Synthesis and Analysis Gulf of Alaska of Small-Mesh Trawl Data 1953 to 1998

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Abstract

Large declines of apex predator populations (murres, kittiwakes, harbor seals, and Steller sea lion) have occurred in the Gulf of Alaska since the 1970s. Changes in composition and abundance of forage species may be responsible for the decline of these predator populations and their chronic low population levels. In an effort to delineate changes in forage species and a trophic regime shift over the last several decades, we have gathered together historical fishery-independent scientific survey data to address this question. Nearly 10,000 individual sampling tows are in the current database of the two agencies. Recent analysis of the 1998 trawl survey data has indicated that the fundamental trophic shift in the ecosystem is still in place. No evidence suggests that the shift is reversing itself. Recent results are discussed and future analysis strategy is discussed. There clearly is a need for moving the survey portion of this project into a long-term monitoring program to keep a time series reference intact. Additionally there is need to integrate oceanographic observations with those from the trawl survey database in order to understand the driving mechanisms that control changes in the community structure of the ecosystem. This will play an increasingly important role in future studies. This report includes several abstracts from recently prepared presentations and manuscripts resulting from project-funded studies.

Introduction

This project pursues analysis of small-mesh trawl sampling results from near-shore surveys in the Gulf of Alaska conducted by the National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G). The data for analysis was collected starting in 1953 and continues through 1998. Only general background material concerning this part of the project will be discussed in this section. The reader is referred to the two recently published manuscripts (Anderson et al., 1997 and Bechtol, 1997) for details of the methodology and analysis used with this portion of the data.

Recently there has been information presented that the Gulf of Alaska ecosystem has undergone some abrupt and significant changes (Piatt and Anderson, 1996; Anderson et al., 1997). The extent and degree of these changes are poorly documented and is important in determining future strategies for management of the marine ecosystem. Analysis of the historic 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 that occurred through time in the Gulf of Alaska.

Historically, there is evidence of major abundance changes in the fish/crustacean community in the western Gulf of Alaska. Fluctuation in Pacific cod availability on a generational scale was reported for coastal Aleutian communities by Turner (1886). Similarly, landings from the near-shore Shumagin Islands cod fishery (Cobb, 1927) showed definite periods of high and low catches with the fishery peaking in late 1870s. King crab commercial catches in the Gulf of Alaska show two major peaks of landings, one in the mid 1960s and another in 1978-1980 (Blau, 1986). All of the area was closed to fishing in response to low population levels in 1983 (Blau, 1986) and has yet to reopen. By the 1960s there was evidence of high Pandalid shrimp abundance in these same areas (Ronholt 1963). One of the highest densities of Pandalid shrimp known in the world was to spur the development of a major shrimp fishery (Anderson and Gaffney, 1977). 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 (Albers and Anderson, 1985). Catches of almost all salmon stocks of Alaskan origin suddenly increased to unprecedented levels in the 1980's (Francis and Hare, 1994, Hare and Francis, 1995). These changes, witnessed over the last century, imply dynamic fluctuations in abundance of commercially fished species. Managers, fisherman, and processors should be aware of these dynamics and their impacts on the ecology and economy.

Results From 1998 Surveys

Late summer surveys continued in the Pavlof Bay study area in 1998. Although this area is outside the EVOS spill zone, it has been the site for the longest annual trawl survey sampling in the entire Gulf of Alaska during the last 27 years. Changes in the trophic structure were first observed in this area which led to expanded analysis of trawl survey data from other areas of the Central and Western Gulf of Alaska. This long-term study has been the impetus toward a better understanding of the degree and magnitude of the trophic shift that has occurred and continuing impacts on the marine ecosystem.

Twenty-two tows were completed in the Pavlof Bay study area. This same survey location has been sampled in the same manner and at the same relative time each year for the past 27 years. It is anticipated that we will again complete this survey again in late summer of 1999, thus keeping this valuable time series continuous.

Osmerids and Pandalid shrimps continue to remain at historic low levels. Pandalid shrimps are at their lowest levels ever during the entire survey series. Shrimp were recorded at 7.47, 2.11, and 2.38 kg/km during 1996, 1997, and 1998 respectively. Cod and pollock remained the major component of catches in each year averaging 212.89, 379.66, and 493.9 kg/km in 1996, 1997, and 1998 respectively. Pleuronectid fish populations have apparently stabilized, and they averaged 144.45, 158.21, and 265.5 kg/km for 1996-98. The relative abundance of Pacific cod declined in survey catches (126.18 kg/km in 1997 and 42.0 kg/km in 1998); observed shrimp density increased slightly from that seen in 1997 2.11 versus 2.38 kg/km. The trend of cod abundance being negatively correlated with observed shrimp abundance seems to support the "predator forcing" hypothesis for adult populations of Pandalid shrimps.

