Appendix A

Forage Fish Species in the Gulf of Alaska

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Executive Summary

This is the first assessment for forage fish species in the Gulf of Alaska (GOA). The purpose of this appendix is to compile the available data for theses species and evaluate future assessment needs. Biomass values for certain forage fish species were calculated by multiple methods. Discussion of the limitations of these estimates is included. Regulations prohibit a directed fishery for forage fish species so OFL and ABC were not calculated. Exploitation rates were estimated for capelin and eulachon in the central GOA for 1999 and 2001. Worst case scenario exploitation rates were found to be 1% or less.

Introduction

In 1999, amendments 36 (BSAI) and 39 (GOA) to the fishery management plan (FMP) created a new forage fish species category from selected species previously non-specified or contained within the other species category. The families and species included within this category are listed in Table 1. This list was compiled from Fishes of Alaska (Mecklenburg et al. 2002). Many of these species are rarely, if ever, encountered by the fishery and the few that are caught are often not identified to species.

The forage fish category includes a diverse collection of species. They range in depth from intertidal to over 1000 meters, are found in the water column from the epinekton to the benthos, and have vastly divergent life histories. However, the species in this category are known to be critical food sources for numerous groundfish, marine mammals and seabirds (Wespestad 1987, Yang and Nelson 2000).

The forage fish species category was created to facilitate specific management goals intended to manage and conserve the forage fish resource for the benefit of the ecosystem. Current management of this category prohibits the development of a directed fishery, limits bycatch, and places limits on the sale, barter, trade, or processing of any species included in the group (FMP Amendment 36 and 39, 3/17/98, 63 FR 13009).

Little is known about the life history characteristics or distribution of many forage fish species in Alaska. Although, there are currently no programs designed to comprehensively sample forage fish, some surveys consistently capture certain members of the forage fish species category. Other species are rarely encountered in surveys, or the fishery, due to their size or habitat.

Life history characteristics of forage fish are described in the Programmatic Supplemental Environmental Impact Statement (PSEIS). General life history information for each of the major families is described in the following section.

Family Osmeridae

Smelts are slender schooling fishes that can either be marine, such as capelin (*Mallotus villosus*), or anadromous, such as eulachon (*Thaleichthys pacificus*). Members of the Osmerid family are found

throughout the GOA and the Bering Sea. Life history characteristics of the two most abundant species of smelts, capelin and eulachon, are listed below.

Capelin

Capelin are distributed along the entire coastline of Alaska and south along British Columbia to the Straight of Juan de Fuca. In the North Pacific Ocean, capelin can grow to a maximum of 25 cm at age 4. Most capelin spawn at age 3 or 4, when they are only 11 to 17 cm (Pahlke 1985). Spawning in Norton Sound, northern Bristol Bay, and around Kodiak Island occurs in intertidal zones of course sand and fine gravel during spring. Few capelin survive spawning. Capelin age of maturity in the Barents Sea was found to be a function of growth rate, with fast-growing cohorts reaching maturity at an earlier age than slow-growing cohorts. Thus, it is possible to have slow- and fast-growing cohorts mature in the same year, resulting in added variability in spawning biomass. In the Bering Sea, adult capelin distribution is associated with the polar ice front. However, in the GOA, which remains ice free year round, capelin are thought to overwinter in bays.

Eulachon

Eulachon spawn during the spring in rivers along the GOA, possibly with some contribution from rivers that drain into the southeastern Bering Sea. Eulachon live to age 5 and grow to 25 cm, but most die following their first spawning at age 3. Eulachon are consistently found by groundfish fisheries and surveys between Unimak Island and the Pribilof Islands in the Bering Sea, and in Shelikof Strait in the GOA. Evidence from fishery observer and survey data suggests that eulachon abundance declined in the 1980s. These data should be interpreted with caution because surveys were not designed to sample small pelagic fishes such as eulachon, and fishery data were collected primarily to estimate total catch of target groundfish. Causes of the decline, if real, are unknown. The decline may be simply related to natural variability in year-class strength or perhaps due to environmental factors that affects the availability of eulachon to fishing gear.

