APPENDIX F.1

ESSENTIAL FISH HABITAT ASSESSMENT REPORT

for the Groundfish Resources of the

Gulf of Alaska Region

April 2005

NOAA Fisheries
NMFS Alaska Region
709 West 9th Street
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NOAA Fisheries
National Marine Fisheries Service

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Introduction

In 1996, the Sustainable Fisheries Act amended the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) to require the description and identification of Essential Fish Habitat (EFH) in Fishery Management Plans (FMPs), adverse impacts on EFH, and actions to conserve and enhance EFH. National Marine Fisheries Service (NMFS) developed guidelines to assist Fishery Management Councils in fulfilling the requirements set forth by the Act.

Essential fish habitat means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of essential fish habitat, “waters” includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; “substrate” includes sediment, hard bottom, structures underlying the waters, and associated biological communities; “necessary” means the habitat required to support a sustainable fishery and a healthy ecosystem; and “spawning, breeding, feeding, or growth to maturity” covers a species’ full life cycle.

With respect to type, the information available for almost all species is primarily broad geographic distributions based on specific samples from surveys and fisheries, which have not been linked with habitat characteristics. Furthermore, NMFS’ ability to precisely define the habitat (and its location) of each life stage of each managed groundfish species in terms of its oceanographic (temperature, salinity, nutrient, current), trophic (presence of food, absence of predators), and physical (depth, substrate, latitude, and longitude) characteristics is very limited. Consequently, the information included in the habitat descriptions for each species and life stage is restricted primarily to their position in the water column (e.g., demersal, pelagic), broad biogeographic and bathymetric areas (e.g., 100 to 200 meter [m] zone, south of the Pribilof Islands and throughout the Aleutian Islands [AI]) and occasional references to known bottom type associations.

Identification of EFH for some species included historical range information. Traditional knowledge and sampling data have indicated that fish distributions may contract and expand due to a variety of factors including, but not limited to, temperature changes, current patterns, changes in population size, and changes in predator and prey distribution.

Background

In preparation of the 1999 EFH Environmental Assessment, EFH Technical Teams, consisting of scientific stock assessment authors, compiled scientific information and prepared the 1999 Habitat Assessment Reports. These reports provided the scientific information baseline to describe EFH. Recent scientific evidence has not proved to change existing life history profiles of the federally managed species. However, where new information does exist, new data help fill information gaps in the region’s limited habitat data environment.

Stock assessment authors used information contained in these summaries and personal knowledge, along with data contained in reference atlases (NOAA 1987, 1990; Council 1997a,b), fishery and survey data (Allen and Smith 1988, Wolotira et al. 1993, NOAA 1998), and fish identification books (Hart 1973, Eschmeyer and Herald 1983, Mecklenburg and Thorsteinson 2002), to describe EFH for each life stage using best scientific judgment and interpretation; see Table 1.

Species Profiles and Habitat Descriptions

FMPs must describe EFH in text, map EFH distributions, and include tables, which provide information on habitat and biological requirements for each life history stage of the species; see Tables 2 to 4.

Information contained in this report details life history information for federally managed fish species. This collection of scientific information is interpreted, then referenced to describe and delineate EFH for each species by life history stage using the geographic information system (GIS). EFH text and map descriptions are not compiled in this report due to differences in the characteristics of a species life history and the overall distribution of the species. Specific EFH text descriptions and maps are in Appendix D.

References

Allen, M.J., and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the BS and northeastern Pacific. U.S. Dep. Commerce., NOAA Tech. Rept. NMFS 66, 151 p.

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Eschmeyer, W.N., and E.S. Herald. 1983. A field guide to Pacific coast fishes. Houghton Mifflin Co., Boston. 336 p.

Hart, J.L. 1973. Pacific fishes of Canada. Fisheries Research Board of Canada Bulletin 180. Ottawa. 740 p.

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NOAA (National Oceanic and Atmospheric Administration). 1987. Bering, Chukchi, and Beaufort Seas. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1990. West coast of North America. Coastal and ocean zones, Strategic assessment: Data atlas. U.S. Dep. Commerce., NOAA, NOS.

NOAA. 1998. Catch-per-unit-effort, length, and depth distributions of major groundfish and bycatch species in the BS, AI, and GOA regions based on groundfish fishery observer data. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-88.

Wolotira, R.J., Jr., T.M. Sample, S.F. Noel, and C.R. Iten. 1993. Geographic and bathymetric distributions for many commercially important fishes and shellfishes off the west coast of North America, based on research survey and commercial catch data, 1912-1984. U.S. Dep. Commerce., NOAA Tech. Memo. NMFS-AFSC-6, 184 p.

Table 1. Summary of Major References and Atlases

Species	Allen and Smith 1988	NOAA 1987	NOAA 1990	Wolotira et al. 1993	NOAA 1998	Mecklenburg and Thorsteinson 2002
	References					
Walleye pollock	X	X	X	X	X	X
Pacific cod	X	X	X	X	X	X
Yellowfin sole	X	X		X	X	X
Greenland turbot	X	X		X	X	X
Arrowtooth flounder	X	X	X	X	X	X
Rock sole	X	X		X	X	X
Alaska plaice	X	X		X	X	X
Flathead sole	X	X	X	X	X	X
Sablefish	X		X	X	X	X
Pacific ocean perch	X		X	X	X	X
Shortraker-rougheye rockfish	X				X	X
Northern rockfish	X				X	X
Dusky rockfish	X				X	X
Thornyhead rockfish	X				X	X
Atka mackerel	X		X	X	X	X
Sculpins	X				X	X
Skates	X				X	X

Abbreviations used in the EFH report tables to specify location, depth, bottom type, and other oceanographic features.

Location

ICS =	inner continental shelf (1-50 m)	USP =	upper slope (200-1000 m)
MCS =	middle continental shelf (50-100 m)	LSP =	lower slope (1000-3000 m)
OCS =	outer continental shelf (100-200 m)	BSN=	basin (>3000 m)

BCH = beach (intertidal)
BAY = nearshore bays, give depth if appropriate (e.g., fjords)
IP = island passes (areas of high current), give depth if appropriate

Water column
D = demersal (found on bottom)
SD/SP =semi-demersal or semi-pelagic if slightly greater or less than 50% on or off bottom
P = pelagic (found off bottom, not necessarily associated with a particular bottom type)
N = neustonic (found near surface)

Bottom Type

M = mud	S = sand	R = rock
SM = sandy mud	CB = cobble	C = coral
MS = muddy sand	G = gravel	K = kelp

SAV = subaquatic vegetation (e.g., eelgrass, not kelp)

Oceanographic Features
UP = upwelling G = gyres F = fronts E = edges
CL = thermocline or pycnocline

General
U = Unknown N/A = not applicable

Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope					
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m
Walleye Pollock	M						x	x	x	x				x
	J					x	x	x						
	L						x	x						
	E						x	x	x	x	x	x	x	x
Pacific Cod	M					x	x	x	x	x				
	LJ					x	x							
	EJ				x	x								
	L					x	x	x						
	E					x	x	x						
Atka Mackerel	M					x	x	x						
	J													
	L													
	E					x								
Sablefish	M								x	x	x	x	x	
	LJ							x	x	x	x			
	EJ					x	x	x						
	L						x	x	x	x	x	x	x	x
	E								x	x	x	x	x	x
Pacific Ocean Perch	M							x	x	x				
	LJ					x	x	x	x					
	EJ					x	x	x					x	x
	L													
Flathead Sole	M					x	x	x	x					
	LJ					x	x	x						
	EJ					x	x							
	L					x	x	x						
	E					x	x	x						
Yellowfin Sole	M					x	x							
	LJ					x	x							
	EJ					x								
	L					x	x							
	E					x	x							
Arrowtooth Flounder	M					x	x	x	x	x	x			
	LJ					x	x	x						
	EJ					x	x							
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Rock Sole	M					x	x	x						
	LJ					x	x							
	EJ					x								
	L					x	x	x						
	E					x	x	x						
Dover Sole	M					x	x	x	x	x	x	x		
	LJ					x	x	x	x	x				
	EJ					x	x							
	L					x	x	x	x	x				
	E					x	x	x	x	x				
Rex Sole	M					x	x	x	x	x				
	LJ					x	x	x	x					
	EJ					x	x							
	L					x	x	x	x					
	E					x	x	x	x					

GOA Groundfish		Stratum Reference							Location							Physical Oceanography				
													Pelagic							
Species	Life Stage	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)
Walleye Pollock	M		x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	J		x	x	x	x	x	x		x	x	x	x			x	x	x	x	x
	L		x	x	x	x	x	x		x	x	x	x			x	x	x	x	x
	E		x	x	x	x	x	x		x	x		x			x	x	x	x	
Pacific Cod	M	x	x	x	x	x	x					x								
	LJ	x	x	x	x	x	x					x								
	EJ	x		x							x	x								
	L												x							
	E											x								
Atka Mackerel	M		x							x	x					x			x	x
	J																			
	L								x	x										
	E		x									x								
Sablefish	M			x				x				x				x				
	LJ			x				x				x				x				
	EJ			x								x	x	x		x				
	L								x	x						x				
	E												x	x		x				
Pacific Ocean Perch	M				x	x	x	x			x	x	x			x				
	LJ																			
	EJ										x	x	x	x	x	x				
	L									x	x		x	x		x				
Flathead Sole	M											x								x
	LJ											x								
	EJ											x								
	L												x					x		
	E												x							
Yellowfin Sole	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E												x							
Arrowtooth Flounder	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E											x								
Rock Sole	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E											x								
Dover Sole	M											x								
	LJ											x								
	EJ											x								
	L												x					x		
	E												x							
Rex Sole	M											x								
	LJ											x								
	EJ											x								
	L												x							
	E												x							

GOA Groundfish		Substrate												
Species	Life Stage	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Walleye Pollock	M		x	x	x	x	x	x	x	x	x	x	x	
	J		x	x	x	x	x	x	x	x	x	x	x	
	L		x	x	x	x	x	x	x	x	x	x	x	
	E													
Pacific Cod	M		x	x	x	x	x	x	x	x	x	x	x	x
	LJ		x	x	x	x	x	x	x	x	x	x	x	x
	EJ		x	x	x	x	x	x	x	x	x	x		
	L													
	E		x	x	x	x	x	x	x	x	x	x	x	x
Atka Mackerel	M			x	x									x
	J													
	L													
	E				x									x
Sablefish	M		x	x	x								x	x
	LJ		x	x	x								x	x
	EJ													
	L													
	E													
Pacific Ocean Perch	M				x								x	x
	LJ													
	EJ				x								x	x
	L													
Flathead Sole	M		x	x	x			x		x				
	LJ		x	x	x			x		x				
	EJ			x	x									
	L							x						
	E													
Yellowfin Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L													
	E													
Arrowtooth Flounder	M		x	x	x			x						
	LJ		x	x	x			x						
	EJ		x	x	x			x						
	L													
	E													
Rock Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L													
	E													
Dover Sole	M		x	x			x							
	LJ		x	x			x							
	EJ		x	x			x							
	L													
	E													
Rex Sole	M		x	x				x						
	LJ		x	x				x						
	EJ		x	x				x						
	L		x	x										
	E													

GOA Groundfish		Structure										Community Associations												Oceanographic Properties			
Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Walleye Pollock	M																							2-10			M
	J																							2-10			J
	L																										L
	E																										E
Pacific Cod	M				x	x			x				x	x	x	x	x					x	x				M
	LJ				x	x			x				x	x	x	x	x					x	x				LJ
	EJ											x	x	x			x		x								EJ
	L																										L
	E																							3-6	13-23	2-3	E
Atka Mackerel	M								x										x					3-5	>17		M
	J																							3-5			J
	L																							2-12			L
	E																		x					3-20			E
Sablefish	M							x																			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Pacific Ocean Perch	M														x												M
	LJ																										LJ
	EJ																										EJ
	L																										L
Flathead Sole	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Yellowfin Sole	M																										M
	LJ																										LJ
	EJ																										EJ
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	E																										E
Arrowtooth Flounder	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E
Rock Sole	M																										M
	LJ																										LJ
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	E																										E
Dover Sole	M																										M
	LJ																										LJ
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	E																										E
Rex Sole	M																										M
	LJ																										LJ
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Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope						Stratum Reference							Location							Physical Oceanography					Substrate													Structure										Community Associations												Oceanographic Properties			
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin												Pelagic																																														
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surfce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Greenland Turbot	M							x	x	x	x														x										x	x	x		x																																	M
	LJ					x	x																		x										x	x			x																																	LJ
	EJ																								x										x	x			x																																	EJ
	L					x	x	x	x	x																x					x																																									L
	E					x	x	x	x	x																x																																														E
Yelloweye Rockfish	M					x	x	x	x	x						x	x								x											x									x	x						x			x																	M
	LJ					x	x	x								x	x								x																					x																											LJ
	EJ					x	x	x								x	x								x																					x						x			x																	EJ
	L																																																																								L
	E																																																																							E
Shortraker/Rougheye Rockfish	M								x	x																x									x	x		x								x							x								x												M
	LJ					x	x	x	x								x	x	x	x	x																																																				LJ
	EJ												x	x									x																																																		EJ
	L																										x																																														L
Northern Rockfish	M						x	x										x							x																				x	x																											M
	LJ						x	x										x	x						x																																																	LJ
	EJ																									x																																															EJ
	L																																																																								L
Thornyhead Rockfish	M								x	x	x	x	x												x												x								x	x							x																				M
	LJ						x	x	x																x												x									x																											LJ
	EJ																									x																																																EJ
	L																									x																																																L
	E																									x																																																E
Light Dusky Rockfish	M							x	x									x		x	x				x												x								x	x																											M
	LJ						x	x										x		x					x																																				x											LJ
	EJ																																																																									EJ
	L																																																																								L
Sculpins	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																												x																				M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Skates	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x																																																	M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Sharks	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x																																														M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Squid	M				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																									x																				M
	LJ																																																																									LJ
	EJ																																																																									EJ
	L																																																																									L
	E																																																																									E
Octopus	M			x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x				x	x	x																																														M
	LJ																																																																								LJ
	EJ																																																																									EJ
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Table 2 - Habitat

Table 2. Summary of Habitat Associations for Groundfish in the GOA

GOA Groundfish		Nearshore				Shelf			Slope					
						Inner	Middle	Outer	Upper		Inter-mediate		Lower	Basin
Species	Life Stage	Freshwater	Estuarine	Intertidal	Subtidal	1-50m	51-100m	101-200m	201-300m	301-500m	501-700m	701-1000m	1001-3000m	>3000m
Eulachon	M						X	X	X					
	LJ						X	X						
	EJ					X	X							
	L	X	X			X	X							
	E	X												
Capelin	M						X	X						
	LJ						X	X						
	EJ					X	X							
	L		X			X	X							
	E			X										
Sand Lance	M			X	X	X								
	LJ			X	X	X								
	EJ		X		X	X								
	L		X			X								
	E			X										

GOA Groundfish		Stratum Reference							Location						
													Pelagic		
Species	Life Stage	Shallows	Island Pass	Bay/Fjord	Bank	Flat	Edge	Gully	Surafce	Near surface	Semi-demersal	Demersal	1-200m (epi)	201-1000m (meso)	>1000m (bathy)
Eulachon	M			X									X		
	LJ												X		
	EJ												X		
	L			X						X					
	E														
Capelin	M			X									X		
	LJ												X		
	EJ												X		
	L			X						X					
	E	X													
Sand Lance	M	X		X					X	X	X	X	X		
	LJ	X		X					X	X	X	X	X		
	EJ	X		X					X	X			X		
	L	X		X					X	X			X		
	E			X											

GOA Groundfish		Physical Oceanography					Substrate												
Species	Life Stage	Upwelling areas	Gyres	Thermo/pycnocline	Fronts	Edges (ice, bath)	Organic Debris	Mud	Sand	Gravel	Mud & sand	Mud & gravel	Sand & mud	Gravel & mud	Gravel & sand	Gravel & sand & mud	Gravel & mud & sand	Cobble	Rock
Eulachon	M	X			X	X													
	LJ	X			X	X													
	EJ	X			X														
	L																		
	E																		
Capelin	M	X			X	X													
	LJ	X			X	X													
	EJ	X			X														
	L																		
	E								X	X					X				
Sand Lance	M								X	X					X				
	LJ								X	X					X				
	EJ																		
	L																		
	E																		

GOA Groundfish		Structure										Community Associations												Oceanographic Properties			
Species	Life Stage	Bars	Sinks	Slumps\Rockfalls\Debris	Channels	Ledges	Pinnacles	Seamount	Reefs	Vertical Walls	Man-made	Algal Cover	Anenomes	Enchinoderms	Soft Coral	Hard Coral	Mollusca	Drift Algae\Kelp	Kelp	Polychaetes	Sea Grasses	Sea Onions	Tunicates	Temperature (Celsius)	Salinity (ppt)	Oxygen Conc (ppm)	Life Stage
Eulachon	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																							4-8			E
Capelin	M																							-2-3			M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																							5-9			E
Sand Lance	M																										M
	LJ																										LJ
	EJ																										EJ
	L																										L
	E																										E

Table 3. Summary of Reproductive Traits for Groundfish in the GOA

GOA Groundfish		Reproductive Traits																											
		Age at Maturity (unless otherwise noted)				Fertilization/Egg Development					Spawning Behavior						Spawning Season												
		Female		Male																									
Species	Life Stage	50%	100%	50%	100%	External	Internal	Oviparous	Ovoviviparous	Viviparous	Batch Spawner	Broadcast Spawner	Egg Case Deposition	Nest Builder	Egg/Young Guarder	Egg/Young Bearer	January	February	March	April	May	June	July	August	September	October	November	December
Walleye Pollock	M	4-5		4-5		x						x						x	x	x	x							
Pacific Cod	M	5		5		x						x					x	x	x	x	x							
Atka Mackerel	M	3.6		3.6		x								x	x						x	x	x	x	x	x		
Sablefish	M	65cm		67cm		x						x					x	x	x	x	x							
Pacific Ocean Perch	M	10.5					x			x	x														x	x	x	x
Flathead Sole	M	10				x											x	x	x	x								x
Yellowfin Sole	M	10.5				x					x										x	x	x					
Arrowtooth Flounder	M	5		4		x											x	x	x	x							x	x
Rock Sole	M	9				x					x						x	x	x									
Rex Sole	M	24cm		16cm		x												x	x	x	x	x	x					
Greenland Turbot	M	5-10				x											x	x	x							x	x	x
Dover Sole	M	33cm				x											x	x	x	x	x	x	x	x				
Yelloweye Rockfish	M	22							x											x	x	x	x					
Shortraker/Rougheye Rockfish	M	20+					x			x	x												x	x	x	x	x	x
Northern Rockfish	M	13					x			x	x																	
Thornyhead Rockfish	M	12									x							x				x						
Dusky Rockfish	M	11					x			x	x																	
Sculpins	M					x									x													
Skates	M						x	x					x															
Sharks	M						x	x	x	x			x			x												
Squid	M						x				x																	
Octopus	M						x				x			x	x													
Eulachon	M	3	5	3	5	X		X			X									X	X	X						
Capelin	M	2	4	2	4	X		X			X										X	X	X	X				
Sand Lance	M	1	2	1	2	X		X			X						X	X									X	X

