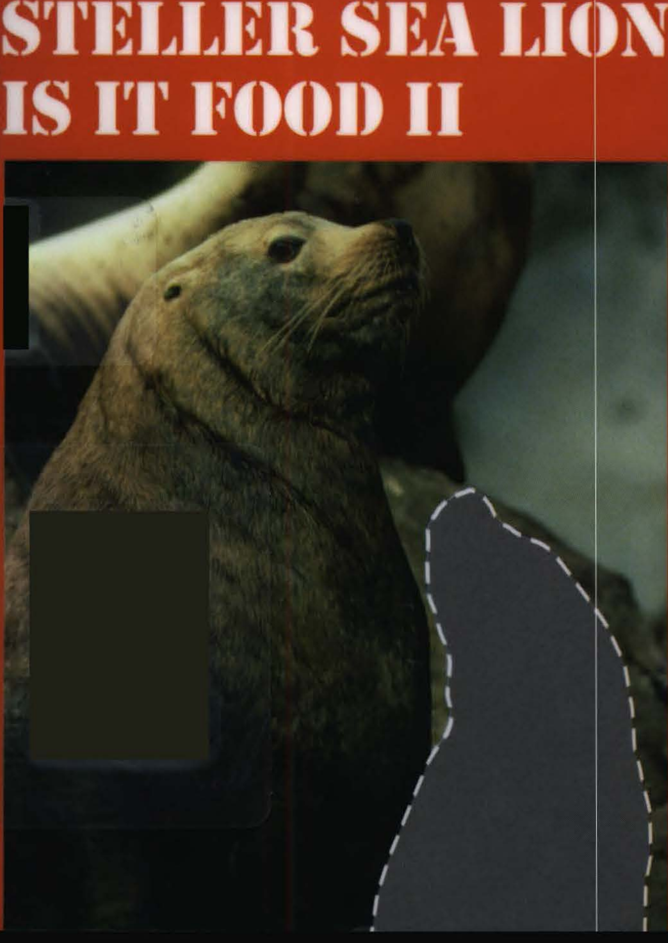

Editors:
Douglas DeMaster
Shannon Atkinson

University of Alaska
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