Family Myctophidae and Bathylagidae

Lantern fishes (family Myctophidae) and deep-sea smelts (family Bathylagidae) are pelagic fishes, distributed in the deep sea throughout the world's oceans. Species in both families occur at depth during the day and migrate to the surface at night to feed. The northern lampfish (*Stenobrachius leucopsarus*), a common Myctophid found in the Bering Sea and GOA, has a maximum length of 13 cm. Deep-sea smelt of the North Pacific Ocean include blacksmelt (*Bathylagus* spp.) and northern smoothtongue (*Leuroglossus stilbius*), which have maximum lengths of 12–25 cm. Lanternfish and deep-sea smelt are important forage fishes for marine birds and mammals. Because they are rarely caught in survey or fishery trawls, little is known of their abundance.

Family Ammodytidae

Pacific sand lance (*Ammodytes hexapterus*) are usually found on bottom, at depths between 0 and 100 m except during pelagic feeding excursions for crustaceans and zooplankton. Spawning is believed to occur in winter. Sand lance mature at 2 to 3 years and lengths of 10 to 15 cm. Little is known of their distribution and abundance; they are rarely caught by trawls. In the Bering Sea, sand lance are common prey of salmon, northern fur seals and many marine bird species. Thus, they may be abundant in Bristol Bay and along the Aleutian Islands and Alaska Peninsula. In the GOA, sand lance are prey of harbor seals, northern fur seals, and marine birds, especially in the Kodiak Island area and along the southern Alaska Peninsula. Given the sand lance's short life span, and the large number of species that prey on them, mortality, fecundity, and growth rates are probably high.

Family Trichodontidae

The Pacific sandfish (*Trichodon trichodon*) lives in shallow inshore waters to about 50 m depth and grows to a maximum length of 30 cm. Sandfish exhibit burrowing behavior in which they bury themselves in the sand and come to rest with only their dorsal surface showing. This behavior makes them effective ambush predators. They are known to be fed upon by salmon and other fish, as well as pinnipeds. Little is known of their abundance trends. There has also been one confirmed account of the sailfin sandfish (*Arctoscopus japonicus*), a western North Pacific species of Trichodontidae, in Alaskan waters.

Family Pholidae and Stichaeidae

Gunnels (family Pholidae) and pricklebacks (family Stichaeidae, including warbonnets, eelblennys, cockscombs and shannys) are long, compressed, eel-like fishes with long dorsal fins often joined with the caudal fin. Pricklebacks are so named because of the spiny rays in the dorsal fin in most species (some have soft rays at the rear of the dorsal fins). Gunnels have flexible dorsal fin rays; they also differ from pricklebacks in that the anal fin is smaller (the distance from the tip of the snout to the front of the anal fin is shorter than the length of the anal fin). Most species of both families live in shallow nearshore waters among seaweed and under rocks and are less than 45 cm in length. Approximately 24 species of stichaeids and 6 species of pholids occur in Alaska. Nothing is known about their abundance, and little is known about growth rates, maturity, and trophic relationships, although they are believed to grow quickly. Some cockscombs in British Columbia attain sexual maturity at age 2 years.

Family Gonostomatidae

This is a large and diverse family (Gonostomatidae) of bathypelagic fish that are rarely observed except by researchers. They grow to about 8 cm and can be abundant at depths of up to 5,000 m. As many as six species may occur in the North Pacific Ocean and Bering Sea. Little is known about trends in their abundance.