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

GOA Groundfish — Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Walleye Pollock	M				X			X			X			X						X	X	X	X	X		X			X	X	X
	LJ				X			X			X			X						X	X	X	X	X		X			X	X	X
	EJ				X			X			X									X	X	X									
	L				X			X			X																				
	E																														
Pacific Cod	M							X		X			X							X										X	
	LJ							X		X			X							X										X	
	EJ							X		X			X							X											
	L			X	X						X																				
	E																														
Atka Mackerel	M							X			X													X							
	J							X			X																				
	L										X																				
	E																														
Sablefish	M							X	X	X	X		X	X				X		X		X	X		X	X		X	X	X	
	LJ							X	X	X	X		X	X				X		X		X	X		X	X		X	X	X	
	EJ							X		X	X		X	X	X			X		X			X					X			
	L				X						X																				
	E																														
Pacifc Ocean Perch	M							X																							
	LJ							X			X																				
	EJ																														
	L			X	X																										
Flathead Sole	M							X		X	X		X			X	X	X	X		X	X								X	
	LJ							X		X	X		X			X	X	X	X											X	
	EJ				X								X			X			X											X	
	L	X		X																											
	E																														
Yellowfin Sole	M							X		X			X			X		X		X					X					X	
	LJ							X		X			X			X		X		X					X						
	EJ				X																										
	L	X		X																											
	E																														
Arrowtooth Flounder	M												X	X				X	X	X			X	X						X	
	LJ												X					X	X	X			X	X						X	
	EJ				X																										
	L	X		X																											
	E																														
Rock Sole	M									X			X			X	X														
	LJ									X			X			X	X														
	EJ				X																										
	L	X		X																											
	E																														

GOA Groundfish — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Hailbut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Walleye Pollock	M								X						X	X	X	X	X	X										
	LJ							X	X						X	X		X	X	X				X		X	X	X		
	EJ							X	X						X	X		X	X	X				X		X	X	X		
	L							X	X						X	X								X		X	X	X		
	E																													
Pacific Cod	M															X	X	X		X		X	X	X						
	LJ															X	X	X		X		X	X	X						
	EJ															X	X	X				X	X	X			X			
	L																													
	E																													
Atka Mackerel	M								X						X	X			X	X	X			X						
	J																			X						X	X			
	L																													
	E																													
Sablefish	M																													
	LJ						X									X														
	EJ																													
	L																													
	E																													
Pacifc Ocean Perch	M															X														
	LJ																													
	EJ						X																							
	L																													
Flathead Sole	M								X				X		X	X														
	LJ																													
	EJ																													
	L																													
	E																													
Yellowfin Sole	M																													
	LJ								X							X														
	EJ								X							X														
	L																													
	E																													
Arrowtooth Flounder	M																													
	LJ							X	X																					
	EJ																													
	L																													
	E																													
Rock Sole	M																													
	LJ							X	X					X		X														
	EJ																													
	L																													
	E																													

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

Predator to

GOA Groundfish Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
Dover Sole	M												X				X	X													
	LJ												X				X	X													
	EJ																														
	L	X		X																											
	E																														
Rex Sole	M							X		X			X					X													
	LJ							X		X			X					X													
	EJ																														
	L	X		X																											
	E																														
Greenland Turbot	M												X					X	X	X			X	X						X	
	LJ																														
	EJ				X																										
	L	X		X																											
	E																														
Yelloweye Rockfish	M																	X		X	X		X				X				
	LJ																														
	EJ										X																				
	L																														
	E																														
Shortraker/Rougheye Rockfish	M													X						X				X							
	LJ																														
	EJ																														
	L																														
Northern Rockfish	M							X			X																				
	LJ																														
	EJ																														
	L																														
Thornyhead Rockfish	M																			X					X						
	LJ																														
	EJ																														
	L																														
	E																														
Light Dusky Rockfish	M							X																							
	LJ																														
	EJ																														
	L																														
Sculpins	M				X			X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X			X	X	
	LJ																														
	EJ																														
	L																														
	E																														
Skates	M								X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Prey of

GOA Groundfish Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
Dover Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Rex Sole	M								X						X															
	LJ								X						X															
	EJ																													
	L																													
	E																													
Greenland Turbot	M																													
	LJ																													
	EJ							X	X					X																
	L																													
	E																													
Yelloweye Rockfish	M						X			X	X					X														
	LJ																													
	EJ																													
	L																													
	E																													
Shortraker/Rougheye Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Northern Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Thornyhead Rockfish	M																													
	LJ																													
	EJ																													
	L																													
	E																													
Light Dusky Rockfish	M																													
	LJ																													
	EJ																													
	L																													
Sculpins	M							X	X		X	X	X		X	X	X	X	X	X	X									
	LJ																													
	EJ																													
	L																													
	E																													
Skates	M																		X											

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Table 4 - Diet Prey

Table 4. Summary of Predator and Prey Associations for Groundfish in the GOA

GOA Groundfish — Predator to

Species	Life Stage	Algae	Plants	Plankton	Zooplankton	Diatoms	Sponges	Eusphausiid	Hydroids	Amphipoda	Copepods	Starfish	Polychaetes	Squid	Philodae (gunnels)	Bi-valves	Mollusks	Crustaceans	Ophiuroids (brittle stars)	Shrimps, mysidacae	Sand lance	Osmerid (eulachon)	Herring	Myctophid (lantern fishes)	Cottidae (sculpins)	Arrowtooth	Rockfish	Salmon	Pacific cod	Pollock	Halibut
	LJ																														
	EJ																														
	L																														
	E																														
Sharks	M						x		x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
	LJ																														
	EJ																														
	L																														
	E																														
Squid	M							x			x										x	x	x	x							
	LJ																														
	EJ																														
	L																														
	E																														
Octopus	M															x	x	x													
	LJ																														
	EJ																														
	L																														
	E																														
Eulachon	M				X			X			X																				
	LJ				X			X			X																				
	EJ				X			X			X																				
	L			X	X	X		X			X																				
	E																														
Capelin	M				X			X			X		X							X											
	LJ				X			X			X																				
	EJ				X			X			X																				
	L			X	X	X		X			X																				
	E																														
Sand Lance	M				X			X		X	X																				
	LJ				X			X		X	X																				
	EJ				X			X		X	X																				
	L			X	X	X		X		X	X																				
	E																														

GOA Groundfish — Prey of

Species	Life Stage	Jellyfish	Starfish	Chaetognaths (arrowworms)	Crab	Herring	Salmon	Pollock	Pacific cod	Ling cod	Rockfish	Rock Sole	Flathead Sole	Yellowfin sole	Arrowtooth flounder	Halibut	Salmon Shark	Northern Fur Seal	Harbor Seal	Steller sea lion	Dalls Porpoise	Beluga whale	Killer Whale	Minke whale	Eagles	Murres	Puffin	Kittiwake	Gull	Terrestrial Mammals
	LJ																													
	EJ																													
	L																													
	E																													
Sharks	M															x														
	LJ																													
	EJ																													
	L																													
	E																													
Squid	M	x						x	x	x	x					x	x	x	x	x	x		x	x		x	x	x	x	
	LJ																													
	EJ																													
	L																													
	E																													
Octopus	M							x	x	x	x					x	x	x	x	x										
	LJ																													
	EJ																													
	L																													
	E																													
Eulachon	M						X	X	X							X		X	X	X	X					X	X			X
	LJ						X	X	X							X		X	X	X	X					X	X			
	EJ					X	X	X	X							X														
	L					X	X	X	X							X														
	E																													
Capelin	M						X	X	X						X	X		X	X	X	X					X	X			
	LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ					X	X	X	X						X	X														
	L					X	X	X	X						X	X														
	E																													
Sand Lance	M						X	X	X						X	X		X	X	X	X					X	X			
	LJ						X	X	X						X	X		X	X	X	X					X	X			
	EJ					X	X	X	X						X	X														
	L					X	X	X	X						X	X														
	E																													

Habitat Description for Walleye Pollock

(*Theragra calcogramma)*

Management Plan and Area GOA

The Gulf of Alaska (GOA) pollock stocks are managed under the GOA Groundfish Fisheries Management Plan, and the eastern Bering Sea (EBS) and AI pollock stocks are managed under the EBS and AI Groundfish Fisheries Management Plan. Pollock occur throughout the area covered by the FMP and straddle into the Canadian and Russian U.S. Exclusive Economic Zone (EEZ), international waters of the central BS, and into the Chukchi Sea.

Life History and General Distribution

Pollock is the most abundant species within the EBS comprising 75 to 80 percent of the catch and 60 percent of the biomass. In the GOA, pollock is the second most abundant groundfish stock comprising 25 to 50 percent of the catch and 20 percent of the biomass.

Four stocks of pollock are recognized for management purposes: GOA, EBS, AI, and Aleutian Basin. There appears to be a high degree of interrelationship among the EBS, AI, and Aleutian Basin stocks with suggestions of movement from one area to the others. There appears to be stock separation between the GOA stocks and stocks to the north.

The most abundant stock of pollock is the EBS stock, which is primarily distributed over the EBS outer continental shelf between approximately 70 to 200 m. Information on pollock distribution in the EBS comes from commercial fishing locations, annual bottom trawl surveys, and triennial acoustic surveys.

The AI stock extends through the AI from 170E W to the end of the AI (Attu Island), with the greatest abundance in the eastern Aleutians (170E W to Seguam Pass). Most of the information on pollock distribution in the AI comes from triennial bottom trawl surveys. These surveys indicate that pollock are primarily located on the BS side of the AI, and have a spotty distribution throughout the AI chain. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass is likely to be unavailable to bottom trawls. Also, many areas of the AI shelf are untrawlable due to rough bottom.

The third stock, Aleutian Basin, appears to be distributed throughout the Aleutian Basin which encompasses the EEZ, Russian EEZ, and international waters in the central BS. This stock appears to move throughout the Basin for feeding, but concentrate in deepwater near the continental shelf for spawning. The principal spawning location is near Bogoslof Island in the eastern AI, but data from pollock fisheries in the first quarter of the year indicate that there are other concentrations of deepwater spawning concentrations in the western AI. The Aleutian Basin spawning stock appears to be derived from migrants from the EBS shelf stock, and possibly some western BS pollock. Recruitment to the stock occurs generally around age 5; very few pollock younger than age 5 have been found in the Aleutian Basin. Most of the pollock in the Aleutian Basin appear to originate from strong year classes.

The GOA stock extends from southeast Alaska to the AI (170E W), with the greatest abundance in the western and central regulatory areas (147E W to 170E W). Most of the information on pollock distribution in the GOA comes from triennial bottom trawl surveys. These surveys indicate that pollock are distributed throughout the shelf regions of the GOA at depths less than 300 m. The bottom trawl data may not provide an accurate view of pollock distribution because a significant portion of the pollock biomass may be pelagic and not available to bottom trawls. The principal spawning location is in Shelikof Strait, but data from pollock fisheries and exploratory surveys indicate that there are other concentrations of spawning in the Shumagin Islands, the east side of Kodiak Island and near Prince William Sound.

Peak pollock spawning occurs on the southeastern BS and eastern AI along the outer continental shelf around mid-March. North of the Pribilof Islands, spawning occurs later (April to May) in smaller spawning aggregations. The deep spawning pollock of the Aleutian Basin appear to spawn slightly earlier, late February to early March. In the GOA, peak spawning occurs in late March in Shelikof Strait. Peak spawning in the Shumagin area appears 2 to 3 weeks earlier than in Shelikof Strait.

Spawning occurs in the pelagic zone and eggs develop throughout the water column (70 to 80 m in the BS shelf, 150 to 200 m in Shelikof Strait). Development is dependent on water temperature. In the BS, eggs take about 17 to 20 days to develop at 4 degrees (º) in the Bogoslof area and 25.5 days at 2º on the shelf. In the GOA, development takes approximately 2 weeks at ambient temperature (5ºC). Larvae are also distributed in the upper water column. In the BS, the larval period lasts approximately 60 days. The larvae eat progressively larger naupliar stages of copepods as they grow and then small euphausiids as they approach transformation to juveniles (~25 millimeters [mm] standard length). In the GOA, larvae are distributed in the upper 40 m of the water column and the diet is similar to BS larvae. FOCI survey data indicate larval pollock may utilize the stratified warmer upper waters of the mid-shelf to avoid predation by adult pollock which reside in the colder bottom water.

At age 1, pollock are found throughout the EBS both in the water column and on bottom. Age 1 pollock from strong year-classes appear to be found in great numbers on the inner shelf, and further north on the shelf than weak year classes which appear to be more concentrated on the outer continental shelf. From ages 2-3, pollock are primarily pelagic and then appear to be most abundant on the outer and mid-shelf northwest of the Pribilof Islands. As pollock reach maturity (age 4) in the BS, they appear to move from the northwest to the southeast shelf to recruit to the adult spawning population. Strong year-classes of pollock persist in the population in significant numbers until about age 12, and very few pollock survive beyond age 16. The oldest recorded pollock was age 31.

Growth varies by area with the largest pollock occurring on the southeastern shelf. On the northwest shelf the growth rate is slower. A newly maturing pollock is around 40 centimeters (cm).

Fishery

The EBS pollock fishery has, since 1990, been divided into two fishing periods; an "A season" occurring in January-March, and a "B season" occurring in August-October. The A season concentrates fishing effort on prespawning pollock in the southeastern BS. During the B season fishing is still primarily in the southeastern BS, but some fishing also occurs on the northwestern shelf. Also during the B season, catcher processor vessels are required to fish north of lat. 56E N because the area to the south is reserved for catcher vessels delivering to shoreside processing plants on Unalaska and Akutan.

Since 1992, the GOA pollock total allowable catch (TAC) has been apportioned spatially and temporally to reduce impacts on Steller sea lions. Although the details of the apportionment scheme have evolved over time, the general objective is to allocate the TAC to management areas based on the distribution of surveyed biomass and to establish three or four seasons between mid-January and autumn during which some fraction of the TAC can be taken. The Steller Sea Lion Protection Measures implemented in 2001 establish four seasons in the Central and Western GOA beginning January 20, March 10, August 25, and October 1, with 25 percent of the total TAC allocated to each season. Allocations to management areas 610, 620, and 630 are based on the seasonal biomass distribution as estimated by groundfish surveys. In addition, a new harvest control rule was implemented that requires a cessation of fishing when spawning biomass declines below 20 percent of unfished stock biomass.

In the GOA, approximately 90 percent of the pollock catch is taken using pelagic trawls. During winter, fishing effort usually targeted primarily on pre-spawning aggregations in Shelikof Strait and near the Shumagin Islands. The pollock fishery has a very low bycatch rate with discards averaging about 2 percent since 1998 (with the 1991-1997 average around 9 percent). Most of the discards in the pollock fishery are juvenile pollock, or pollock too large to fit filleting machines. In the pelagic trawl fishery, the catch is almost exclusively pollock.

The EBS pollock fishery primarily harvests mature pollock. The age where fish are selected by the fishery roughly corresponds to the age at maturity (management guidelines are oriented towards conserving spawning biomass). Fishery selectivity increases to a maximum around age 6-8 and declines slightly. The reduced selectivity for older ages is due to pollock becoming increasingly demersal with age. Younger pollock form large schools and are semi-demersal, thereby being easier to locate by fishing vessels. Immature fish (ages 2 and 3) are usually caught in low numbers. Generally the catch of immature pollock increases when strong year-classes occur and the abundance of juveniles increase sharply. This occurred with the 1989 year-class, the second largest year-class on record. Juvenile bycatch increased sharply in 1991 and 1992 when this year-class was age 2 and 3. A secondary problem is that strong to moderate year-classes may reside in the Russian EEZ adjacent to the EEZ as juveniles. Russian catch-age data and anecdotal information suggest that juveniles may comprise a major portion of the catch. There is a potential for the Russian fishery to reduce subsequent abundance in the U.S. fishery.

The GOA pollock fishery also targets mature pollock. Fishery selectivity increases to a maximum around age 5-7 and then declines. In both the EBS and GOA, the selectivity pattern varies between years due to shifts in fishing strategy and changes in the availability of different age groups over time.

In response to continuing concerns over the possible impacts groundfish fisheries may have on rebuilding populations of Steller sea lions, NMFS and the North Pacific Fishery Management Council (Council) have made changes to the Atka mackerel (mackerel) and pollock fisheries in the Bering Sea/Aleutian Islands (BSAI) and GOA. These have been designed to reduce the possibility of competitive interactions with Steller sea lions. For the pollock fisheries, comparisons of seasonal fishery catch and pollock biomass distributions (from surveys) by area in the EBS led to the conclusion that the pollock fishery had disproportionately high seasonal harvest rates within critical habitat which could lead to reduced sea lion prey densities. Consequently, the management measures were designed to redistribute the fishery both temporally and spatially according to pollock biomass distributions. The underlying assumption in this approach was that the independently derived area-wide and annual exploitation rate for pollock would not reduce local prey densities for sea lions. Here NMFS examines the temporal and spatial dispersion of the fishery to evaluate the potential effectiveness of the measures.