Interesting life history table changes are also being observed for shrimp and fish species. Change in sex transformation of Pandalid shrimp in response to density dependant population levels was first reported by Charnov and Anderson, 1989. The continuing survey results continue to support the hypothesis, that shrimp are transforming earlier as first presented in the earlier preliminary analysis. This will lead to important future work not supported by project funding that will improve our understanding of the dynamics of Pandalid shrimp in Alaskan waters.

It is interesting to note that this was the first year since the survey series began that spiny dogfish shark (*Squalus acanthias*) was encountered in survey samples. They were also present in survey samples taken around Kodiak Island in the ADFG triennial trawl strata. Despite this unusual occurrence recently, historical fish survey records indicate that spiny dogfish were once common locally in inshore waters during the later part of the 1880s (Tanner, 1890). Maintaining accurate and published accounts from surveys that have taken place in the past is one important means of maintaining the proper perspective on survey results.

Papers and Presentations

1. Title: Community reorganization in the Gulf of Alaska following ocean climate regime shift.

Authors: Paul J. Anderson and John F. Piatt

Submitted to: Marine Ecology Progress Series. Status: In Review

ABSTRACT: A shift in ocean climate during the late 1970s triggered a reorganization of community structure in the Gulf of Alaska ecosystem, as evidenced in changing catch composition on long-term (1953-1997) small-mesh trawl surveys. Forage species such as pandalid shrimp and capelin declined and never recovered because of recruitment failure and predator forcing. Total trawl catch biomass declined > 50% and remained low through the 1980s. In contrast, recruitment of high trophic-level groundfish improved during the 1980s, yielding a > 250% increase in catch biomass during the 1990s. This trophic reorganization apparently occurred at the expense of piscivorus sea birds and marine mammals.

2.Title: Accessing Forty-five Years of Trawl Survey Data from the Gulf of Alaska with a GIS.

Authors: Sharon D. Loy and Paul J. Anderson

Presented: First International Symposium on GIS in Fishery Sciences; Seattle, WA March 2 - 4, 1999.

Abstract:

The Gulf of Alaska is a vitally important region containing a great wealth and variety of marine organisms. Questions regarding the driving mechanisms behind recent spatial and temporal changes in distribution and abundance of many species have resulted in a need for access to long-term data. The National Marine Fisheries Service (NMFS) has collected small-mesh research trawl data from the Gulf of Alaska since 1953. This data includes spatial data (locations of each haul in lat/long), parameters of each haul(date, time, distance, duration, depth, etc.), and environmental data (surface and near-bottom temperatures). The species composition of each haul (by both numbers and mass) is in an associated "Catch" data file .

This data is integrated into a GIS using ArcInfo and Arcview (Environmental Systems Research Institute, Redlands CA) software (1) to make the data accessible and easy to query for a broad audience, (2) to enable spatial and temporal analysis of the data to identify long-term patterns in distribution and density both between and within species, and (3) to create visual representations of these spatial and temporal patterns. The GIS project contains themes showing the Alaska Coastline, bathymetry contours, spatial locations of the start of each trawl survey haul, and an area of interest theme which outlines regions in the Gulf of Alaska. The user chooses an area

of interest to view, the GIS zooms into that view, and the user selects survey trawl data to view from that area. The user is given the choice to select data by species, by location (bay), or by user-selected points.

This GIS will increase the accessibility and application of past and current research survey trawl data, and will be maintained for future surveys as well. The system can be queried for simple and complex relationships such as species distributions and how they change over time, changes in species density over time, or changes in spatial relationships between species. This type of analysis improves understanding of the spatial interdependence between organisms and their environment.

3. Title: Distribution Shift of Pacific Cod in Crab Pot Surveys in the Kodiak Area 1971 Through 1986.

Author: James E. Blackburn

Abstract: Catches of Pacific cod were recorded from 26,995 pots during red king crab surveys in the Kodiak area of the Gulf of Alaska from 1971 through 1986. The abundance of cod increased through out the area during this time period. The inshore areas had a higher inter-annual coefficient of variation than offshore areas. The inshore areas were largely devoid of cod prior to about 1982 and cod were common in these same areas in 1982 through 1986. The inshore waters are where juveniles of many species commonly are found. Cod is a major component of the marine community, and a significant predator on some species. The inter annual variability of cod predation in the nursery habitat is identified as a potentially significant source of variability in recruitment of some stocks. Similarly, the inter decadal variability described is likely a source of long term changes in abundance of some species. The warming of waters that seems to be associated with the distribution shift of cod likely affected other species also, generalizing this impact.

4. Patterns in Space and Time; Small-mesh Trawl Surveys in the Gulf of Alaska 1953-98.

Author: Paul J. Anderson

Seminar Presented at the Alaska Fisheries Science Center, Seattle WA and Kodiak, AK on February 6 and 16, 1999.