Order Euphausiacea

Along with many copepod species, the euphausiids form a critical zooplanktonic link between the primary producers (phytoplankton) and all upper pelagic trophic levels. These crustaceans, also known as krill, occur in large swarms in both neritic (nearshore) and oceanic (offshore) waters. Members of at least 11 genera of euphausiids are known from the North Pacific Ocean. The most important, in terms of numbers of species, being *Thysanopoda, Euphausia, Thysanoëssa,* and *Stylocheiron*. Euphausiids are generally thought to make diurnal vertical migrations, remaining at depth during the day and ascending at night to 100 m or less to feed. However, this is complicated by the fact that as euphausiids grow they are found at deeper depths, except during spawning, which occurs in surface waters.

Spawning occurs in spring to take advantage of the seasonal phytoplankton bloom. Hatched nauplii larvae live near the surface to about 25 m. By winter, the young crustaceans are found mainly at depths of 100 m or less, and make diurnal vertical migrations to feed. Sexual maturity is reached the following spring at age 1. After spawning, adult euphausiids gradually descend to deeper depths until winter, when they no longer migrate daily to near-surface waters. In their second spring, they again rise to the surface to spawn; euphausiids older than 2 years are very rarely found. This classical view of euphausiid life history and longevity was recently questioned by Nichol (1990), who reported that Antarctic euphausiids may live as long as 6 to 10 years. If north Pacific euphausiids exhibited similar longevity then expected productivity may be much lower.

While euphausiids are found throughout oceanic and neritic waters, their swarms are most commonly encountered in areas where nutrients are available for phytoplankton growth. This occurs primarily in

areas where upwelling waters are a consistent oceanographic feature. Areas with such features are at the edges of the various domains on the shelf or at the shelf-break, at the heads of submarine canyons, on the edges of gullies on the continental shelf (e.g., Shumagin, Barnabus, Shelikof gullies in the GOA), in island passes in the Aleutian Islands (e.g., Seguam Pass, Tanaga Pass), and around submerged seamounts (e.g., west of Kiska Island). It is no coincidence that these are also prime fishing locations used by commercial fishing vessels seeking zooplanktivorous groundfish, such as pollock, Atka mackerel, sablefish, and many rockfish and flatfish.

The species comprising the euphausiid group occupy a position of considerable importance within the North Pacific Ocean food web. Euphausiids are eaten by almost all other major taxa inhabiting the pelagic realm. The diet of many fish species other than the groundfish listed previously, including salmon, smelt (capelin, eulachon, and other osmerids), gadids such as Arctic cod and Pacific tomcod, and Pacific herring is composed, to varying degrees, of euphausiids (Yang and Nelson 2000). They are also the principal item in the diet of most baleen whales (Perez 1990). While copepods generally constitute the major portion of the diet of planktivorous seabirds (e.g., auklets), euphausiids are prominent in the diets of some predominately piscivorous seabirds in certain areas (e.g., kittiwakes on Buldir Island in the Aleutian Islands, Middleton Island in the GOA, and Saint Matthew Island in the Bering Sea). Euphausiids are not currently sought for human use or consumption from the North Pacific Ocean on a scale other than local, but large (about 500,000 mt per year) krill fisheries from Japan and Russia have been operating in Antarctic waters since the early 1980s.

Fishery Information

Amendments 36 (BSAI) and 39 (GOA) to the FMP prohibits the directed fishery of any species in the forage fish species category. It also limits bycatch and places limits on the sale, barter, trade or processing of any species included in the group. A maximum of 2 percent retainable bycatch of forage fish species was established by the rule. This is thought not to increase forage fish discards because bycatch rarely, if ever, exceeds this level.

Estimates of forage fish catch are complicated by a number of factors. First, observer coverage is only approximately 30% in the GOA. To generate catch estimates it is assumed that the catch of forage fish species observed on covered vessels is representative of unobserved vessels. However, the observer coverage is also not randomly assigned throughout the fisheries and could therefore violate this assumption. Second, most forage fish species are only identified to the familial level. This is a problem in particular for smelts. Smelts comprise the largest percentage of the forage fish bycatch yet little information exists on the species composition. This leads to difficulties in determining species specific catch trends.