Three types of measures were implemented in the pollock fisheries:

- Additional pollock fishery exclusion zones around sea lion rookery or haulout sites
- Phased-in reductions in the seasonal proportions of TAC that can be taken from critical habitat
- Additional seasonal TAC releases to disperse the fishery in time

Prior to the management measures, the pollock fishery occurred in each of the three major fishery management regions of the North Pacific ocean managed by the Council: the AI (1,001,780 square kilometer [km^2] inside the EEZ), the EBS (968,600 km^2), and the GOA (1,156,100 km^2). The marine portion of Steller sea lion critical habitat in Alaska west of 150ºW encompasses 386,770 km^2 of ocean surface, or 12 percent of the fishery management regions.

Prior to 1999, a total of 84,100 km^2, or 22 percent of critical habitat, was closed to the pollock fishery. Most of this closure consisted of the 10 and 20 nm radius all-trawl fishery exclusion zones around sea lion rookeries (48,920 km^2 or 13 percent of critical habitat). The remainder was largely management area 518 (35,180 km^2, or 9 percent of critical habitat) which was closed pursuant to an international agreement to protect spawning stocks of central BS pollock.

In 1999, an additional 83,080 km^2 (21 percent) of critical habitat in the AI was closed to pollock fishing along with 43,170 km^2 (11 percent) around sea lion haulouts in the GOA and EBS. Consequently, a total of 210,350 km^2 (54 percent) of critical habitat was closed to the pollock fishery. The portion of critical habitat that remained open to the pollock fishery consisted primarily of the area between 10 and 20 nm from rookeries and haulouts in the GOA and parts of the EBS foraging area.

The BSAI pollock fishery was also subject to changes in total catch and catch distribution. Disentangling the specific changes in the temporal and spatial dispersion of the EBS pollock fishery resulting from the sea lion management measures from those resulting from implementation of the 1999 American Fisheries Act (AFA) is difficult. The AFA reduced the capacity of the catcher/processor fleet and permitted the formation of cooperatives in each industry sector by 2000. Both of these changes would be expected to reduce the rate at which the catcher/processor sector (allocated 36 percent of the EBS pollock TAC) caught pollock beginning in 1999, and the fleet as a whole in 2000. Because of some of its provisions, the AFA gave the industry the ability to respond efficiently to changes mandated for sea lion conservation that otherwise could have been more disruptive to the industry.

In 2000, further reductions in seasonal pollock catches from BSAI sea lion critical habitat were realized by closing the entire AI region to pollock fishing and by phased-in reductions in the proportions of seasonal TAC that could be caught from the Sea Lion Conservation Area, an area which overlaps considerably with sea lion critical habitat. In 1998, over 22,000 t of pollock were caught in the Aleutian Island regions, with over 17,000 t caught in AI critical habitat. Since 1998 directed fishery removals of pollock have been prohibited.

Relevant Trophic Information

Juvenile pollock through newly maturing pollock primarily utilize copepods and euphausiids for food. At maturation and older ages pollock become increasingly piscivorous, with pollock (cannibalism) a major food item in the BS. Most of the pollock consumed by pollock are age 0 and 1 pollock, and recent research suggests that cannibalism can regulate year-class size. Weak year-classes appear to be those located within the range of adults, while strong year-classes are those that are transported to areas outside the range of adult abundance.

Being the dominant species in the EBS pollock is an important food source for other fish, marine mammals, and birds. On the Pribilof Islands hatching success and fledgling survival of marine birds has been tied to the availability of age 0 pollock to nesting birds.

Approximate Upper Size Limit of Juvenile Fish (in cm): The upper size limit for juvenile pollock in the EBS and GOA is about 38 to 42 cm. This is the size of 50 percent maturity. There is some evidence that this has changed over time.

Habitat and Biological Associations

Egg-Spawning: Pelagic on outer continental shelf generally over 100 to 200 m depth in Bering Sea. Pelagic on continental shelf over 100 to 200 m depth in GOA.

Larvae: Pelagic outer to mid-shelf region in BS. Pelagic throughout the continental shelf within the top 40 m in the GOA.

Juveniles: Age 0 appears to be pelagic, as is age 2 and 3. Age 1 pelagic and demersal with a widespread distribution and no known benthic habitat preference.

Adults: Adults occur both pelagically and demersally on the outer and mid-continental shelf of the GOA, EBS and AI. In the EBS few adult pollock occur in waters shallower than 70 m. Adult pollock also occur pelagically in the Aleutian Basin. Adult pollock range throughout the BS in both the U.S. and Russian waters, however, the maps provided for this document detail distributions for pollock in the EEZ and the basin.

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SPECIES: GOA Walleye Pollock

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	14 d. at 5 C	None	Feb-Apr	OCS, UCS	P	N/A	G?	
Larvae	60 days	copepod naupli and small euphausiids	Mar-Jul	MCS, OCS	P	N/A	G? F	pollock larvae with jellyfish
Juveniles	0.4 to 4.5 years	Pelagic crustaceans, copepods and euphausiids	Aug. +	OCS, MCS, ICS	P, SD	N/A	CL, F	
Adults	4.5 to 16 years	Pelagic crustaceans and fish	Spawning Feb-Apr	OCS, BSN	P, SD	UNK	F UP	Increasingly demersal with age

Habitat Description for Pacific Cod

(Gadus macrocephalus)

Management Plan and Area GOA

Life History and General Distribution

Pacific cod is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about lat. 34° N, with a northern limit of about lat. 63° N. Adults are demersal and form aggregations during the peak spawning season, which extends approximately from January through May. Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15 to 20 days. Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25 to 35 mm. Juvenile Pacific cod start appearing in trawl surveys at a fairly small size, as small as 10 cm in the EBS. Pacific cod can grow to be more than 1 m in length, with weights in excess of 10 kilogram (kg). Natural mortality is believed to be somewhere between 0.3 and 0.4. Approximately 50 percent of Pacific cod are mature by ages 5 to 6. The maximum recorded age of a Pacific cod from the BSAI or GOA is 19 years.

Fishery

The fishery is conducted with bottom trawl, longline, pot, and jig gear. The age at 50 percent recruitment varies between gear types and regions. In the BSAI, the age at 50 percent recruitment is 6 years for trawl gear, 4 years for longline, and 5 years for pot gear. In the GOA, the age at 50 percent recruitment is 5 years for trawl gear and 6 years for longline and pot gear. More than 100 vessels participate in each of the three largest fisheries (trawl, longline, pot). The trawl fishery is typically concentrated during the first few months of the year, whereas fixed-gear fisheries may sometimes run, intermittently, at least, throughout the year. Bycatch of crab and halibut sometimes causes the Pacific cod fisheries to close prior to reaching the TAC. In the BSAI, trawl fishing is concentrated immediately north of Unimak Island, whereas the longline fishery is distributed along the shelf edge to the north and west of the Pribilof Islands. In the GOA, the trawl fishery has centers of activity around the Shumagin Islands and south of Kodiak Island, while the longline fishery is located primarily in the vicinity of the Shumagins.

Relevant Trophic Information

Pacific cod are omnivorous. In terms of percent occurrence, the most important items in the diet of Pacific cod in the BSAI and GOA are polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausiids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important dietary items are walleye pollock, fishery discards, and yellowfin sole. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include halibut, salmon shark, northern fur seals, sea lions, harbor porpoises, various whale species, and tufted puffin.

Approximate Upper Size Limit of Juvenile Fish (in cm): The estimated size at 50 percent maturity is 67 cm.

Habitat and Biological Associations

Egg/Spawning: Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near bottom. Eggs sink to the bottom after fertilization and are somewhat adhesive. Optimal temperature for incubation is 3 to 6°C, optimal salinity is 13 to 23 parts per thousand (ppt), and optimal oxygen concentration is from 2 to 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Larvae: Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Juveniles: Juveniles occur mostly over the inner continental shelf at depths of 60 to 150 m.

Adults: Adults occur in depths from the shoreline to 500 m. Average depth of occurrence tends to vary directly with age for at least the first few years of life, with mature fish concentrated on the outer continental shelf. Preferred substrate is soft sediment, from mud and clay to sand.

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SPECIES: Pacific Cod

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	15 to 20 days	NA	winter-spring	ICS, MCS, OCS	D	M, SM, MS, S	U	optimum 3-6°C optimum salinity 13-23 ppt
Larvae	U	copepods (?)	winter-spring	U	P (?), N (?)	U	U	
Early Juveniles	to 2 years	small invertebrates (mysids, euphausiids, shrimp)	all year	ICS, MCS	D	M, SM, MS, S	U	
Late Juveniles	to 5 years	pollock, flatfish, fishery discards, crab	all year	ICS, MCS, OCS	D	M, SM, MS, S	U	
Adults	5+ yr	pollock, flatfish, fishery discards, crab	spawning (Jan-May) non-spawning (Jun-Dec)	ICS, MCS, OCS ICS, MCS, OCS	D	M, SM, MS, S,G	U	

Habitat Description for Dover Sole

(*Microstomus pacificus*)

Management Plan and Area GOA

Life History and General Distribution

Dover sole are distributed in deep waters of the continental shelf and upper slope from northern Baja California to the BS and the western AI (Hart 1973, Miller and Lea 1972). They exhibit a widespread distribution throughout the GOA. Adults are demersal and are mostly found in water deeper than 300 m in the winter but occur in highest biomass in the 100- to 200-m depth range during summer in the GOA (Turnock et al. 2004). The spawning period off Oregon is reported to range from January through May (Hunter et al. 1992). Off California, Dover sole spawn in deep water, and the larvae eventually settle in the shallower water of the continental shelf. They gradually move down the slope into deeper water as they grow and reach sexual maturity (Jacobson and Hunter 1993,Vetter et al. 1994, Hunter et al. 1990). For mature adults, most of the biomass may inhabit the oxygen minimum zone in deep waters Spawning in the GOA has been observed from January through August, with a peak period in May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over mid-shelf and slope areas (Kendall and Dunn 1985). The age or size at metamorphosis is unknown, but the pelagic larval period is known to be protracted and may last as long as 2 years (Markle et al. 1992). Pelagic postlarvae as large as 48 mm have been reported, and the young may still be pelagic at 10 cm (Hart 1973). Dover sole are batch spawners, and Hunter et al. (1992) concluded that the average 1 kg female spawns its 83,000 advanced yolked oocytes in about nine batches. Maturity studies from Oregon indicate that females were 50 percent mature at 33 cm total length. Juveniles less than 25 cm are rarely found with the adult population from bottom trawl surveys (Martin and Clausen 1995). The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 2002).

Fishery

Dover sole are caught in bottom trawls, both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 5. They are caught as bycatch in the rex sole, thornyhead, and sablefish fisheries, and they are caught with these species and Pacific halibut in Dover sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate Upper Size Limit of Juvenile Fish (in cm): The approximate upper size limit of juvenile Dover sole is 32 cm.

Habitat and Biological Associations

<u>*Larvae/Juveniles*</u>: Dover sole are planktonic larvae for up to 2 years until metamorphosis occurs; juvenile distribution is unknown.

Adults: Dover sole are winter and spring spawners, and summer feeding occurs on soft substrates (combination of sand and mud) of the continental shelf and upper slope. Shallower summer distribution occurs mainly on the middle to outer portion of the shelf and upper slope. They feed mainly on polychaetes, annelids, crustaceans, and mollusks (Livingston and Goiney 1983).

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SPECIES: Dover Sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	spring summer	ICS? MCS OCS USP	P			
Larvae	up to 2 years	U phyto/zoo plankton?	all year	ICS? MCS OCS USP	P			
Early Juveniles	to 3 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Late Juveniles	3 to 5 years	polychaetes amphipods annelids	all year	MCS? ICS?	D	S, M		
Adults	5+ years	polychaetes amphipods annelids mollusks	spawning Jan-August non-spawning July-January	MCS OCS USP	D	S, M		

Habitat Description for Greenland Turbot

(Reinhardtius hippoglossoides)

Management Plan and Area GOA

Life History and General Distribution

Greenland turbot has an amphiboreal distribution, occurring in the North Atlantic and North Pacific, but not in the intervening Arctic Ocean. In the North Pacific, species abundance is centered in the EBS and, secondly, in the Aleutians. On the Asian side, they occur in the Gulf of Anadyr along the BS coast of Russia, in the Okhotsk Sea, around the Kurile Islands, and south to the east coast of Japan to northern Honshu Island (Hubbs and Wilimovsky 1964, Mikawa 1963, Shuntov 1965). Adults exhibit a benthic lifestyle, living in deep waters of the continental slope but are known to have a tendency to feed off the sea bottom. During their first few years as immature fish, they inhabit relatively shallow continental shelf waters (<200 m) until about age 4 or 5 before joining the adult population (200 to 1,000 m or more, Templeman 1973). Adults appear to undergo seasonal shifts in depth distribution moving deeper in winter and shallower in summer (Chumakov 1970, Shuntov 1965). Spawning is reported to occur in winter in the EBS and may be protracted starting in September or October and continuing until March with an apparent peak period in November to February (Shuntov 1970, Bulatov 1983). Females spawn relatively small numbers of eggs with fecundity ranging from 23,900 to 149,300 for fish 83 cm and smaller in the BS (D'yakov 1982).

Eggs and early larval stages are benthypelagic (Musienko 1970). In the Atlantic Ocean, larvae (10 to 18 cm) have been found in benthypelagic waters, which gradually rise to the pelagic zone in correspondence to absorption of the yolk sac; this is reported to occur at 15 to 18 mm with the onset of feeding (Pertseva-Ostroumova 1961 and Smidt 1969). The period of larval development extends from April to as late as August or September (Jensen 1935), which results in an extensive larval drift and broad dispersal from the spawning waters of the continental slope. Metamorphosis occurs in August or September at about 7 to 8 cm in length at which time the demersal life begins. Juveniles are reported to be quite tolerant of cold temperatures to less than 0ºC (Hognestad 1969) and have been found on the northern part of the BS shelf in summer trawl surveys (Alton et al. 1988).

The age of 50 percent maturity is estimated to range from 5 to 10 years (D'yakov 1982, 60 cm used in stock assessment), and a natural mortality rate of 0.18 has been used in the most recent BS stock assessment (Ianelli et al. 2002).

Fishery

Greenland turbot are not a fishery target in the GOA. They are caught in bottom trawls and on longlines both as a directed fishery and in the pursuit of other bottom-dwelling species (primarily sablefish). These fisheries operate on the southern side of the AI. Bycatch primarily occurs in the sablefish directed fisheries and also to a smaller extent in the Pacific cod fishery. Recruitment begins at about 50 and 60 cm in the trawl and longline fisheries, respectively.

Relevant Trophic Information

Groundfish predators include Pacific cod, pollock, and yellowfin sole, mostly on fish ranging from 2 to 5 cm standard length (probably age 0).

Approximate Upper Size Limit of Juvenile Fish (in cm): 59 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for up to 9 months until metamorphosis occurs, usually with a widespread distribution inhabiting shallow waters. Juveniles live on continental shelf until about age 4 or 5 feeding primarily on euphausiids, polychaetes and small walleye pollock.

Adults: Inhabit continental slope waters with annual spring/fall migrations from deeper to shallower waters. Diet consists of walleye pollock and other miscellaneous fish species.

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SPECIES: Greenland Turbot

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	winter	OCS MCS	SD, SP			
Larvae	8 to 9 months	U phyto/zoo plankton?	Spring summer	OCS ICS MCS	P			
Juveniles	1 to 5 years	euphausiids polychaets small pollock	all year	ICS MCS OCS USL	D, SD	M/S+M[1]		
Adults	5+ years	pollock small fish	spawning Nov-February non-spawning March-October	OCS USP LSP OCS USP LSP	D, SD	M/S+M[1]		

[1]Pers. Comm. Dr. Robert McConnaughey

Habitat Description for Rock Sole

(Lepidopsetta bilineatus)

The shallow water flatfish management complex in the GOA consists of eight species: rock sole (*Lepidopsetta bileneata and Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), starry flounder (*Platichthys stellatus*), butter sole (*Isopsetta isolepis*), English sole (*Parophrys vetulus*), Alaska plaice (*Pleuronectes quadrituberculatus*) and sand sole (*Psettichthys melanostictus*). The rock sole resource in the GOA consists of two separate species; a northern and a southern form which have distinct characteristics and overlapping distributions. The two species of rock sole and yellowfin sole are the most abundant and commercially important species of this management complex in the GOA, and the description of their habitat and life history best represents the shallow water complex species.

Management Plan and Area GOA

Life History and General Distribution

Rock sole are distributed from California waters north into the GOA and BS to as far north as the Gulf of Anadyr. The distribution continues along the AI westward to the Kamchatka Peninsula and then southward through the Okhotsk Sea to the Kurile Islands, Sea of Japan, and off Korea. Centers of abundance occur off the Kamchatka Peninsula (Shubnikov and Lisovenko 1964), British Columbia (Forrester and Thompson 1969), the central GOA, and in the southeastern BS (Alton and Sample 1975). Adults exhibit a benthic lifestyle and, in the EBS, occupy separate winter (spawning) and summertime feeding distributions on the continental shelf. Rock sole spawn during the winter-early spring period of December-March. Soviet investigations in the early 1960s established two spawning concentrations: an eastern concentration north of Unimak Island at the mouth of Bristol Bay and a western concentration eastward of the Pribilof Islands between 55°30' and 55°0' N and approximately 165°2' W (Shubnikov and Lisovenko 1964). Rock sole spawning in the eastern and western BS was found to occur at depths of 125 to 250 m, close to the shelf/slope break. Spawning females deposit a mass of eggs that are demersal and adhesive (Alton and Sample 1975). Fertilization is believed to be external. Incubation time is temperature dependent and may range from 6.4 days at 11ºC to about 25 days at 2.9ºC (Forrester 1964). Newly hatched larvae are pelagic and have occurred sporadically in EBS plankton surveys (Waldron and Vinter 1978). Kamchatka larvae are reportedly 20 mm in length when they assume their side-swimming, bottom-dwelling form (Alton and Sample 1975). Forrester and Thompson (1969) report that by age 1 they are found with adults on the continental shelf during summer.