Abstract: Recognition of changing patterns in species composition from annual small-mesh surveys in the Gulf of Alaska was first realized from the long-term data collected from Pavlof Bay. One of the first criticisms was that this represented a small area. How was it related to the wider Gulf of Alaska? Further studies combined long-term survey data from Alaska Department of Fish and Game with data from NMFS surveys to explore the patterns in the central and western Gulf. These studies 1972-97 showed that at least with the same gear, trends that were first evident in Pavlof were found over a broad area of the Gulf. Since there is broad temporal coherence in the observed patterns, there is probably not a need to conduct extensive annual surveys. Study results suggest selecting

representative areas that are logistically capable of producing a reliable time series is more important than trying to provide coverage over a broad area. Analysis success of current survey data demonstrates the importance of maintaining a stable sampling protocol. Sampling gear has remained unchanged throughout the data series, as well as time of day and methodology.

5. Web Page on APEX Project 98163L : www.fakr.noaa.gov/trawl/index.htm

Authors: Sharon Loy, Paul Anderson, John Piatt, and Jim Blackburn.

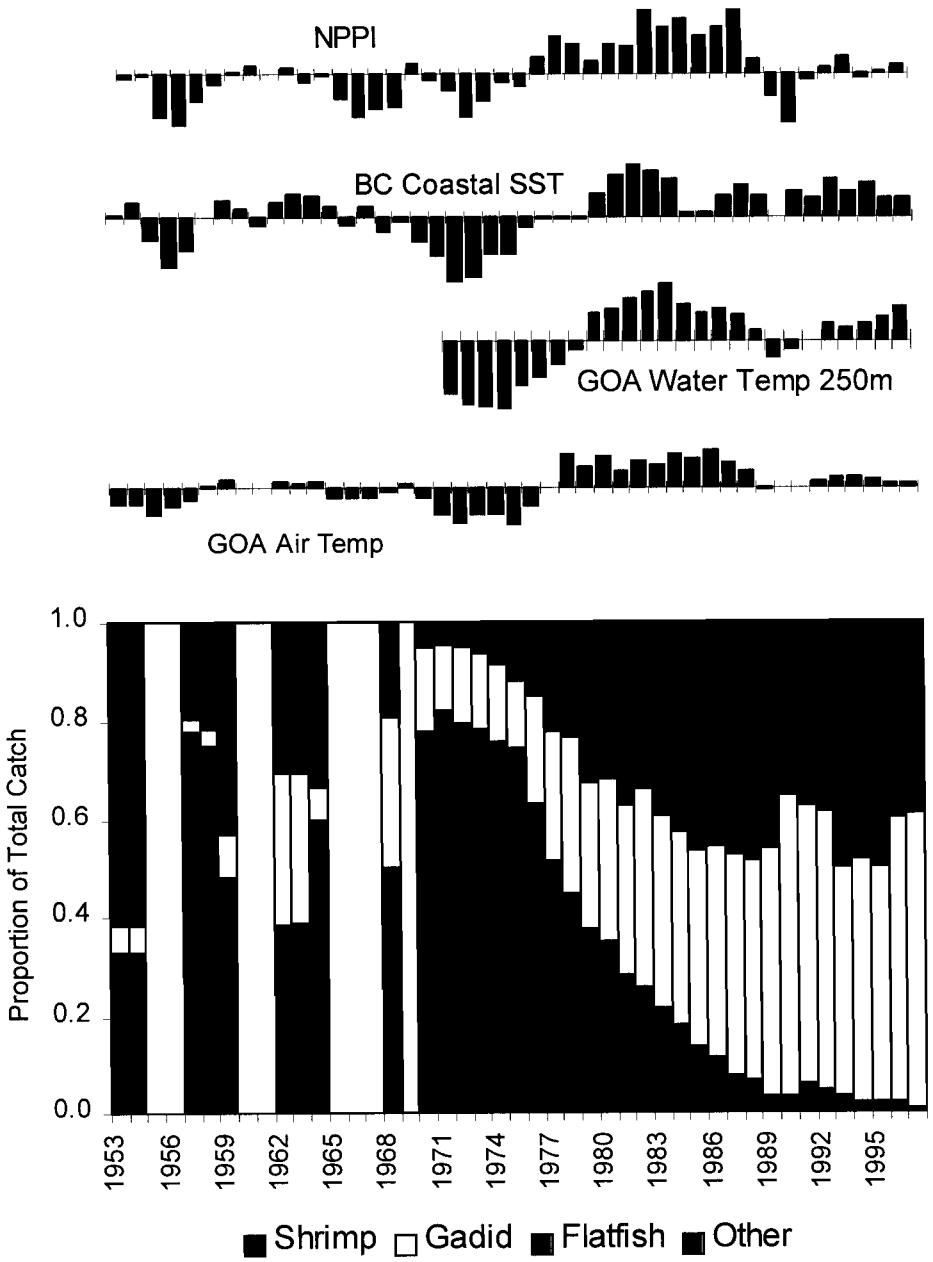

Figure 1. Composition of small-mesh trawl catches in the Gulf of Alaska between 1953 and 1997 in relation to climate indices. Climate data expressed as normalized anomalies NPPI is the North Pacific Pressure Index. Trends smoothed by taking 3-year running averages.

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