Forage fish are only a small part of commercial fisheries catch. From 1997 to 2002, total catch of forage fish, ranged from 27.2 to 534.8 tons in the GOA (Table 2). Of the familial groups within the category, Osmerids contributed over 90% of total forage fish bycatch in most years. Excluding 2001, the historical range of the smelt catch between 1997 and 2002, was 23-156 tons. The 2001 smelt bycatch in the GOA was remarkably high, exceeding 500t. Most of the smelt catch came from the pollock fishery in the central GOA. Unfortunately, the identification of smelt to species has not been a priority of observers, and the proportion of the catch attributed to capelin, eulachon or other species is unknown.

The catch of Stichaeids in the GOA from 1997 to 2002 was small, less than 5 tons per year (Table 2). Pacific sandfish has also maintained a small catch in the GOA never exceeding 4 tons annually. No other family in the forage fish species category had a recorded catch of greater than one ton since 1997.

Data

GOA Groundfish Survey Data

Currently, NMFS does not conduct a comprehensive Gulf wide survey directed to sample forage fish populations. Due to habitat and life history characteristics, such as, small size, pelagic distribution, and extreme depth, most forage species are not sampled well by standard NMFS surveys. Although some members of the forage fish category are caught in the GOA groundfish survey, other forage fish species are rarely, if ever, encountered. Therefore, reliable estimates of abundance for many of the forage fish species are difficult to develop.

The GOA groundfish survey is not designed to sample forage fish species. However, by making some assumptions biomass estimates for Pacific sand lance, Pacific sandfish, pricklebacks, capelin and eulachon were attained. Survey estimates were calculated for the western, central and eastern GOA from 1984 to 2003 (Table 3 and Figure 1). The survey years were 1984, 1987, 1990, 1993, 1996, 1999, 2001 and 2003. In 2001 the survey did not extend into the eastern GOA; therefore, there is no regional estimate for that year.

As stated above, the GOA survey is not designed to sample forage fish species. The survey selectivity of forage species is unknown. These estimates assume a selectivity of one, which is most likely incorrect for most forage fish species. The survey employs a bottom trawl with roller gear and a 5-inch mesh size. This gear is presumably inefficient in catching small fish, especially species that burrow into the substrate, such as sandlance and sandfish. In addition, this survey poorly samples species which form pelagic schools off bottom, such as smelts. Therefore this survey likely underestimates the abundance of these species. Further complicating the estimate, many forage species, such as smelts, tend to exhibit patchy distributions leading to high variation in the biomass estimates.

GOA Echo Integration Trawl Survey

In the summer of 2003 MACE conducted an echo-integration trawl survey in the GOA between the Shumagin Islands and Prince Williams Sound. The primary focus of this survey was to assess pollock biomass in the GOA. However, data collected on this survey may also be used to develop a Gulf wide biomass estimate for certain forage species, such as capelin and eulachon. Currently, the data from this survey has not been processed but it is hopeful that this survey could prove to be a useful tool in studying capelin and eulachon abundance patterns.

Pavlof Bay

NMFS and ADF&G have conducted a small-mesh (32 mm stretched mesh) trawl survey in Pavlof Bay every year since 1972 (Anderson et al. 1997). This survey is directed to sample shrimp populations in the bay. The survey uses a small mesh net, which has proven to be effective at capturing smelt and other forage species when they are present.

Biomass estimates were calculated for capelin in Pavlof Bay by an area swept technique involving simple extrapolation of the CPUE data across the entire bay (Table 4). The 2001 biomass for capelin was 0.2 tons.

As these numbers attest, estimated capelin biomass has fallen precipitously from a peak estimate of over 1,500 tons to virtually no biomass in recent years. In 1999 and 2000 no capelin were recorded in the survey. Anderson and Piatt (1999) attribute this decline to a transformation in the ebibenthic community due to an oceanic climate regime shift. The benthic community in the inshore regions of the GOA changed from a historical domination of crustaceans to a flatfish dominated system. It was hypothesized

that the reduction in the capelin catch was due to recruitment failure and increased predation caused by the regime change.