In the springtime, after spawning, rock sole begin actively feeding and commence a migration to the shallow waters of the continental shelf. This migration has been observed on both the eastern (Alton and Sample 1975) and western (Shvetsov 1978) areas of the BS. During this time they spread out and form much less dense concentrations than during the spawning period. Summertime trawl surveys indicate most of the population can be found at depths from 50 to 100 m (Armistead and Nichol 1993). The movement from winter/spring to summer grounds is in response to warmer temperatures in the shallow waters and the distribution of prey on the shelf seafloor (Shvetsov 1978). In September, with the onset of cooling in the northern latitudes, rock sole begin the return migration to the deeper wintering grounds. Fecundity varies with size and was reported to be 450,00 eggs for fish 42 cm long. Larvae are pelagic, but their occurrence in plankton surveys in the EBS is rare (Musienko 1963). The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach age 1 (Forrester 1969). The estimated age of 50 percent maturity is 9 years for southern rock sole females (approximately 35 cm) and 7 years for northern rock sole females (Stark and Somerton 2002). The natural mortality rate is believed to range from 0.18 to 0.20 (Tournock et al. 2002).

Fishery

Rock sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 4 and they are fully selected at age 11. Historically, the fishery has occurred throughout the mid and inner BS shelf during ice-free conditions and on spawning concentrations north of the Alaska Peninsula during winter for their high-value roe. They are caught as bycatch in Pacific cod, bottom pollock, and other flatfish fisheries and are caught with these species and Pacific halibut in rock sole directed fisheries.

Relevant Trophic Information

Groundfish predators to rock sole include Pacific cod, walleye pollock, skates, Pacific halibut, and yellowfin sole, mostly on fish ranging from 5 to 15 cm standard length.

Approximate Upper Size Limit of Juvenile Fish (in cm): 34 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, juveniles inhabit shallow areas at least until age 1.

Adults: Summertime feeding on primarily sandy substrates of the EBS shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding on bivalves, polychaetes, amphipods and miscellaneous crustaceans. Wintertime migration to deeper waters of the shelf margin for spawning and to avoid extreme cold water temperatures, feeding diminishes.

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SPECIES: Rock Sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	winter	OCS	D			
Larvae	2 to 3 months?	U phyto/zoo plankton?	winter/spring	OCS MCS ICS	P			
Early Juveniles	to 3.5 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Late Juveniles	up to 9 years	polychaetes bivalves amphipods misc. crust.	all year	BAY ICS OCS MCS	D	S[1],G		
Adults	9+ years	polychaetes bivalves amphipods misc. crust.	feeding May-September spawning Dec.-April	MCS ICS MCS OCS	D	S[1], G	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey

Habitat Description for Yellowfin Sole

(Limanda aspera)

Management Plan and Area Shallow water flatfish complex in the GOA

Life History and General Distribution

Yellowfin sole are distributed in North American waters from off British Columbia, Canada (approximately lat. 49° N) to the Chukchi Sea (about lat. 70° N) and south along the Asian coast to about lat. 35° N off the South Korean coast in the Sea of Japan. Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the EBS shelf. From over-winter grounds near the shelf margins, adults begin a migration onto the inner shelf in April or early May each year for spawning and feeding. A protracted and variable spawning period may range from as early as late May through August occurring primarily in shallow water. Fecundity varies with size and was reported to range from 1.3 to 3.3 million eggs for fish 25 to 45 cm long. Eggs have been found to the limits of inshore ichthyoplankton sampling over a widespread area to at least as far north as Nunivak Island. Larvae have been measured at 2.2 to 5.5 mm in July and 2.5 to 12.3 mm in late August - early September. The age or size at metamorphosis is unknown. Juveniles are separate from the adult population, remaining in shallow areas until they reach approximately 15 cm. The estimated age of 50 percent maturity is 10.5 years (approximately 29 cm) for females based on samples collected in 1992 and 1993. Natural mortality rate is believed to range from 0.12 to 0.16.

Fishery

Yellowfin sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 6 and they are fully selected at age 13. Historically, the fishery has occurred throughout the mid and inner BS shelf during ice-free conditions although much effort has been directed at the spawning concentrations in nearshore northern Bristol Bay. They are caught as bycatch in Pacific cod, bottom pollock and other flatfish fisheries and are caught with these species and Pacific halibut in yellowfin sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, skates, and Pacific halibut, mostly on fish ranging from 7 to 25 cm standard length.

Approximate Upper Size Limit of Juvenile Fish (in cm): 27 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Summertime spawning and feeding on sandy substrates of the EBS shelf. Widespread distribution mainly on the middle and inner portion of the shelf, feeding mainly on bivalves, polychaetes, amphipods and echiurids. Wintertime migration to deeper waters of the shelf margin to avoid extreme cold water temperatures, feeding diminishes.

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SPECIES: Yellowfin Sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	summer	BAY, BCH	P			
Larvae	2 to 3 months?	U phyto/zoo plankton?	summer autumn?	BAY BCH ICS	P			
Early Juveniles	to 5.5 years	polychaetes bivalves amphipods echiurids	all year	BAY ICS OCS MCS	D	S[1]		
Late Juveniles	5.5 to 10 years	polychaetes bivalves amphipods echiurids	all year	BAY ICS, OCS, MCS IP	D	S[1]		
Adults	10+ years	polychaetes bivalves amphipods echiurids	spawning/ feeding May-August non-spawning Nov.-April	BAY BEACH ICS, MCS, OCS IP	D	S[1]	ice edge	

1Pers. Comm. Dr. Robert McConnaughey

Habitat Description for Rex Sole

(*Glyptocephalus zachirus)*

Management Plan and Area GOA

Life History and General Distribution

Rex sole are distributed from Baja California to the BS and western AI (Hart 1973, Miller and Lea 1972), and are widely distributed throughout the GOA. Adults exhibit a benthic lifestyle and are generally found in water deeper than 300 m. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year. The spawning period off Oregon is reported to range from January through June with a peak in March and April (Hosie and Horton 1977). Spawning in the GOA was observed from February through July, with a peak period in April and May (Hirschberger and Smith 1983). Eggs have been collected in neuston and bongo nets mainly in the summer, east of Kodiak Island (Kendall and Dunn 1985), but the duration of the incubation period is unknown. Larvae were captured in bongo nets only in summer over midshelf and slope areas (Kendall and Dunn 1985). Fecundity estimates from samples collected off the Oregon coast ranged from 3,900 to 238,100 ova for fish 24 to 59 cm (Hosie and Horton 1977). The age or size at metamorphosis is unknown Maturity studies from Oregon indicate that males were 50 percent mature at 16 cm and females at 24 cm. Juveniles less than 15 cm are rarely found with the adult population. The natural mortality rate used in recent stock assessments is 0.2 (Turnock et al. 2002).

Fishery

Rex sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3 or 4. They are caught as bycatch in the Pacific ocean perch, Pacific cod, bottom pollock, and other flatfish fisheries and are caught with these species and Pacific halibut in rex sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod and most likely arrowtooth flounder.

Approximate Upper Size Limit of Juvenile Fish (in cm): Males 15 cm and females 23 cm

Habitat and Biological Associations

<u>*Larvae/Juveniles*</u>: Planktonic larvae for an unknown time period until metamorphosis occurs, juvenile distribution is unknown.

<u>*Adults*</u>: Spring spawning and summer feeding on a combination of sand, mud and gravel substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on polychaetes, amphipods, euphausids and snow crabs.

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SPECIES: Rex Sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	Feb - May	ICS? MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS? MCS OCS	P			
Juveniles	2 years	polychaetes amphipods euphausiids Tanner crab	all year	MCS ICS OCS	D	G, S, M		
Adults	2+ years	polychaetes amphipods euphausiids Tanner crab	spawning Feb-May non-spawning May-January	MCS, OCS USP	D	G, S, M		

Habitat Description for Flathead Sole

(*Hippoglossoides elassodon*)

Management Plan and Area GOA

Life History and General Distribution

Flathead sole are distributed from northern California, off Point Reyes, northward along the west coast of North America and throughout the GOA and the BS, the Kuril Islands, and possibly the Okhotsk Sea (Hart 1973).

Adults exhibit a benthic lifestyle and occupy separate winter spawning and summertime feeding distributions on the EBS shelf and in the GOA. From over-winter grounds near the shelf margins, adults begin a migration onto the mid and outer continental shelf in April or May each year for feeding. The spawning period may range from as early as January but is known to occur in March and April, primarily in deeper waters near the margins of the continental shelf. Eggs are large (2.75 to 3.75 mm) and females have egg counts ranging from about 72,000 (20 cm fish) to almost 600,000 (38 cm fish). Eggs hatch in 9 to 20 days depending on incubation temperatures within the range of 2.4 to 9.8°C and have been found in ichthyoplankton sampling on the southern portion of the BS shelf in April and May (Waldron 1981). Larvae absorb the yolk sac in 6 to 17 days, but the extent of their distribution is unknown. Nearshore sampling indicates that newly settled larvae are in the 40 to 50 mm size range (Norcross et al. 1996). Flathead sole females in the GOA become 50 percent mature at 8 years or about 32 cm (Turnock et al. 2002). Juveniles less than age 2 have not been found with the adult population, remaining in shallow areas. The natural mortality rate used in recent stock assessments is 0.2.

Fishery

Flathead sole are caught in bottom trawls both as a directed fishery and in the pursuit of other bottom-dwelling species. Recruitment begins at about age 3. Historically, the fishery has occurred throughout the mid and outer BS shelf during ice-free conditions (mostly summer and fall). They are caught as bycatch in Pacific cod, bottom Pollock and other flatfish fisheries and are caught with these species and Pacific halibut in flathead sole directed fisheries.

Relevant Trophic Information

Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder, and also cannibalism by large flathead sole, mostly on fish less than 20 cm standard length.

Approximate Upper Size Limit of Juvenile Fish (in cm): 31 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for 3 to 5 months until metamorphosis occurs, usually inhabiting shallow areas.

Adults: Winter spawning and summer feeding on sand and mud substrates of the continental shelf. Widespread distribution mainly on the middle and outer portion of the shelf, feeding mainly on ophiuroids, tanner crab, osmerids, bivalves and polychaetes.

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SPECIES: Flathead Sole

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	winter	ICS MCS OCS	P			
Larvae	U	U phyto/zoo plankton?	spring summer	ICS MCS OCS	P			
Juveniles	U	polychaetes bivalves ophiuroids	all year	MCS ICS OCS	D	S+M[1]		
Adults	U	polychaetes bivalves ophiuroids pollock and Tanner crab	spawning Jan-April non-spawning May-December	MCS OCS ICS	D	S+M[1]	ice edge	

[1]Pers. Comm. Dr. Robert McConnaughey

Habitat Description for Arrowtooth Flounder

(Atheresthes stomias)

Management Plan and Area GOA

Life History and General Distribution

Arrowtooth flounder are distributed in North American waters from central California to the EBS on the continental shelf and upper slope.

Adults exhibit a benthic lifestyle and occupy separate winter and summer distributions on the EBS shelf. From over-winter grounds near the shelf margins and upper slope areas, adults begin a migration onto the middle and inner shelf in April or early May each year with the onset of warmer water temperatures. A protracted and variable spawning period may range from as early as September through March (Rickey 1994, Hosie 1976). Little is known of the fecundity of arrowtooth flounder. Larvae have been found from ichthyoplankton sampling over a widespread area of the EBS shelf in April and May and also on the continental shelf east of Kodiak Island during winter and spring (Waldron and Vinter 1978, Kendall and Dunn 1985). Nearshore sampling in the Kodiak Island area indicates that newly settled larvae are in the 40 to 60 mm size range (Norcross et al. 1996). Juveniles are separate from the adult population, remaining in shallow areas until they reach the 10 to 15 cm range (Martin and Clausen 1995). The estimated length at 50 percent maturity is 28 cm for males (4 years) and 37 cm for females (5 years) from samples collected off the Washington coast (Rickey 1994) and 47 cm for GOA females (Zimmerman 1997). The natural mortality rate used in stock assessments differs by sex with females estimated at 0.2 and male natural mortality ranging from 0.28 to 0.35 (Turnock et. al 2002, Wilderbuer and Sample 2002).

Fishery

Arrowtooth flounder are caught in bottom trawls usually in pursuit of other higher value bottom-dwelling species. Historically, they have been undesirable to harvest due to a flesh softening condition caused by protease enzyme activity. Recruitment begins at about age 3 and females are fully selected at age 10. They are caught as bycatch in Pacific cod, bottom pollock, sablefish, and other flatfish fisheries.

Relevant Trophic Information

They are very important as a large, aggressive and abundant predator of other groundfish species. Groundfish predators include Pacific cod and pollock, mostly on small fish.

Approximate Upper Size Limit of Juvenile Fish (in cm): Males 27 cm and females 46 cm

Habitat and Biological Associations

Larvae/Juveniles: Planktonic larvae for at least 2 to 3 months until metamorphosis occurs, juveniles usually inhabit shallow areas until about 10 cm in length.

Adults: Widespread distribution mainly on the middle and outer portions of the continental shelf, feeding mainly on walleye pollock and other miscellaneous fish species when arrowtooth flounder attain lengths greater than 30 cm. Wintertime migration to deeper waters of the shelf margin and upper continental slope to avoid extreme cold water temperatures and for spawning.

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SPECIES: Arrowtooth Flounder

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs		NA	winter, spring?	ICS OCS	P			
Larvae	2 to 3 months?	U phyto/zoo plankton?	spring summer?	BAY ICS OCS	P			
Juveniles	males - 4 years females - 5 years	euphausiids crustaceans amphipods pollock	all year	ICS OCS USP	D	GMS[1]		
Adults	males - 4+ years females- 5+ years	pollock misc. fish Gadidae sp. Euphausiids	spawning Nov-March non-spawning April-Oct.	ICS OCS USP BAY	D	GMS[1]	ice edge (EBS)	

[1]Pers. Comm., Dr. Robert McConnaughey

Habitat Description for Sablefish

(*Anoplopoma fimbria*)

Management Plan and Area GOA

Life History and General Distribution

Sablefish are distributed from Mexico through the GOA to the Aleutian Chain, BS, along the Asian coast from Sagami Bay, and along the Pacific sides of Honshu and Hokkaido Islands and the Kamchatkan Peninsula. Adult sablefish occur along the continental slope, shelf gullies, and in deep fjords such as Prince William Sound and southeast Alaska, at depths generally greater than 200 m. Adults are assumed to be demersal. Spawning or very ripe sablefish are observed in late winter or early spring along the continental slope. Eggs are apparently released near the bottom where they incubate. After hatching and yolk adsorption, the larvae rise to the surface, where they have been collected with neuston nets. Larvae are oceanic through the spring and by late summer, small pelagic juveniles (10 to 15 cm) have been observed along the outer coasts of Southeast Alaska, where they apparently move into shallow waters to spend their first winter. During most years, there are only a few places where juveniles have been found during their first winter and second summer. It is not clear if the juvenile distribution is highly specific or appears so because sampling is highly inefficient and sparse. During the occasional times of large year-classes, the juveniles are easily found in many inshore areas during their second summer. They are typically 30 to 40 cm long during their second summer, after which they apparently leave the nearshore bays. One or two years later, they begin appearing on the continental shelf and move to their adult distribution as they mature.

Pelagic ocean conditions appear to determine when strong young-of-the-year survival occurs. Water mass movements and temperature appear to be related to recruitment success (Sigler et al. 2001). Above-average young of the year survival was somewhat more likely with northerly winter currents and much less likely for years when the drift was southerly. Recruitment success also appeared related to water temperature. Recruitment was above average in 61 percent of the years when temperature was above average, but was above average in only 25 percent of the years when temperature was below average. Recruitment success did not appear to be directly related to the presence of El Ninos or eddies, but these phenomena could potentially influence recruitment indirectly in years following their occurrence (Sigler et al. 2001).

While pelagic oceanic conditions determine the egg, larval, and juvenile survival through their first summer, juvenile sablefish spend 3 to 4 years in demersal habitat along the shorelines and continental shelf before they recruit to their adult habitat, primarily along the upper continental slope, outer continental shelf, and deep gulleys. As juveniles in the inshore waters and on the continental shelf, they are subject to myriad factors that determine their ability to grow, compete for food, avoid predation, and otherwise survive to adults. Perhaps demersal conditions that may have been brought about by bottom trawling (habitat, bycatch, and increased competitors) have limited the ability of the large year classes that, though abundant at the young-of-the-year stage, survive to adults.

Fishery

The major fishery for sablefish in Alaska uses longlines; however sablefish are valuable in the trawl fishery as well. Sablefish enter the longline fishery at 4 to 5 years of age, perhaps slightly younger in the trawl fishery. The longline fishery takes place between March 1 and November 15. The take of the trawl share of sablefish occurs primarily in association with openings for other species, such as the July rockfish openings, where they are taken as allowed bycatch. Deeper dwelling rockfish, such as shortraker, rougheye, and thornyhead rockfish are the primary bycatch in the longline sablefish fishery. Halibut and rattails (*Albatrossia pectoralis and Corphaenoides acrolepis*) also are taken. By regulation, there is no directed trawl fishery for sablefish; however, directed fishing standards have allowed some trawl hauls to target sablefish, where the bycatch is similar to the longline fishery, in addition perhaps to some deep dwelling flatfish.

In addition to the fishery for sablefish, there are significant fisheries for other species that may have an effect on the habitat of sablefish, primarily juveniles. As indicated above, before moving to adult habitat on the slope and deep gulleys, sablefish 2 to 4 years of age reside on the continental shelf, where significant trawl fisheries have taken place. It is difficult to evaluate the potential effect such fisheries could have had on sablefish survival, as a clear picture of the distribution and intensity of the groundfish fishery prior to 1997 has not been available. It is worth noting however, that the most intensely trawled area from 1998 to 2002 which is just north of the Alaska Peninsula, was closed to trawling by Japan in 1959 and apparently was untrawled until it was opened to U.S. trawling in 1983 (Witherell 1997, Fredin 1987). Juvenile sablefish of the 1977 year class were observed in the western portion of this area by the AFSC trawl survey in 1978 to 1980 at levels of abundance that far exceed levels that have been seen since (Umeda et al 1983). Observations of 1-year-old and young-of-the-year sablefish in inshore waters from 1980 to 1990 indicate that above-average egg to larval survival has occurred for a number of year classes since.

Relevant Trophic Information

Larval sablefish feed on a variety of small zooplankton ranging from copepod naupli to small amphipods. The epipelagic juveniles feed primarily on macrozooplankton and micronekton (i.e., euphausiids).