Hollowed et al. (in review) described the mesoscale distribution of capelin in two trough systems off Kodiak Island. They found that capelin spatial distribution was strongly correlated with thermal fronts, not depth or specific bottom traits. This association to thermal cues has also been shown in Atlantic populations (Carscadden and Nakashima 1997).

The ocean regime shift witnessed in the late 1970s resulted in warmer costal water temperatures. Hollowed et al. (In review) hypothesized that the rapid decline in the catches in the inshore small-mesh survey may have been a result of capelin being displaced by warm water in the nearshore areas. In other words, a change in water temperature altered the habitat, such that capelin moved out of the nearshore survey area. If this is the case, perceived capelin declines may be linked to changes in distribution. This could explain the continuing high predation rates of capelin by groundfish seen in the more offshore shelf areas of the GOA sampled by the NMFS groundfish survey (Yang and Nelson 200).

GOA Ecopath Model

An Ecopath model for the GOA has been developed which can give certain insights into the abundance of forage fish species (Aydin et al. 2002). In short, the GOA Ecopath model uses a top down approach at a mass-balance food web model. The estimates for forage fish species biomass are calculated by finding the amount of forage fish that would need to be present in order to support the trophic levels above them. The model currently estimates gulf wide biomass for Bathylagids, Myctophids, Pacific sand lance, capelin and eulachon. In addition, the model has two miscellaneous forage fish species categories, other pelagic smelt and managed forage fish.

The GOA Ecopath model suggests that capelin have the highest biomass of any forage species followed by Pacific sand lance, about 2 million tons and 1 million tons respectively. All other species and species groups are estimated to be within the 100,000 – 400,000 ton range.

These numbers are not estimates of current biomass. The majority of the data used to make the calculations were taken from 1990 through 1993. Therefore, these estimates refer to a state that existed in the early 90's. Also, the Ecopath model misses any surplus production of these species. It is known that many of these species, such as smelt, can go through large population swings. This model is unable to estimate biomass which may be in surplus to what the upper trophic levels need.

Evaluation of Biomass estimates

Biomass estimates from the GOA groundfish survey and Ecopath model differ by more than an order of magnitude. This reflects the fact that the GOA groundfish survey forage fish biomass estimates are highly uncertain and should be viewed as underestimates. There are also limitations in biomass estimates from the Ecopath model. Upon inspection of the data, it was noticed that model inputs from Northern fur seal diet were driving the high estimates of capelin and sand lance. The Northern fur seal diet inputs were derived from values found in the literature from the 1970's, when capelin were thought to be more abundant. Therefore, there is reason to believe that this data could be suspect.

All things considered, the biomass estimates we have for forage fish species are dubious at best. Without a survey that adequately samples forage fish species it is unlikely that we will be able to develop an accurate estimate for forage fish populations.

Estimated exploitation rates

Biomass estimates for forage species have proven to be difficult to attain. However, exploitation rates for capelin and eulachon were calculated using biomass estimates from the groundfish survey. As stated above, these values likely underestimate biomass; therefore, these exploitation rates should be interpreted as biased high.

The vast majority of the smelt catch comes from the central GOA. Catch data and biomass estimates from areas 620 and 630 were used for this analysis. Smelt bycatch from the fishery was only identified to family. Individual species catch was estimated by multiplying the total catch by the ratio of capelin to eulachon in the GOA survey. This species specific catch was used to calculate the exploitation rate for each species (Table 5). Biomass estimates and catch data were available only for 1999 and 2001. The exploitation rate was low for each year, 1% or less. In 2001, the smelt bycatch was relatively high, but so was estimated biomass.

These exploitation rates are very low. Considering that they are calculated from what is thought to be an underestimate of biomass, actual exploitation rates are likely lower.

Data Gaps and Research Priorities

Currently, NMFS does not conduct a survey that adequately samples forage fish species in the GOA. New surveys, or new techniques in current surveys, need to be developed to develop a reasonable biomass estimate. Catch data is also problematic for the forage fish species category. Currently, forage fish identification is not a priority for observers. However, the observer program is investigating the feasibility of identifying smelts to species. The identification of forage species in catch, is necessary to understand the dynamics between target fisheries and specific forage fish species.

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Tables

Table 1. List of scientific name and common name of species contained within the forage fish category. Compiled from Fishes of Alaska (Mecklenburg et al. 2002).

Scientific Name	Common Name
Family Osmeridae	smelts
Mallotus villosus	capelin
Hypomesus pretiosus	surf smelt
Osmerus mordax	rainbow smelt
Thaleichthys pacificus	eulachon
Spirinchus thaleichthys	longfin smelt
Spirinchus starksi	night smelt
Family Myctophidae	lanternfish
Protomyctophum thompsoni	bigeye lanternfish
Benthosema glaciale	glacier lanternfish
Tarletonbeania taylori	taillight lanternfish
Tarletonbeania crenularis	blue lanternfish
Diaphus theta	California headlightfish
Stenobrachius leucopsarus	northern lampfish
Stenobrachius nannochir	garnet lampfish
Lampanyctus jordani	brokenline lanternfish
Nannobrachium regale	pinpoint lampfish
Nannobrachium ritteri	broadfin lanternfish
Family Bathylagidae	blacksmelts
Leuroglossus schmidti	northern smoothtongue
Lipolagus ochotensis	popeye blacksmelt
Pseudobathylagus milleri	stout blacksmelt
Bathylagus pacificus	slender blacksmelt
Family Ammodytidae	sand lances
Ammodytes hexapterus	Pacific sand lance
Family Trichodontidae	sandfish
Trichodon trichodon	Pacific sandfish
Arctoscopus japonicus	sailfin sandfish
Family Pholidae	gunnels
Apodichthys flavidus	penpoint gunnel
Rhodymenichthys dolichogaster	stippled gunnel
Pholis fasciata	banded gunnel
Pholis clemensi	longfin gunnel
Pholis laeta	crescent gunnel
Pholis schultzi	red gunnel

Table 1. List of scientific name and common name of species contained within the forage fish category. Compiled from Fishes of Alaska (Mecklenburg et al. 2002) (continued).

Scientific Name	**Common Name**
Family Stichaeidae	pricklebacks
Eumesogrammus praecisus	fourline snakeblenny
Stichaeus punctatus	arctic shanny
Gymnoclinus cristulatus	trident prickleback
Chirolophis tarsodes	matcheek warbonnet
Chirolophis nugatory	mosshead warbonnet
Chirolophis decoratus	decorated warbonnet
Chirolophis snyderi	bearded warbonnet
Bryozoichthys lysimus	nutcracker prickleback
Bryozoichthys majorius	pearly prickleback
Lumpenella longirostris	longsnout prickleback
Leptoclinus maculates	daubed shanny
Poroclinus rothrocki	whitebarred prickleback
Anisarchus medius	stout eelblenny
Lumpenus fabricii	slender eelblenny
Lumpenus sagitta	snake prickleback
Acantholumpenus mackayi	blackline prickleback
Opisthocentrus ocellatus	ocellated blenny
Alectridium aurantiacum	lesser prickleback
Alectrias alectrolophus	stone cockscomb
Anoplarchus purpurescens	high cockscomb
Anoplarchus insignis	slender cockscomb
Phytichthys chirus	ribbon prickleback
Xiphister mucosus	rock prickleback
Xiphister atropurpureus	black prickleback
Family Gonostomatidae	bristlemouths
Sigmops gracilis	slender fangjaw
Cyclothone alba	white bristlemouth
Cyclothone signata	showy bristlemouth
Cyclothone atraria	black bristlemouth
Cyclothone pseudopallida	phantom bristlemouth
Cyclothone pallida	tan bristlemouth
Order Euphausiacea	Krill

Table 2. Estimated forage fish catch (mt) from all Gulf of Alaska fisheries and areas).