In their demersal stage, juvenile sablefish less than 60 cm feed primarily on euphausiids, shrimp, and cephalopods (Yang and Nelson 2000) while sablefish greater than 60 cm feed more on fish. Both juvenile and adult sablefish are considered opportunistic feeders. Fish most important to the sablefish diet include pollock, eulachon, capelin, Pacific herring, Pacific cod, Pacific sand lance, and some flatfish, with pollock being the most predominant (10 to 26 percent of prey weight, depending on year). Squid, euphasiids, and jellyfish were also found, squid being the most important of the invertebrates (Yang and Nelson 2000). Feeding studies conducted in Oregon and California found that fish made up 76 percent of the diet (Laidig et al. 1997). Off the southwest coast of Vancouver Island, euphausiids dominated sablefish diet (Tanasichuk 1997). Among other goundfish in the GOA, the diet of sablefish overlaps mostly with that of large flatfish, arrowtooth flounder and Pacific halibut (Yang and Nelson 2000).

Nearshore residence during their second year provides sablefish with the opportunity to feed on salmon fry and smolts during the summer months, while young-of-the-year sablefish are commonly found in the stomachs of salmon taken in the Southeast Alaska troll fishery during the late summer.

Approximate Upper Size Limit of Juvenile Fish (in cm): Size at 50 percent maturity is as follows:

BS:	males 65 cm, females 67 cm
AI:	males 61 cm, females 65 cm
GOA:	males 57 cm, females 65 cm

At the end of the second summer (~1.5 years old), they are 35 to 40 cm long.

Stock Condition

The estimated productivity and sustainable yield of the combined GOA,BS, and AI sablefish stock have declined steadily since the late 1970s. This is demonstrated by a decreasing trend in recruitment and subsequent estimates of biomass reference points and the inability of the stock to rebuild to the target biomass levels despite the decreasing level of the targets and fishing rates below the target fishing rate. While years of strong young-of-the-year survival has occurred in the 1980s and the1990s, the failure of strong recruitment to the mature stage suggests a decreased survival of juveniles during their residence as 2 to 4 year olds on the continental shelf.

Habitat and Biological Associations

Egg/Spawning
Larvae
Juveniles
Adults - other than depth, none is noted

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SPECIES: GOA Sablefish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	14 to 20 days	NA	late winter-early spring: Dec-Apr	USP, LSP, BSN	P,200-3000 m	NA	U	
Larvae	up to 3 months	copepod nauplii, small copepodites, etc	spring-summer: Apr-July	MCS, OCS, USP, LSP, BSN	N, neustonic near surface	NA	U	
Early Juveniles	up to 3 years	small prey fish, sandlance, salmon, herring, etc		OCS, MCS, ICS, during first summer, then obs in BAY, IP, till end of 2nd summer; not obs'd till found on shelf	P when offshore during first summer, then D, SD/SP when inshore	NA when pelagic. The bays where observed were soft bottomed, but not enough obs. to assume typical.	U	
Late Juveniles	3 to 5 years	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	all year	continental slope, and deep shelf gullies and fjords.	presumably D	varies	U	
Adults	5 to 35+ years	opportunistic: other fish, shellfish, worms, jellyfish, fishery discards	apparently year around, spawning movements (if any) are undescribed	continental slope, and deep shelf gullies and fjords.	presumably D	varies	U	

Habitat Description for Pacific Ocean Perch

(*Sebastes alutus*)

Management Plan and Area GOA

Life History and General Distribution

Pacific ocean perch (*Sebastes alutus,* POP) has a wide distribution in the North Pacific from southern California around the Pacific rim to northern Honshu Island, Japan, including the BS. The species appears to be most abundant in northern British Columbia, the GOA, and the AI (Allen and Smith 1988). Adults are found primarily offshore on the outer continental shelf and the upper continental slope in depths from 150 to 420 m. Seasonal differences in depth distribution have been noted by many investigators. In the summer, adults inhabit shallower depths, especially those between 150 and 300 m. In the fall, the fish apparently migrate farther offshore to depths from approximately 300 to 420 m. They reside in these deeper depths until about May, when they return to their shallower summer distribution (Love et al. 2002). This seasonal pattern is probably related to summer feeding and winter spawning. Although small numbers of Pacific ocean perch are dispersed throughout their preferred depth range on the continental shelf and slope, most of the population occurs in patchy, localized aggregations (Hanselman et al. 2001). Pacific ocean perch are generally considered to be semi-demersal, but there can at times be a significant pelagic component to their distribution. Pacific ocean perch often move off-bottom at night to feed, apparently following diel euphausiid migrations. Commercial fishing data in the GOA since 1995 show that pelagic trawls fished off-bottom have accounted for as much as 20 percent of the annual harvest of this species.

There is much uncertainty about the life history of Pacific ocean perch, although generally more is known than for other rockfish species (Kendall and Lenarz 1986). The species appears to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Insemination occurs in the fall, and sperm are retained within the female until fertilization takes place approximately 2 months later. The eggs hatch internally, and parturition (release of larvae) occurs in April and May. Information on early life history is very sparse, especially for the first year of life. Pacific ocean perch larvae are thought to be pelagic and drift with the current. Oceanic conditions may sometimes cause advection to suboptimal areas (Ainley et al. 1993), resulting in high recruitment variability. However, larval studies of rockfish have been hindered by difficulties in species identification since many larval rockfish species share the same morphological characteristics (Kendall 2001). Genetic techniques using allozymes (Seeb and Kendall 1991) and mitochondrial DNA (Li 2004) are capable of identifying larvae and juveniles to species, but are expensive and time-consuming. Post-larval and early young-of-the-year Pacific ocean perch have been positively identified in offshore, surface waters of the GOA (Gharrett et al. 2002), which suggests this may be the preferred habitat of this life stage. Transformation to a demersal existence may take place within the first year (Carlson and Haight 1976). Small juveniles probably reside inshore in very rocky, high relief areas and begin to migrate to deeper offshore waters of the continental shelf by age 3 (Carlson and Straty 1981). As they grow, they continue to migrate deeper, eventually reaching the continental slope, where they attain adulthood.

Pacific ocean perch is a very slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (10.5 years for females in the GOA), and a very old maximum age of 98 years in Alaska (84 years maximum age in the GOA) (Hanselman et al. 2003). Age at 50 percent recruitment to the commercial fishery has been estimated to be between 7 and 8 years in the GOA.

Despite their viviparous nature, the fish is relatively fecund with number of eggs/female in Alaska ranging from 10,000 to 300,000, depending upon size of the fish (Leaman 1991).

Fishery

The Pacific ocean perch is the most abundant GOA rockfish and the most important commercially. The species was fished intensely in the 1960s by foreign factory trawlers (350,000 mt at its peak in 1965), and the population declined drastically due to this pressure. The domestic fishery began developing in 1985. Quotas climbed rapidly, and the species was declared overfished in 1989. A rebuilding plan was put into place, and quotas were small in the early 1990s. After some good recruitments and high survey biomass estimates, the stock was declared to be recovered in 1995. Pacific ocean perch are caught almost exclusively with trawls. Before 1996, nearly all the catch was taken by factory trawlers using bottom trawls, but a sizeable portion (up to 20 percent some years) has also been taken by pelagic trawls since then. Also in 1996, a shore-based fishery developed that consisted of smaller vessels operating out of the port of Kodiak. These shore-based trawlers now take about 50 percent of the catch in the central GOA. The fishery in the Gulf in recent years has occurred in the summer months, especially July, due to management regulations. Reflecting the summer distribution of this species, the fishery is concentrated in a relatively narrow depth band at approximately180 to 250 m along the outer continental shelf and shelf break, inside major gullies and trenches running perpendicular to the shelf break, and along the upper continental slope. Major fishing grounds include Ommaney Trough (which is no longer fished because of an Council amendment that prohibits trawling in the eastern GOA), Yakutat Canyon, Amatuli Trough, off Portlock and Albatross Banks, Shelikof Trough, off Shumagin Bank, and south of Unimak and Unalaska Islands.

Major bycatch species in the GOA Pacific ocean perch trawl fishery from 1994 to 1996 (the most recent years for which an analysis was done) included (in descending order by percent bycatch rate) other species of rockfish, arrowtooth flounder, and sablefish. Among the other species of rockfish, northern rockfish and shortraker/rougheye were most common, followed by pelagic shelf rockfish (Ackley and Heifetz 2001).

Because collection of small juvenile Pacific ocean perch is virtually unknown in any existing type of commercial fishing gear, it is assumed that fishing does not occur in their habitat. Trawling on the offshore fishing grounds of adults may affect the composition of benthic organisms, but the impact of this on Pacific ocean perch or other fish is unknown.

Relevant Trophic Information

Pacific ocean perch are mostly planktivorous (Carlson and Haight 1976, Yang 1993, 1996, Yang and Nelson 2000, Yang 2003). In a sample of 600 juvenile perch stomachs, Carlson and Haight (1976) found that juveniles fed on an equal mix of calanoid copepods and euphausiids. Larger juveniles and adults fed primarily on euphausiids and, to a lesser degree, on copepods, amphipods, and mysids (Yang and Nelson 2000). In the AI, myctophids have increasingly comprised a substantial portion of the Pacific ocean perch diet, which also compete for euphausiid prey (Yang 2003). It has been suggested that Pacific ocean perch and walleye pollock compete for the same euphausiid prey. Consequently, the large removals of Pacific ocean perch by foreign fishermen in the GOA in the 1960s may have allowed walleye pollock stocks to greatly expand in abundance.

Pacific ocean perch predators are likely sablefish, Pacific halibut, and sperm whales (Major and Shippen 1970). Juveniles are consumed by seabirds (Ainley et al. 1993), other rockfish (Hobson et al. 2001), salmon, lingcod, and other large demersal fish.

Approximate Upper Size Limit of Juvenile Fish (in cm): For GOA, the upper size limit of juvenile fish is 38 cm for females; it is unknown for males, but is presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Habitat and Biological Associations Narrative

Egg/Spawning: Little information is known. Insemination is thought to occur after adults move to deeper offshore waters in the fall. Parturition is reported to occur from 20 to 30 off-bottom at depths from 360 to 400 m.

Larvae: Little information is known. Earlier information suggested that after parturition, larvae rise quickly to near surface, where they become part of the plankton. More recent data from British Columbia indicates that larvae may remain at depths 175 m for some period of time (perhaps 2 months), after which they slowly migrate upward in the water column.

Post-larvae and early young-of-the year: A recent, preliminary study has identified Pacific ocean perch in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). Some of the samples were as much as 100 nm from land, beyond the continental slope and over very deep water.

Juveniles: Again, information is very sparse, especially for younger juveniles. It is unknown how long young-of-the-year remain in a pelagic stage before eventually becoming demersal. At ages 1 to 3, the fish probably live in very rocky inshore areas. Afterward, they move to progressively deeper waters of the continental shelf. Older juveniles are often found together with adults at shallower locations of the continental slope in the summer months.

Adults: Commercial fishery and research data have consistently indicated that adult Pacific ocean perch are found in aggregations over reasonably smooth, trawlable bottom of the outer continental shelf and upper continental slope (Westrheim 1970; Matthews et al. 1989; Krieger 1993). Generally, they are found in shallower depths (150 to 300 m) in the summer, and deeper (300 to 420 m) in the fall, winter, and early spring. Observations from a manned submersible in Southeast Alaska found adult Pacific ocean perch associated with pebble substrate on flat or low-relief bottom (Krieger 1993). Pacific ocean perch have been observed in association with sea whips in both the GOA (Krieger 1993) and the BS (Brodeur 2001). The fish can at times also be found off-bottom in the pelagic environment, especially at night when they may move up in the water column to feed. There presently is no evidence to support previous conjectures that adult Pacific ocean perch might sometimes inhabit rough, untrawlable bottom.

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SPECIES: GOA Pacific Ocean Perch

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	Internal incub-tion; ~90 d	NA	Winter-spring	NA	NA	NA	NA	NA
Larvae	U;2 months (?)	U; assumed to be micro-zooplankton	Spring-summer	ICS, MCS, OCS, USP, LSP, BSN	P	NA	U	U
Post-larvae/ early juvenile	U; 2 months to ?	U	Summer to ?	LSP, BSN	Epipelagic	NA	U	U
Juveniles	<1 year (?) to 10 years	Calanoid copepods (young juv.); Euphausiids (older juv.)	All year	ICS, MCS, OCS, USP	D	R (<age 3); CB,G,?M, ?SM,?MS (>age 3)	U	U
Adults	10 to 84 years of age (98 years in AI)	Euphausiids	Insemination (fall); Fertilization, incubation (winter); Larval release (spring); Feeding in shallower depths (summer)	OCS, USP	D, SD, P	CB, G,?M, ?SM,?MS	U	Eggs

Habitat Description for Shortraker Rockfish (*Sebastes borealis*) and Rougheye Rockfish (*Sebastes aleutianus*)

Management Plan and Area GOA

Life History and General Distribution

Shortraker and rougheye rockfish are found around the arc of the north Pacific from southern California to northern Japan, including the BS (Mecklenburg et al. 2002). Both species are demersal. Rougheye rockfish inhabit depths ranging from 82 to 2,953 feet (25 to 900 m), and shortraker rockfish range from 328 to 3,937 feet (100 to 1,200 m) (Mecklenburg et al. 2002). However, survey and commercial fishery data indicate that the fish are most abundant along a narrow band of the continental slope at depths of 984 to 1,640 feet (300 to 500 m) (Ito 1999), where both shortraker and rougheye rockfish often co-occur in the same haul. Within this habitat, shortraker and rougheye rockfish tend to have a relatively even distribution when compared with the highly aggregated and patchy distribution of many other rockfish such as Pacific ocean perch[1]. Similar to other *Sebastes*, the fish appear to be viviparous (the eggs develop internally and receive at least some nourishment from the mother), with internal fertilization and the release of live young. Though relatively little is known about their biology and life history, both species appear to be K-selected with late maturation, slow growth, extreme longevity, and low natural mortality. Rougheye rockfish attain maturity relatively late in life, at about 20 years of age (McDermott 1994). Age of maturity for shortraker rockfish is unknown, but is presumably similar to that of rougheye rockfish. Both species are among the largest *Sebastes* species in the north Pacific, attaining sizes of up to 47 inches (120 cm) for shortraker and 38 inches (97 cm) for rougheye rockfish (Mecklenburg et al. 2002). Shortraker and rougheye rockfish are estimated to attain ages in excess of 100 years, and one ageing laboratory has reported ages up to 157 years for shortraker and 205 years for rougheye (Chilton and Beamish 1982, Munk 2001). Natural mortality for both species is low, estimated to be on the order of 0.01 to 0.04 (Archibald et al. 1981, McDermott 1994, Nelson and Quinn 1987, Clausen et al. 2003).

Fishery

Although shortraker and rougheye rockfish are found as far south as southern California, commercial quantities are primarily harvested from Washington north to Alaska waters. Shortraker and rougheye rockfish are presently managed as bycatch-only species in Alaska and are taken by both trawl and longline gear. In recent years, trawling has accounted for about 60 percent of the catch and longlining about 40 percent (Clausen et al. 2003). Commercial harvests usually occur on the slope from 984 to 1,640 feet (300 to 500 m) deep. Both species are associated with soft to rocky habitats along the continental slope, although boulders and steeply sloping terrain appear to be a desirable habitat feature for both species (Krieger 1992, Krieger and Ito 1999). Trawling in such habitats often requires specialized fishing skills to avoid gear damage and to keep the trawl in the proper fishing configuration. One study estimated age at recruitment for rougheye rockfish to be 30 years (Nelson and Quinn 1987), and it is probably on the order of 20+ years for shortraker rockfish. Shortraker and rougheye rockfish are often caught as bycatch in trawl fisheries for Pacific ocean perch and in longline fisheries for sablefish and halibut.

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[1]Clausen, D. M., and J. T. Fujioka. Variability in trawl survey catches of shortraker rockfish, rougheye rockfish, and Pacific ocean perch, and possible implications for survey design. Presentation at 2002 Western Groundfish Conference, Ocean Shores, WA, February 12-14, 2002.

Relevant Trophic Information

Rougheye rockfish in Alaska feed primarily on shrimps (especially pandalids), and various fish species such as myctophids are also consumed (Yang and Nelson 2000; Yang 2003). However, smaller juvenile rougheye rockfish (less than 12 inches [30 cm] fork length) in the GOA also consume a substantial amount of smaller invertebrates such as amphipods, mysids, and isopods (Yang and Nelson 2000). The diet of shortraker rockfish in the GOA is not well known; however, based on a very small sample size in the Yang and Nelson (2000) study, the diet appears to be mostly squid, shrimp, and deepwater fish such as myctophids. A food study in the AI with a larger sample size of shortraker rockfish also found myctophids, squid, and shrimp to be major prey items (Yang 2003). In addition, gammarid amphipods, mysids, and miscellaneous fish were important food items in some years. It is uncertain what constitute the main predators on both species.

Approximate Upper Size Limit of Juvenile Fish (in cm): Length at 50 percent sexual maturity has been estimated to be about 45 cm fork length for female shortraker rockfish and about 44 cm fork length for female rougheye rockfish (McDermott 1994). For both species, the largest immature females were about 50 to 55 cm. For either species, there is no information on male size at maturity or on maximum size of juvenile males.

Habitat and Biological Associations

Egg/Spawning: The timing of reproductive events is apparently protracted. One study indicated that vitellogenesis was present for 4 to 5 months and lasted from about July until late October and November (McDermott 1994). This study also reported that parturition (i.e., larval release) occurred mainly in February through August for shortraker rockfish and December through April for rougheye rockfish. There is no information as to when males inseminate females or if migrations for spawning/breeding occur.

Larvae: Information on larval shortraker and rougheye rockfish is very limited. Larval shortraker rockfish have been identified in pelagic plankton tows in coastal Southeast Alaska (Gray et al. 2004), and it is likely that larval rougheye rockfish are also pelagic. Larval studies are hindered because the larvae at present can be positively identified only by genetic analysis, which is both expensive and labor-intensive.

Post-larvae and early young-of-the year: One study used genetics to identify two specimens of shortraker rockfish and one of rougheye rockfish in these life stages from samples collected in epipelagic waters far offshore in the GOA (Gharrett et al. 2002). This limited information is the only documentation of habitat preferences for these life stages.

Juveniles: Little information is available regarding the habitats and biological associations of juvenile shortraker and rougheye rockfish. This is especially true for small juvenile shortraker rockfish, as only a few specimens less than 14 inches (35 cm) fork length have been caught in the GOA. Juvenile shortraker rockfish are presumably demersal, as there have been no known catches in pelagic trawls or in off-bottom sampling gear. In contrast, juvenile rougheye rockfish 6 to 16 inches (15 to 40 cm) fork length are frequently caught in GOA bottom trawl surveys (Clausen et al. 2003). They are generally found at shallower, more inshore areas than adults. These areas range from inshore fiords to offshore waters of the continental shelf. Other than the fact that they have been taken on trawlable bottom, however, habitat preferences for juvenile rougheye rockfish are unknown.

Adults: Adult shortraker and rougheye rockfish are demersal and are concentrated at depths of 984 to 1,640 feet (300 to 500 m) along the continental slope. Observations from a manned submersible indicate that these fish occur over a wide range of habitats (Krieger 1992, Krieger and Ito 1999, Krieger and Wing

2002). Soft substrates of sand or mud usually had the highest densities, whereas hard substrates of bedrock, cobble, or pebble usually had the lowest adult densities (Krieger and Ito 1999). Habitats with steep slopes and frequent boulders were used at a higher rate than habitats with gradual slopes and few boulders (Krieger 1992, Krieger and Ito 1999). One of the submersible studies found shortraker and rougheye rockfish had a strong association with *Primnoa* spp. coral growing on boulders: less than 1 percent of the observed boulders had coral, but 85 percent of the "large" rockfish (which included redbanded rockfish along with shortraker and rougheye) were next to boulders with coral (Krieger and Wing 2002).

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SPECIES: Shortraker (SR) and Rougheye (RE) Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	N/A	N/A	N/A	N/A	N/A	N/A	
Larvae	U	U	Parturition: SR: Feb-Aug RE: Dec-Apr	U	Pelagic	N/A	U	
Post-larvae/ early juvenile	< 6 months	U	Summer	LSP, BSN	Epipelagic	N/A	U	
Juveniles	Up to 20 years of age	Shrimp Mysids Amphipods Isopods	U	SR: U RE: ICS, MCS, OCS	SR: U, probably D RE: D	SR: U RE: U, but trawlable	U	
Adults	20 to >100 years of age	Shrimp Squid Myctophids	Year-round?	USP	D	M, S, R, SM, CB, MS, G, C steep slopes and boulders	U	Observed associated with *Primnoa* coral

Habitat Description for Northern Rockfish

(*Sebastes polyspinis*)

Management Plan and Area GOA

Life History and General Distribution

Northern rockfish range from northern British Columbia through the GOA and AI to eastern Kamchatka, including the BS. The species is most abundant from about Portlock Bank in the central GOA to the western end of the AI. Within this range, adult fish appear to be concentrated at discrete, relatively shallow offshore banks of the outer continental shelf. Typically, these banks are separated from land by an intervening stretch of deeper water. The preferred depth range is ~75 to 150 m in the GOA. Information available at present suggests the fish are mostly demersal, as very few have been caught in pelagic trawls. In common with many other rockfish species, northern rockfish tend to have a localized, patchy distribution, even within their preferred habitat, and most of the population occurs in aggregations. Most of what is known about northern rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on northern rockfish is extremely sparse. The fish are assumed to be viviparous, as other *Sebastes* appear to be, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is mostly completed by summer. Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage is unknown, but the fish apparently metamorphose to a pelagic juvenile stage, which also has been described. There is no information on when the juveniles become benthic or what habitat they occupy. Older juveniles are found on the continental shelf, generally at locations inshore of the adult habitat.

Northern rockfish is a slow growing species, with a low rate of natural mortality (estimated at 0.06), a relatively old age at 50 percent maturity (12.8 years for females in the GOA), and an old maximum age of 72 years in Alaska (maximum reported age in the GOA is 44 years). No information on fecundity is available.

Fishery

Northern rockfish are caught almost exclusively with bottom trawls. Age at 50 percent recruitment is unknown. The fishery in the GOA in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated of live relatively shallow, offshore banks of the outer continental shelf: which include Portlock Bank, Albatross Bank, the "Snakehead" south of Kodiak Island, Shumagin Bank, and Davidson Bank. Of these, the Snakehead has been the most productive. Outside of these banks, catches are generally sparse. The majority of the catch in the GOA comes from depths of 75 to 125 m.

The major bycatch species in the GOA northern rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate): light dusky rockfish, "other slope rockfish", and Pacific ocean perch. Of these, light dusky rockfish was by far the most common bycatch, having a bycatch rate as high as 34 percent, depending on the year.

Relevant Trophic Information

Although no comprehensive food study of northern rockfish has been done, smaller studies have ~~all~~ shown euphausiids to be the predominant food item of adults in both the GOA and AI. Copepods, hermit crabs, and shrimp have also been noted as prey items in much smaller quantities.

Predators of northern rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Approximate Upper Size Limit of Juvenile Fish (in cm): For GOA: 38 cm for females; unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring.

Larvae: No information known.

Juveniles: No information known for small juveniles (<20 cm), except that juveniles apparently undergo a pelagic phase immediately after metamorphosis from the larval stage. Larger juveniles have been taken in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. Substrate preference of these larger juveniles is unknown.

Adults: Commercial fishery and research survey data have consistently indicated that adult northern rockfish in the GOA are primarily found on offshore banks of the outer continental shelf at depths of 75 to 150 m. Preferred substrate in this habitat has not been documented, but observations from trawl surveys suggest that large catches of northern rockfish are often associated with hard or rough bottoms. For example, some of the largest catches in the trawl surveys have occurred in hauls in which the net hung-up on the bottom or was torn by a rough substrate. Generally, the fish appear to be demersal, and most of the population occurs in large aggregations. There is no information on seasonal migrations. Northern rockfish often co-occur with light dusky rockfish.

Additional Information Sources

Eggs and Larvae: None at present.

Older juveniles and adults: NMFS, Alaska Fisheries Science Center, Auke Bay Laboratory, David Clausen.

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SPECIES: Northern Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	From end of larval stage to ?	U	All year	U	?P	U	U	U
Late Juveniles	to 13 years	U	All year	MCS, OCS	D	U	U	U
Adults	13 to 44 years of age (maximum of 72 years in AI)	Euphausiids	U, except that larval release is probably in the spring in the GOA	OCS,	D	CB, R	U	Often co-occur with light dusky rockfish

Habitat Description for Light Dusky Rockfish

(*Sebastes ciliatus*)

Previously, the taxonomy of dusky rockfish was unclear. Two varieties occur which are now believed to be distinct species: an inshore, shallow water, dark-colored variety; and a lighter-colored variety found in deeper water offshore. A taxonomic study is soon to be completed that will describe the light variety as a new species. To avoid confusion, and because the light variety appears to be more abundant and is the object of a directed trawl fishery, this discussion of essential habitat will deal only with “light” dusky rockfish.

Management Plan and Area GOA

Life History and General Distribution

Light dusky rockfish range from Dixon Entrance at the US/Canada boundary, around the arc of the GOA, and westward throughout the AI. They are also found in the EBS north to about Zhemchug Canyon west of the Pribilof Islands. In the northwest Pacific, dusky rockfish are reported to range southwestward to Japan, but it is unknown which variety this refers to. Their distribution south of Dixon Entrance in Canadian waters is likewise uncertain; dusky rockfish have been reported as far south as Johnstone Strait, Vancouver Island, but it is likely these were of the dark variety. The center of abundance for light dusky rockfish appears to be the GOA. Adult light dusky rockfish have a very patchy distribution, and are usually found in large aggregations at specific localities of the outer continental shelf. These localities are often relatively shallow offshore banks. Because the fish are taken with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no particular evidence of a pelagic tendency based on the information available at present. Most of what is known about light dusky rockfish is based on data collected during the summer months from the commercial fishery or in research surveys. Consequently, there is little information on seasonal movements or changes in distribution for this species.

Life history information on light dusky rockfish is extremely sparse. The fish are assumed to be viviparous, as are other *Sebastes*, with internal fertilization and incubation of eggs. Observations during research surveys in the GOA suggest that parturition (larval release) occurs in the spring, and is probably completed by summer. Another, older source, however, lists parturition as occurring “after May.” Pre-extrusion larvae have been described, but field-collected larvae cannot be identified to species at present. Length of the larval stage, and whether a pelagic juvenile stage occurs, are unknown. There is no information on habitat and abundance of young juveniles (<25 cm fork length), as catches of these have been virtually nil in research surveys. Even the occurrence of older juveniles has been very uncommon in surveys, except for one year. In this latter instance, older juveniles were found on the continental shelf, generally at locations inshore of the adult habitat.

Light dusky rockfish is a slow growing species, with a low rate of natural mortality estimated at 0.09. However, it appears to be faster growing than many other rockfish species. Maximum age is 51 to 59 years. Estimated age at 50 percent maturity for females is 11.3 years. No information on fecundity is available.

Fishery

Light dusky rockfish are caught almost exclusively with bottom trawls. A precise estimate of age at 50 percent recruitment is not available, but has been roughly estimated to be about 10 years based on length frequency information from the fishery. The fishery in the GOA in recent years has mostly occurred in the summer months, especially July, due to management regulations. Catches are concentrated at a number of relatively shallow, offshore banks of the outer continental shelf, especially the "W" grounds west of Yakutat, and Portlock Bank. Other fishing grounds include Albatross Bank, the "Snakehead" south of Kodiak Island, and Shumagin Bank. Outside of these banks, catches are generally sparse. Most of the catch appears to be taken at depths of 100 to 200 m.

The major bycatch species in the GOA light dusky rockfish trawl fishery in 1994-96 included (in descending order by percent bycatch rate) northern rockfish and Pacific ocean perch.

Relevant Trophic Information

Although no comprehensive food study of light dusky rockfish has been done, one smaller study in the GOA showed euphausiids to be the predominate food item of adults. Larvaceans, cephalopods, pandalid shrimp, and hermit crabs were also consumed.

Predators of light dusky rockfish have not been documented, but likely include species that are known to consume rockfish in Alaska, such as Pacific halibut, sablefish, Pacific cod, and arrowtooth founder.

Approximate Upper Size Limit of Juvenile Fish (in cm): For GOA: 47 cm for females (size at 50 percent maturity is 43 cm); unknown for males, but presumed to be slightly smaller than for females based on what is commonly the case in other species of *Sebastes*.

Habitat and Biological Associations

Egg/Spawning: No information known, except that parturition probably occurs in the spring, and may extend into summer.

Larvae: No information known.

Juveniles: No information known for small juveniles <25 cm fork length. Larger juveniles have been taken infrequently in bottom trawls at various localities of the continental shelf, usually inshore of the adult fishing grounds. A manned submersible study in the eastern Gulf observed juvenile (<40 cm) light dusky rockfish associated with *Primnoa* spp. coral.

Adults: Commercial fishery and research survey data indicate that adult light dusky rockfish are primarily found on offshore banks of the outer continental shelf at depths of 100 to 200 m. Type of substrate in this habitat has not been documented, but it may be rocky. During submersible dives on the outer shelf (40 to 50 m) in the eastern Gulf, adult light dusky rockfish were observed in association with rocky habitats and in areas with extensive sponge beds where the fish were observed resting in large vase sponges (pers. Comm. V. O'Connell). Light dusky rockfish are the most highly aggregated of the rockfish species caught in GOA trawl surveys. Outside of these aggregations, the fish are sparsely distributed. Because the fish are generally taken only with bottom trawls, they are presumed to be mostly demersal. Whether they also have a pelagic distribution is unknown, but there is no evidence of a pelagic tendency based on the information available at present. There is no information on seasonal migrations. Light dusky rockfish often co-occur with northern rockfish.

Additional Information Sources

<u>Eggs, Larvae, and Juveniles</u>: None at present.

<u>Adults:</u> Rebecca Reuter, c/o NMFS, Alaska Fisheries Science Center, REFM Division.

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SPECIES: Light Dusky Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	NA	U	NA	NA	NA	NA	NA
Larvae	U	U	Spring-summer	U	P (assumed)	NA	U	U
Early Juveniles	U	U	All year	U	U	U	U	U
Late Juveniles	Up to 11 years	U	U	ICS, MCS, OCS	D	CB, R, G	U	Observed associated with *Primnoa* coral
Adults	11 up to 51-59 years.	Euphausiids	U, except that larval release may be in the spring in the GOA	OCS, USP	D,	CB, R, G	U	Observed associated with large vase-type sponges

Habitat Description for Yelloweye Rockfish (*Sebastes ruberrimus*) and Other Demersal Rockfishes

Management Plan and Area GOA

Yelloweye rockfish *Sebastes ruberrimus* (primary species, described below)
Quillback rockfish, *Sebastes maliger*
Rosethorn rockfish, *Sebastes helvomaculatus*
Tiger rockfish, *Sebastes nigrocinctus*
Canary rockfish, *Sebastes pinniger*
China rockfish, *Sebastes nebulosus*
Copper rockfish, *Sebastes caurinus*

Life History and General Distribution

These species are distributed from Ensendada, northern Baja California to Umnak Island and Unalaska Island, Aleutians in depths from 60 to 1,800 feet but commonly in 300 to 600 feet in rocky, rugged habitat (Allen and Smith 1988, Eschmeyer et al. 1983). Little is known about the young of the year and settlement. Young juveniles between 2.5 and 10 cm have been observed in areas of high and steep relief, in depths deeper than 15 m. Subadult and adult fish are generally solitary, occurring in rocky areas and high relief with refuge space, particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Yelloweye are ovoviviparous. Parturition occurs in southeast Alaska between April and July with a peak in May (O'Connell 1987). Fecundity ranges from 1,200,000 to 2,700,000 eggs per season (Hart 1942, O'Connell unpublished data). Yelloweye feed on a variety of prey, primarily fishes (including other rockfishes, herring, and sandlance) as well as caridean shrimp and small crabs. Yelloweye are a K-selected species with late maturation, slow growth, extreme longevity, and low natural mortality. They reach a maximum length of about 91 cm and growth slows considerably after age 30. Approximately 50 percent are mature at 45 cm and 22 years, natural mortality (M) is estimated to be 0.02, and maximum age reported is 118 years (O'Connell and Fujioka 1991, O'Connell and Funk 1987).

Fishery

Demersal shelf rockfish are the target of a directed longline fishery and are the primary bycatch species in the longline fishery for Pacific halibut. They recruit into the fishery at about age 18 to 20 at a length between 45 and 50 cm. The commercial fishery grounds are usually areas of rocky bottom between 20 and 100 fm. The directed fishery now occurs between November and March both because of higher winter prices and limitations imposed due to the halibut IFQ regulations.

Relevant Trophic Information:

Yelloweye rockfish eat a large variety of organisms, primarily fishes included small rockfishes, herring and sandlance as well as caridean shrimp and small crabs (Rosenthal et al 1988). They also opportunistically consume lingcod eggs. Young rockfishes are in turn eaten by a variety of predators including lingcod, large rockfish, salmon, and halibut.

Approximate Upper Size Limit of Juvenile Fish (in cm): Length at 50 percent sexual maturity is 45 cm for females and 50 cm for males.

Habitat and Biological Associations

Young juveniles between 2.5 (1 inch) and 10 cm (4 inches) have been observed in areas of high relief (vertical walls, cloud sponges, fjord-like areas) in depths deeper than 15 m (Christiansen, Jeff, The Seattle Aquarium, personal communication). Subadult (late juveniles) and adult fish are generally solitary, occurring in rocky areas and high relief with refuge spaces particularly overhangs, caves and crevices (O'Connell and Carlile 1993). Not infrequently an adult yelloweye rockfish will cohabitate a cave or refuge space with a tiger rockfish. Habitat specific density data shows an increasing density with increasing habitat complexity: deep water boulder fields consisting of very large boulders have significantly higher densities than other rock habitats (O'Connell and Carlile 1993). Although yelloweye do occur over cobble and sand bottoms, generally this is when foraging and often these areas directly interface with a rock wall or outcrop.

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SPECIES: Yelloweye Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	na							
Larvae	<6 mo	Copepod	Spring/ Summer	U	N?	U	U	
Early Juveniles	to 10 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Late Juveniles	10 to 18 years	U		ICS, MCS, OCS, BAY, IP	D	R, C	U	
Adults	At least 118 years	Fish, shrimp, crab	Parturition: Apr-Jul	ICS, MCS, OCS, USP, BAY, IP	D	R, C, CB	U	

Other Rockfishes:

Species	Range/Depth	Maximum Age	Trophic	Parturition	Known Habitat
Quillback	Kodiak Island to San Miguel Island, CA To 274 m (commonly 12-76 m)	At least 32 50 percent SM=30 cm	Main prey = crustaceans, herring, Sandlance	Spring (Mar-Jun)	Juveniles have been observed at the margins of kelp beds, adults occur over rock bottom, or over cobble/sand next to reefs
Copper	Shelikof St to central Baja, CA Shallow to 183 m (commonly to 122 m)	At least 31 years 50 percent SM=5 yr	Crustaceans Octopi Small fishes	Mar-Jul	Juveniles have been observed near eelgrass beds and in kelp, in areas of mixed sand and rock. Adults are in rocky bays and shallow coastal areas, generally less exposed than the other DSR
Tiger	Kodiak Is and Prince William Sound to Tanner-Cortes Banks, CA From 33 to 183 m	To 116 years	Invertebrates, primarily crustaceans	Early spring	Juveniles and adults in rocky areas: most frequently observed in boulder areas, generally under overhangs.
China	Kachemak Bay to San Miguel Island, CA To 128 m	To 72 years	Invertebrates, Brittle stars are significant component of diet	Apr-Jun	Juveniles have been observed in shallow kelp beds, adults in rocky reefs and boulder fields. Some indications that adults have a homesite.
Rosethorn	Kodiak Is to Guadalupe Is, Baja, CA To 25 m to 549 m	To 87 years Mature 7-10 years		Feb-Sept (May)	Observed over rocky habitats and in rock pavement areas with large sponge cover
Canary	Shelikof St to Cape Colnett, Baja, CA To 424 m (commonly to 137 m)	To 75 years 50 percent sm = 9	Macroplankton and small fishes		Occur over rocky and sand/cobble bottoms, often hovering in loose schools over soft bottom near rock outcrops. Schools often associate with schools of yellowtail and silvergrey.