	1997	1998	1999	2000	2001	2002
Smelt	23.1	122.7	26.1	123.8	534.8	156.4
Sandfish	3.7	2.2	0.5	0.3	1.2	1.7
Pricklebacks	0.3	0.0	3.5	0.5	4.7	0.1
Sandlance	0.0	0.0	0.1	0.4	0.0	0.0
Gunnel	0.1	0.0	0.0	0.0	0.0	0.0
Lanternfish	0.0	0.0	0.0	0.0	0.0	0.0
Total FFS	27.2	125.0	30.2	124.9	540.8	158.3

Table 3. Biomass estimates of forage fish species for the western, central and eastern GOA attained from the GOA groundfish survey.

Pacific sand lance

	Biomass (mt)		
Year	Western	Central	Eastern
1984	0	3	0
1987	2	13	0
1990	0	63	1
1993	0	2	0
1996	1	5	0
1999	1	8	2
2001	5	7	
2003	2	8	1

Capelin

	Biomass (mt)		
Year	Western	Central	Eastern
1984	37	387	7
1987	5	38	8
1990	0	136	14
1993	2	46	76
1996	5	718	755
1999	34	102	106
2001	4	275	
2003	18	2,258	298

Pacific sandfish

	Biomass (mt)		
Year	Western	Central	Eastern
1984	12	1,858	354
1987	28	558	529
1990	16	329	377
1993	69	155	296
1996	2	135	16
1999	9	22	542
2001	6	89	
2003	29	81	3,832

Eulachon

	Biomass (mt)		
Year	Western	Central	Eastern
1984	38	4,767	2,300
1987	1,787	8,663	5,864
1990	453	19,043	8,493
1993	2,553	24,172	8,278
1996	1,444	26,470	4,334
1999	438	11,665	2,587
2001	2,867	49,061	
2003	1,610	95,014	16,882

Pricklebacks

	Biomass (mt)		
Year	Western	Central	Eastern
1984	7	163	0
1987	0	9	5
1990	5	141	3
1993	23	180	1
1996	19	100	24
1999	2	187	28
2001	7	2,001	
2003	10	231	39

Table 4. CPUE (in kg / km^2) and biomass estimates (mt) for capelin in Pavlof Bay.

Year	CPUE	Biomass
1972	23.264	1,597.7
1973	2.119	145.5
1974	20.867	1,433.1
1975	12.579	863.9
1976	12.167	835.6
1977	17.039	1,170.2
1978	0.701	48.2
1979	7.540	517.8
1980	15.399	1,057.6
1981	2.700	185.4
1982	0.078	5.4
1983	0.050	3.4
1984	0.008	0.5
1985	0.024	1.7
1986	0.169	11.6
1987	0.005	0.3
1988	0.022	1.5
1989	0.044	3.0
1990	0.040	2.7
1991	0.052	3.5
1992	0.003	0.2
1993	0.002	0.1
1994	0.004	0.3
1995	0.004	0.3
1996	0.000	0.0
1997	0.039	2.7
1998	0.019	1.3
1999	0.000	0.0
2000	0.000	0.0
2001	0.003	0.2

Table 5. Estimated biomass, catch (mt) and exploitation rate for GOA capelin and eulachon.