Habitat Description for Thornyhead Rockfish

(*Sebastolobus spp.*)

Management Plan and Area GOA

Life History and General Distribution

Thornyheads of the northeastern Pacific Ocean comprise two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is not common in the GOA. The shortspine thornyhead is a demersal species which inhabits deep waters from 93 to 1,460 m from the BS to Baja California. This species is common throughout the GOA, EBS and AI. The population structure of shortspine thornyheads, however, is not well defined. Thornyheads are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 75 cm and 2 kg. Thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface. Juvenile shortspine thornyheads have a pelagic period of about 14 to 15 months and settle out at about 22 to 27 mm. Fifty percent of female shortspine thornyheads are sexually mature at about 21 cm and 12 to 13 years of age.

Fishery

Trawl and longline gear are the primary methods of harvest. The bulk of the fishery occurs in late winter or early spring through the summer. In the past, this species was seldom the target of a directed fishery. Today thornyheads are one of the most valuable of the rockfish species, with most of the domestic harvest exported to Japan. Thornyheads are taken with some frequency in the longline fishery for sablefish and cod and is often part of the bycatch of trawlers concentrating on pollock and Pacific ocean perch.

Relevant Trophic Information

Shortspine thornyheads prey mainly on epibenthic shrimp and fish. Yang (1993, 1996) showed that shrimp were the top prey item for shortspine thornyheads in the GOA; whereas, cottids were the most important prey item in the AI region. Differences in abundance of the main prey between the two areas might be the main reason for the observed diet differences. Predator size might by another reason for the difference since the average shortspine thornyhead in the AI area was larger than that in the GOA (33.4 cm vs 29.7 cm).

Approximate Upper Size Limit of Juvenile Fish (in cm): Female shortspine thornyheads appear to be mature at about 21 to 22 cm.

Habitat and Biological Associations

Egg/Spawning: Eggs float in masses of various sizes and shapes. Frequently the masses are bilobed with the lobes 15 cm to 61 cm in length, consisting of hollow conical sheaths containing a single layer of eggs in a gelatinous matrix. The masses are transparent and not readily observed in the daylight. Eggs are 1.2 to 1.4 mm in diameter with a 0.2 mm oil globule. They move freely in the matrix. Complete hatching time is unknown but is probably more than 10 days.

Larvae: Three day-old larvae are about 3 mm long and apparently float to the surface. It is believed that the larvae remain in the water column for about 14 to 15 months before settling to the bottom.

<u>Juveniles</u>: Very little information is available regarding the habitats and biological associations of juvenile shortspine thornyheads

<u>Adults</u>: Adults are demersal and can be found at depths ranging from about 90 to 1,500 m. Groundfish species commonly associated with thornyheads include: arrowtooth flounder (*Atheresthes stomias*), Pacific ocean perch (*Sebastes alutus*), sablefish *(Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), Dover sole (*Microstomus pacificus*), shortraker rockfish (*Sebastes borealis*), rougheye rockfish (*Sebastes aleutianus*), and grenadiers (family Macrouridae). Two congeneric thornyhead species, the longspine thornyhead (*Sebastolobus altivelis*) and a species common off of Japan, *S. Macrochir*, are infrequently encountered in the GOA.

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SPECIES: Thornyhead Rockfish

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	U	Spawning: Late winter and early spring	U	P	U	U	
Larvae	<15 Months	U	Early spring through summer	U	P	U	U	
Juveniles	> 15 months when settling to bottom occurs (?)	U Shrimp, Amphipods, Mysids, Euphausiids?	U	MCS, OCS, USP	D	M, S, R, SM, CB, MS, G	U	
Adults	U	Shrimp Fish (cottids), Small crabs	Year-round?	MCS, OCS, USP, LSP	D	M, S, R, SM, CB, MS, G	U	

Habitat Description for Atka Mackerel

(Pleurogrammus monopterygius)

Management Plan and Area GOA

Life History and General Distribution

Atka mackerel are distributed from the GOA to the Kamchatka Peninsula, and they are most abundant along the Aleutians. Adult Atka mackerel occur in large localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for AI Atka mackerel. Adults are semi-demersal, displaying strong diel behavior with vertical movements away from the bottom occurring almost exclusively during the daylight hours, presumably for feeding, and little to no movement at night. Spawning is demersal in moderately shallow waters and peaks in June through September, but may occur intermittently throughout the year. Female Atka mackerel deposit eggs in nests built and guarded by males on rocky substrates or on kelp in shallow water. Eggs develop and hatch at depth in 40 to 45 days, releasing planktonic larvae that have been found up to 800 km from shore. Little is known of the distribution of young Atka mackerel before their appearance in trawl surveys and the fishery at about age 2 to 3 years. R-traits are as follows: young age at maturity (approximately 50 percent are mature at age 3), fast growth rates, high natural mortality (M=0.3), and young average and maximum ages (about 5 and 14 years, respectively). K-selected traits indicate low fecundity (only about 30,000 eggs/female/year, large egg diameters (1 to 2 mm) and male nest-guarding behavior).

Fishery

The fishery consists of bottom trawls, which recruit at about age 3, and it is conducted in the AI and western GOA at depths between from 70 to 225 m, in trawlable areas on rocky, uneven bottom, along edges, and in the lee of submerged hills during periods of high current. Currently, the fishery occurs on reefs west of Kiska Island, south and west of Amchitka Island, in Tanaga Pass and near the Delarof Islands, and south of Seguam and Umnak Islands. Historically the fishery occurred east into the GOA as far as Kodiak Island (through the mid-1980s), but is no longer conducted there.

Relevant Trophic Information

Atka mackerel are important food for Steller sea lions in the AI, particularly during summer, and for other marine mammals (minke whales, Dall's porpoise, and northern fur seals). Juveniles are eaten by thick billed murres, tufted puffins, and short-tailed shearwaters. The main groundfish predators are Pacific halibut, arrowtooth flounder, and Pacific cod.

Approximate Upper Size Limit of Juvenile Fish (in cm): The estimated size is 35 cm.

Habitat and Biological Associations

Egg/Spawning: Adhesive eggs are deposited in nests built and guarded by males on rocky substrates or on kelp in moderately shallow water.

<u>Larvae/Juveniles</u>: Planktonic larvae have been found up to 800 km from shore, usually in the upper water column (neuston), but little is known of the distribution of Atka mackerel until they are about 2 years old and start to appear in the fishery and surveys.

<u>Adults</u>: Adults occur in localized aggregations usually at depths less than 200 m and generally over rough, rocky, and uneven bottom near areas where tidal currents are swift. Associations with corals and sponges have been observed for AI Atka mackerel. Adults are semi-demersal/pelagic during much of the year, but they migrate annually to moderately shallow waters where the males become demersal during spawning; females move between nesting and offshore feeding areas.

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SPECIES: Atka Mackerel

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	40 to 45 days	NA	summer	IP,ICS	D	GR,R,K	U	develop 3-20˚C optimum 9-13˚C
Larvae	up to 6 mos	U copepods?	fall-winter	U	U N?	U	U	2-12˚C optimum 5-7˚C
Juveniles	½ to 2 years of age	U copepods & euphausiids?	all year	U	U	U	U	3-5˚C
Adults	3+ years of age	copepods euphausiids meso-pelagic fish (myctophids)	spawning (May-Oct) non-spawning (Nov-Apr) tidal/diurnal, year-round?	ICS and MCS, IP MCS and OCS, IP ICS,MCS, OCS,IP	D (males) SD females SD/D all sexes D when currents high/day SD slack	GR,R,K	F,E	3-5˚C all stages >17 ppt only

Habitat Description for Capelin

(*osmeridae*)

Management Plan and Area GOA

Species Representative:

Capelin (*Mallotus villosus*)

Life History and General Distribution

Capelin is a short-lived marine (neritic), pelagic, filter-feeding schooling fish distributed along the entire coastline of Alaska and the BS, and south along British Columbia to the Strait of Juan de Fuca; circumpolar. In the North Pacific, capelin grow to a maximum of 25 cm and 5 years of age. Spawn at ages 2 to 4 in spring and summer (May to August; earlier in south, later in north) when about 11 to 17 cm on coarse sand, fine gravel beaches, especially in Norton Sound, northern Bristol Bay, along the Alaska Peninsula and near Kodiak. Age at 50 percent maturity is 2 years. Fecundity is 10,000 to 15,000 eggs per female. Eggs hatch in 2 to 3 weeks. Most capelin die after spawning. Larvae and juveniles are distributed on inner-mid shelf in summer (rarely found in waters deeper than about 200 m), and juveniles and adults congregate in fall in mid-shelf waters east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands, and north into the Gulf of Anadyr. They are distributed along outer shelf and under ice edge in winter. Larvae, juveniles, and adults have diurnal vertical migrations following scattering layers – night near surface, at depth during the day. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery

Capelin are not a target species in groundfish fisheries of BSAI or GOA, but are caught as bycatch (up to several hundred tons per year in the 1990s) principally during the yellowfin sole trawl fishery in Kuskokwim and Togiak Bays in spring in the BSAI; almost all are discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information

Capelin are important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance and juvenile pollock (Hunt et al. 1981a, Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987, Wespestad 1987). Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the BS (Allen 1987, Yang 1993, Livingston, in prep.).

Approximate Upper Size Limit of Juvenile Fish (in cm): 13 cm

Habitat and Biological Associations

Egg/Spawning: Spawn adhesive eggs (about 1 mm in diameter) on fine gravel or coarse sand (0.5 to 1 mm grain size) beaches intertidally to depths of up to 10 m in May-July in Alaska (later to the north in Norton Sound). Hatching occurs in 2 to 3 weeks. Most intense spawning when coastal water temperatures are 5 to 9ºC.

Larvae: After hatching, 4 to 5 mm larvae remain on the middle-inner shelf in summer; distributed pelagically; centers of distribution are unknown, but have been found in high concentrations north of Unimak Island, in the western GOA, and around Kodiak Island.

Juveniles: In fall, juveniles are distributed pelagically in mid-shelf waters (50 to 100 m depth; -2 to 3ºC), and have been found in highest concentrations east of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

Adults: Found in pelagic schools in inner-mid shelf in spring-fall, feed along semi-permanent fronts separating inner, mid, and outer shelf regions (~50 and 100 m). In winter, found in concentrations under ice-edge and along mid-outer shelf.

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SPECIES: Capelin

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	2 to 3 weeks to hatch	na	May-August	BCH (to 10 m)	D	S,CB		5-9˚C peak spawning
Larvae	4 to 8 months?	Copepods phytoplankton	summer/fall/ winter	ICS-MCS	N,P	U NA?	U	
Juveniles	1.5+ years up to age 2	Copepods Euphausiids	all year	ICS-MCS	P	U NA?	U F? Ice edge in winter	
Adults	2 years ages 2-4+	Copepods Euphausiids polychaetes small fish	spawning (May-August) non-spawning (Sep-Apr)	BCH (to 10 m) ICS-MCS-OCS	D,SD P	S,CB NA?	 F Ice edge in winter	 -2 - 3˚C Peak distributions in EBS?

Habitat Description for Eulachon

(*osmeridae*)

Management Plan and Area GOA

Species Representative:

Eulachon, candlefish *(Thaleichthys pacificus*)

Life History and General Distribution

Eulachon is a short-lived anadromous, pelagic schooling fish distributed from the Pribilof Islands in the EBS, throughout the GOA, and south to California. Consistently found pelagically in Shelikof Strait (hydroacoustic surveys in late winter-spring) and between Unimak Island and the Pribilof Islands (bycatch in groundfish trawl fisheries) from the middle shelf to over the slope. In the North Pacific, eulachon grow to a maximum of 23 cm and 5 years of age. They spawn at ages 3 to 5 in spring and early summer (April to June) when they are about 14 to 20 cm in rivers on coarse sandy bottom. Their age at 50 percent maturity is 3 years. Fecundity equals ~25,000 eggs per female. Eggs adhere to sand grains and other substrates on river bottom. Eggs hatch in 30 to 40 days in BC at 4 to 7ºC. Most eulachon die after first spawning. Larvae drift out of rivers and develop at sea. Smelts are captured during trawl surveys, but their patchy distribution both in space and time reduces the validity of biomass estimates.

Fishery

Eulachon and candlefish are not target species in groundfish fisheries of BSAI or GOA, but are caught as bycatch (up to several hundred tons per year in the 1990s) principally by midwater pollock fisheries in Shelikof Strait (GOA), on the east side of Kodiak (GOA), and between the Pribilof Islands and Unimak Island on the outer continental shelf and slope (EBS); almost all are discarded. Small local coastal fisheries occur in spring and summer.

Relevant Trophic Information

Eulachon may be important prey for marine birds and mammals as well as other fish. Surface feeding (e.g., gulls and kittiwakes), as well as shallow and deep diving piscivorous birds (e.g., murres and puffins) largely consume small schooling fishes such as capelin, eulachon, herring, sand lance, and juvenile pollock (Hunt et al. 1981a, Sanger 1983). Both pinnipeds (Steller sea lions, northern fur seals, harbor seals, and ice seals) and cetaceans (such as harbor porpoise and fin, sei, humpback, and beluga whales) feed on smelts, which may provide an important seasonal food source near the ice-edge in winter, and as they assemble nearshore in spring to spawn (Frost and Lowry 1987, Wespestad 1987). Smelts are also found in the diets of some commercially exploited fish species, such as Pacific cod, walleye pollock, arrowtooth flounder, Pacific halibut, sablefish, Greenland turbot, and salmon throughout the North Pacific Ocean and the BS (Allen 1987; Yang 1993; Livingston, in prep.).

Approximate Upper Size Limit of Juvenile Fish (in cm): 14 cm

Habitat and Biological Associations

Egg/Spawning: Anadromous; return to spawn in spring (May to June) in rivers; demersal eggs adhere to bottom substrate (sand, cobble, etc.). Hatching occurs in 30 to 40 days.

Larvae: After hatching, 5 to 7 mm larvae drift out of river and develop pelagically in coastal marine waters; centers of distribution are unknown.

Juveniles and Adults: Distributed pelagically in mid-shelf to upper slope waters (50 to 1,000 m water depth), and have been found in highest concentrations between the Pribilof Islands and Unimak Island on the outer shelf, and in Shelikofeast of the Pribilof Islands, west of St. Matthew and St. Lawrence Islands and north into the Gulf of Anadyr.

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SPECIES: Eulachon (Candlefish)

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	30 to 40 days	na	April-June	Rivers-FW	D	S (CB?)		4 - 8˚C for egg development
Larvae	1 to 2 months ?	Copepods phytoplankton mysids, larvae	summer/fall	ICS ?	P?	U NA?	U	
Juveniles	2.5+ years up to age 3	Copepods Euphausiids	all year	MCS-OCS-USP	P	U NA?	U F?	
Adults	3 years ages 3 to 5+		spawning (May-June)	Rivers-FW	D	S (CB?)		
		Copepods Euphausiids	non-spawning (July-Apr)	MCS-OCS-USP	P	NA?	F?	

Habitat Description for Sculpins

(*cottidae*)

Management Plan and Area GOA

Species Representatives:

Yellow Irish lord (*Hemilepidotus jordani)*
Red Irish lord (*Hemilepidotus hemilepidotus*)
Butterfly sculpin (*Hemilepidotus papilio*)
Bigmouth sculpin (*Hemitripterus bolini*)
Great sculpin (*Myoxocephalus polyacanthocephalus*)
Plain sculpin (*Myoxocephalus jaok*)

Life History and General Distribution:

Cottidae (sculpins) is a large circumboreal family of demersal fishes inhabiting a wide range of habitats in the north Pacific Ocean and BS. Most species live in shallow water or in tidepools, but some inhabit the deeper waters (to 1,000 m) of the continental shelf and slope. Most species do not attain a large size (generally 10 to 15 cm), but those that live on the continental shelf and are caught by fisheries can be 30 to 50 cm; the cabezon is the largest sculpin and can be as long as 100 cm. Most sculpins spawn in the winter. All species lay eggs, but in some genera, fertilization is internal. The female commonly lays demersal eggs amongst rocks where they are guarded by males. Egg incubation duration is unknown; larvae were found across broad areas of the shelf and slope all year-round in ichthyoplankton collections from the southeast BS and GOA. Larvae exhibit diel vertical migration (near surface at night and at depth during the day). Sculpins generally eat small invertebrates (e.g., crabs, barnacles, mussels), but fish are included in the diet of larger species; larvae eat copepods.

Yellow Irish lords: They are distributed from subtidal areas near shore to the edge of the continental shelf (down to 200 m) throughout the BS, AI, and eastward into the GOA as far as Sitka, AK; up to 40 cm in length. 12 to 26 mm larvae collected in spring on the western GOA shelf.

Red Irish lords: They are distributed from rocky, intertidal areas to about 100 m depth on the middle continental shelf (most shallower than 50 m), from California (Monterey Bay) to Kamchatka; throughout the BS and GOA; rarely over 30 cm in length. Spawns masses of pink eggs in shallow water or intertidally. Larvae were 7 to 20 mm long in spring in the western GOA.

Butterfly sculpins: They are distributed primarily in the western north Pacific and northern BS, from Hokkaido, Japan, Sea of Okhotsk, Chukchi Sea, to southeast BS and in AI; depths of 20 to 250 m, most frequent 50 to 100 m.

Bigmouth sculpin: They are distributed in deeper waters offshore, between about 100 to 300 m in the BS, AI, and throughout the GOA; up to 70 cm in length.

Great sculpin: They are distributed from the intertidal to 200 m, but may be most common on sand and muddy/sand bottoms in moderate depths (50 to 100 m); up to 80 cm in length. They are found throughout the BS, AI, and GOA, but may be less common east of Prince William Sound. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

Plain sculpin: They are distributed throughout the BS and GOA (not common in the AI) from intertidal areas to depths of about 100 m, but most common in shallow waters (<50 m); up to 50 cm in length. *Myoxocephalus* spp. larvae ranged in length from 9 to 16 mm in spring ichthyoplankton collections in the western GOA.