Year	Species	Biomass	Catch	Exploitation rate
1999	Eulachon	11,665	25.0	0.2%
	Capelin	102	0.2	0.2%
2001	Eulachon	49,061	511.6	1.0%
	Capelin	275	2.9	1.0%

Figures

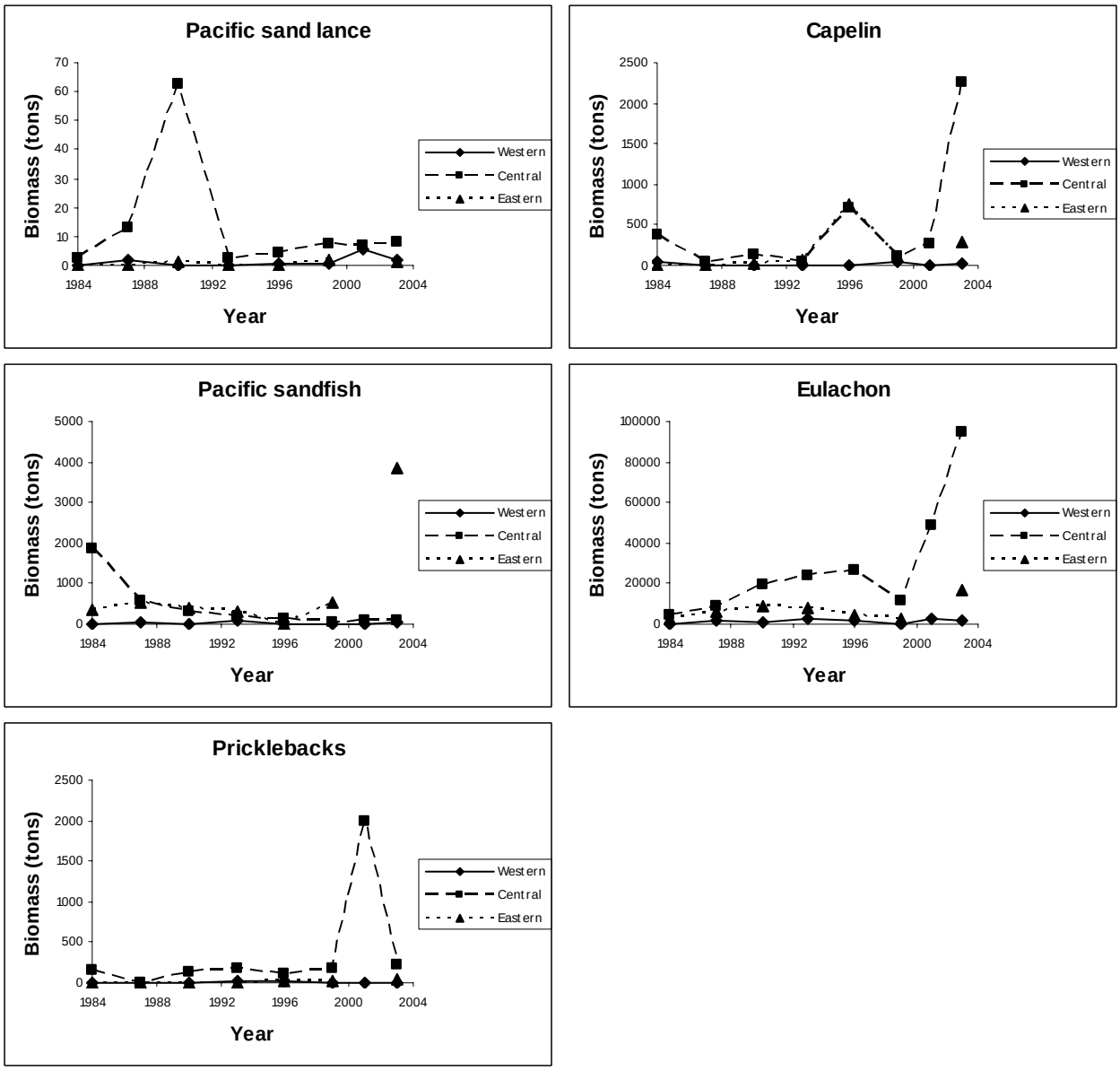

Figure 1. Biomass estimates of forage fish species for the western, central and eastern GOA attained from the GOA groundfish survey.

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