Fishery

Sculpins are not a target of groundfish fisheries of BSAI or GOA, but sculpin bycatch (second to skates in weight amongst the other species) has ranged from 6,000 to 11,000 metric tons (mt) per year in the BSAI from 1992 to 1995, and 500 to 1,400 mt per year in the GOA. Bycatch occurs principally in bottom trawl fisheries for flatfish, Pacific cod, and pollock, but also while longlining for Pacific cod; almost all is discarded. Annual sculpin bycatch in the BSAI ranges between 1 and 4 percent of annual survey biomass estimates; however, little is known of the species distribution of the bycatch.

Relevant Trophic Information

Sculpin feed on bottom invertebrates (e.g., crabs, barnacles, mussels, and other molluscs); larger species eat fish.

Approximate Upper Size Limit of Juvenile Fish (in cm): Unknown

Habitat and Biological Associations

<u>*Egg/Spawning*</u>: Lay demersal eggs in nests guarded by males; many species in rocky shallow waters near shore.

<u>*Larvae*</u>: Distributed pelagically and in neuston across broad areas of shelf and slope, but predominantly on inner and middle shelf; have been found year-round.

<u>*Juveniles and Adults*</u>: Sculpins are demersal fish and live in a broad range of habitats from rocky intertidal pools to muddy bottoms of the continental shelf and in rocky, upper slope areas. Most commercial bycatch occurs on middle and outer shelf areas used by bottom trawlers for Pacific cod and flatfish.

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SPECIES: Sculpins

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	na	winter?	BCH,ICS (MSC-OSC?)	D	R (others?)	U	
Larvae	U	copepods	all year?	ICS-MSC,OCS,US	N,P	na?	U	
Juveniles and Adults	U	bottom invertebrates (crabs, molluscs, barnacles) and small fish	all year	BCH,ICS, MSC, OSC, USP	D	R, S, M, SM	U	

Habitat Description for Sharks

Management Plan and Area GOA

Species Representatives:

Lamnidae: Salmon shark (*Lamna ditropis*)
Squalidae: Sleeper shark (*Somniosus pacificus*)
Spiny dogfish (*Squalus acanthias*)

Life History and General Distribution:

Sharks of the order Squaliformes (which includes the two families Lamnidae and Squalidae) are the higher sharks with five gill slits and two dorsal fins. The Lamnidae are large, ovoviviparous (with small litters, 1 to 4; embryos nourished by intrauterine cannibalism), widely migrating sharks which are highly aggressive predators (salmon and white sharks). The Lamnidae are partly warm-blooded; the heavy trunk muscles are warmer than water for greater power and efficiency. Salmon sharks are distributed epipelagically along the shelf (can be found in shallow waters) from California through the GOA (where they occur all year and are probably most abundant in Alaska waters), the BS, and off Japan. In groundfish fishery and survey data, they occur chiefly on outer shelf/upper slope areas in the BS, but near the coast to the outer shelf in the GOA, particularly near Kodiak Island. They are not commonly seen in AI. They are believed to eat primarily fish, including salmon, sculpins, and gadids and can be up to 3 m in length.

The Pacific sleeper shark is distributed from California around the Pacific rim to Japan and in the BS principally on the outer shelf and upper slope (but has been observed nearshore), generally demersal (but also seen near surface). Other members of the Squalidae are ovoviviparous, but fertilization and development of sleeper sharks are not known; adults are up to 8 m in length. They are voracious, omnivorous predators of flatfish, cephalopods, rockfish, crabs, seals, and salmon; they may also prey on pinnipeds. In groundfish fishery and survey data, they occur chiefly on outer shelf/upper slope areas in the BS, but near coast to the outer shelf in the GOA, particularly near Kodiak Island.

Spiny dogfish (or closely related species?) are widely distributed through the Atlantic, Pacific, and Indian Oceans. In the north Pacific, they may be most abundant in the GOA, but are also common in the BS. They are pelagic species and are found at surface and to depths of 700 m; they are mostly found at 200 m or less on shelf and neritic; they are often found in aggregations. They are ovoviviparous, with litter size proportional to the size of the female, from 2 to 9; gestation may be 22 to 24 months. Young are 24 to 30 cm at birth, with growth initially rapid, then it slows dramatically. Maximum adult size is about 1.6 m and 10 kg; maximum age is about 40 years. Fifty percent of females are mature at 94 cm and 29 years old; males are mature at 72 cm and 19 years old. Females give birth in shallow coastal waters, usually from September to January. Dogfish eat a wide variety of foods, including fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus). Tagging experiments indicate local indigenous populations in some areas and widely migrating groups in others. They may move inshore in summer and offshore in winter.

Fishery

Sharks are not a target of groundfish fisheries of BSAI or GOA, but shark bycatch has ranged from 300 to 700 mt per year in the BSAI from 1992 to 1995; 500 to 1,400 mt per year in the GOA principally by pelagic trawl fishery for pollock, longline fisheries for Pacific cod and sablefish, and bottom trawl fisheries for pollock, flatfish, and cod; almost all are discarded. Little is known of shark biomass in BSAI or GOA.

Approximate Upper Size Limit of Juvenile Fish (in cm): Unknown for salmon sharks and sleeper sharks; for spiny dogfish: 94 cm for females, 72 cm for males.

Habitat and Biological Associations

Egg/Spawning: Salmon sharks and spiny dogfish are ovoviviparous; reproductive strategy of sleeper sharks is not known. Spiny dogfish give birth in shallow coastal waters, while salmon sharks probably give birth offshore and pelagic.

Juveniles and Adults: Spiny dogfish are widely dispersed throughout the water column on shelf in the GOA, and along outer shelf in the EBS; apparently they are not as commonly found in the AI and are not commonly found at depths >200 m.

Salmon sharks are found throughout the GOA, but are less common in the EBS and AI; they are epipelagic and are found primarily over shelf/slope waters in the GOA and on the outer shelf in the EBS.

Sleeper sharks are widely dispersed on shelf/upper slope in the GOA and along the outer shelf/upper slope only in the EBS; they are generally demersal and may be less commonly found in the AI.

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SPECIES: Sharks

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs and Larvae								
Juveniles and Adults Salmon shark	U	fish (salmon, sculpins and gadids)	all year	ICS, MSC. OCS, US in GOA; OCS, US in BSAI	P	NA	U	
Sleeper shark	U	omnivorous; flatfish, cephalopods, rockfish, crabs, seals, salmon, pinnipeds	all year	ICS, MSC, OCS, US in GOA; OCS, US in BSAI	D	U	U	
Spiny dogfish	40 years	fish (smelts, herring, sand lance, and other small schooling fish), crustaceans (crabs, euphausiids, shrimp), and cephalopods (octopus)	all year	ICS, MSC, OCS in GOA; OCS in BSAI give birth ICS in fall/winter?	P	U	U	Euhaline 4-16˚C

Habitat Description for Skates

(Rajidae)

Management Plan and Area GOA

Species Representatives:

Alaska skate (*Bathyraja parmifera*)
Aleutian skate (*Bathyraja aleutica*)
Bering skate (*Bathyraja interrupta*)

Life History and General Distribution:

Skates (Rajidae) that occur in the BSAI and GOA are grouped into two genera: *Bathyraja* sp., or soft-nosed species (rostral cartilage slender and snout soft and flexible), and *Raja* sp., or hard-nosed species (rostral cartilage is thick making the snout rigid). Skates are oviparous; fertilization is internal, and eggs (one to five or more in each case) are deposited in horny cases for incubation. Adults and juveniles are demersal and feed on bottom invertebrates and fish. Adult distributions from survey are Alaska skate: mostly 50 to 200 m on shelf in EBS and AI (AI), less common in the GOA (GOA); Aleutian skate: throughout EBS and AI, but less common in GOA, mostly 100 to 350 m; Bering Skate: throughout EBS and GOA, less common in AI, mostly 100 to 350 m. Little is known of their habitat requirements for growth or reproduction, nor of any seasonal movements. BSAI skate biomass estimate more than doubled between 1982 to 1996 from bottom trawl survey; it may have decreased in the GOA and remained stable in the AI in the 1980s.

Fishery

Until 2003, skates were not a target of groundfish fisheries of BSAI or GOA, but were caught as bycatch (13,000 to 17,000 mt per year in the BSAI from 1992 to 1995; 1,000 to 2,000 mt per year in the GOA) principally by the longline Pacific cod and bottom trawl pollock and flatfish fisheries; almost all were discarded. Skate bycatches in the EBS groundfisheries ranged between 1 and 4 percent of the annual EBS trawl survey biomass estimates from 1992 to 1995.

Starting in 2003, a directed fishery for skates developed in the GOA centered around Kodiak Island. It is prosecuted primarily on longline vessels less than 60 feet long, with some additional targeting by trawlers using large mesh nets. The primary target species appears to be Raja binoculata, followed by Raja rhina, but this is difficult to determine given that there is almost no observer coverage of the fishery. As of late July 2003, over 2,000 tons of skates had been landed. The market price per pound of skates is comparable to that of cod so the fishery is expected to continue and perhaps expand.

Relevant Trophic Information: Skates feed on bottom invertebrates (crustaceans, molluscs, and polychaetes) and fish.

Approximate Upper Size Limit of Juvenile Fish (in cm): Unknown

Habitat and Biological Associations

Egg/Spawning: Skates deposit eggs in horny cases on shelf and slope.

Juveniles and Adults: After hatching, juveniles probably remain in shelf and slope waters, but distribution is unknown. Adults found across wide areas of shelf and slope; surveys found most skates at depths <500 m in the GOA and EBS, but >500 m in the AI. In the GOA, most skates found between 4-7˚C, but data are limited.

Additional Information Source

NMFS, Alaska Fisheries Science Center, Sarah Gaichas

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SPECIES: Skates

Life Stage	Duration or Age	Diet/Prey	Season/Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U	na	U	MCS,OCS, USP	D	U	U	
Larvae	na	na	na	na	na	na	na	
Juveniles	U	Invertebrates small fish	all year	MCS,OCS, USP	D	U	U	
Adults	U	Invertebrates small fish	all year	MCS,OCS, USP	D	U	U	

Habitat Description for Squid

(*Cephalopoda, Teuthida*)

Management Plan and Area GOA

Species Representatives:

Gonaditae:
  Red or magistrate armhook squid (*Berryteuthis magister*)
Onychoteuthidae:
  Boreal clubhook squid (*Onychoteuthis banksii borealjaponicus)*
  Giant or robust clubhook squid (*Moroteuthis robusta*);
Sepiolidae:
  Eastern Pacific bobtail squid (*Rossia pacifica*).

Life History and General Distribution:

Squid are members of the molluscan class *Cephalopoda*, along with octopus, cuttlefish, and nautiloids. In the BSAI and GOA, gonatid and onychoteuthid squids are generally the most common, along with chiroteuthids. All cephalopods are stenohaline, occurring only at salinities >30 ppt. Fertilization is internal, and development is direct ("larval" stages are only small versions of adults). The eggs of inshore neritic species are often enveloped in a gelatinous matrix attached to rocks, shells, or other hard substrates, while the eggs of some offshore oceanic species are extruded as large, sausage-shaped drifting masses. Little is known of the seasonality of reproduction, but most species probably breed in spring-early summer, with eggs hatching during the summer. Most small squid are generally thought to live only 2 to 3 years, but the giant *Moroteuthis robusta* clearly lives longer.

B magister is widely distributed in the boreal north Pacific from California, throughout the BS, to Japan in waters 30 to 1,500 m deep; adults are most often found at mesopelagic depths or near bottom on shelf, rising to the surface at night; juveniles are widely distributed across shelf, slope, and abyssal waters in meso- and epipelagic zones, and they rise to the surface at night. They migrate seasonally, moving northward and inshore in summer, and southward and offshore in winter, particularly in the western north Pacific. Maximum size for females is 50 cm mantle length (ML); for males, maximum size is 40 cm ML. Spermatophores are transferred into the mantle cavity of the female, and eggs are laid on the bottom on the upper slope (200 to 800 m). Fecundity is estimated at 10,000 eggs/female. Spawning of eggs occurs from February to March in Japan, but apparently year-round in the BS. Eggs hatch after 1 to 2 months of incubation; development is direct. Adults are gregarious prior to and most die after mating.

O. banksii borealjaponicus, an active, epipelagic species, is distributed in the north Pacific from the Sea of Japan, throughout the AI and south to California, but is absent from the Sea of Okhotsk and is not common in the BS. Juveniles can be found over shelf waters at all depths and near shore. Adults apparently prefer the upper layers over slope and abyssal waters; they are diel migrators and gregarious. Development includes a larval stage; maximum size is about 55 cm.

M. robusta, a giant squid, lives near the bottom on the slope and mesopelagically over abyssal waters; it is rare on the shelf. It is distributed in all oceans and is found in the BS, AI, and GOA. Mantle length can be up to 2.5 m long, with tentacles, at least 7 m, but most are about 2 m long.

R. pacifica is a small (maximum length with tentacles of less than 20 cm) demersal, neritic and shelf, boreal species, distributed from Japan to California in the North Pacific and in the BS in waters of about 20 to 300 m depth. Other *Rossia* spp. deposit demersal egg masses.

Fishery

Squid are not currently a target of groundfish fisheries of BSAI or GOA. A Japanese fishery catching up to 9,000 mt of squid annually existed until the early 1980s for *B. magister* in the BS and *O. banksii borealjaponicus* in the AI. Since 1990, annual squid bycatch has been about 1,000 mt or less in the BSAI and between 30 to 150 mt in the GOA; in the BSAI, almost all squid bycatch is in the midwater pollock fishery near the continental shelf break and slope, while in the GOA, trawl fisheries for rockfish and pollock (again mostly near the edge of the shelf and on the upper slope) catch most of the squid bycatch.

Relevant Trophic Information

The principal prey items of squid are small forage fish pelagic crustaceans (e.g., euphausiids and shrimp) and other cephalopods; cannibalism is not uncommon. After hatching, small planktonic zooplankton (copepods) are eaten. Squid are preyed upon by marine mammals, seabirds, and, to a lesser extent by fish, and they occupy an important role in marine food webs worldwide. Perez (1990) estimated that squids comprise over 80 percent of the diets of sperm whales, bottlenose whales, and beaked whales and about half of the diet of Dall's porpoise in the EBS and AI. Seabirds (e.g., kittiwakes, puffins, murres) on island rookeries close to the shelf break (e.g., Buldir Island, Pribilof Islands) are also known to feed heavily on squid (Hatch et al. 1990, Byrd et al. 1992, Springer 1993). In the GOA, only about 5 percent or less of the diets of most groundfish consisted of squid (Yang 1993). However, squid play a larger role in the diet of salmon (Livingston and Goiney 1983).

Approximate Upper Size Limit of Juvenile Fish (in cm): For *B. magister*, approximately 20 cm ML for males, 25 cm ML for females; both at approximately 1 year of age.

Habitat Narrative for *B. magister*

Egg/Spawning: Eggs are laid on the bottom on the upper slope (200 to 800 m); incubate for 1 to 2 months.

Young Juveniles: Distributed epipelagically (top 100 m) from the coast to open ocean.

Old Juveniles and Adults: Distributed mesopelagically (most from 150 to 500 m) on the shelf (summer only?), but mostly in outer shelf/slope waters (to lesser extent over the open ocean). They migrate to slope waters to mate and spawn demersally.

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SPECIES: Berryteuthis Magister (Red Squid)

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	1 to 2 months	NA	varies	USP,LSP	D	M,SM, MS	U	
Young juveniles	4 to 6 months	zooplankton		All shelf, slope, BSN	P,N	NA	UP,F?	
Older Juveniles and Adults	1 to 2 years (may be up to 4 years)	euphausiids, shrimp, small forage fish, and other cephalopods	summer winter	All shelf, USP,LSP,BSN OS,USP,LSP,BSN	SP SP	U U	UP,F? UP,F?	Euhaline waters, 2-4˚C

Habitat Description for Octopus

Management Plan and Area GOA

Species Representatives:

Octopoda: Octopus *(Octopus gilbertianus; O. dofleini*)
Vampyromorpha: Pelagic octopus (*Vampyroteuthis infernalis*)

Life History and General Distribution:

Octopus are members of the molluscan class Cephalopoda, along with squid, cuttlefish, and nautiloids. In the BSAI and GOA, the most commonly encountered octopods are the shelf demersal species *O. gilbertianus* and *O. dofleini*, and the bathypelagic finned species, *V. infernalis*. Octopods, like other cephalopods are dioecious, with fertilization of eggs (usually within the mantle cavity of the female) requiring transfer of spermatophores during copulation. Octopods probably do not live longer than about 2 to 4 years, and females of some species (e.g., *O. vulgaris*) die after brooding their eggs on the bottom.

O. gilbertianus is a medium-size octopus (up to 2 m in total length) distributed across the shelf (to 500 m depth) in the eastern and western BS (where it is the most common octopus), AI, and GOA (endemic to the North Pacific). Little is known of its reproductive or trophic ecology, but eggs are laid on the bottom and tended by females. It lives mainly among rocks and stones.

O. dofleini is a giant octopus (up to 10 m in total length, though mostly about 3 to 5 m) distributed in the southern boreal region from Japan and Korea, through the AI, GOA, and south along the Pacific coast of North America to California. Inhabits the sublittoral to upper slope. Egg length is 6 to 8 mm, and they are laid on the bottom. Copulation may occur in late fall and winter, but oviposition is the following spring; each female lays several hundred eggs.

V. infernalis is a relatively small (up to about 40 cm total length) bathypelagic species, living at depths well below the thermocline; they may be most commonly found at 700 to 1,500 m. They are found throughout the world's oceans. Eggs are large (3 to 4 mm in diameter) and are shed singly into the water. Hatched juveniles resemble adults, but with different fin arrangements, which change to the adult form with development. Little is known of their food habits, longevity, or abundance.

Fishery

Octopus are not currently a target of groundfish fisheries of BSAI or GOA. Bycatch has ranged between 200 to 1,000 mt in the BSAI and 40 to 100 mt in the GOA, chiefly in the pot fishery for Pacific cod and bottom trawl fisheries for cod and flatfish, but sometimes in the pelagic trawl pollock fishery. Directed octopus landings have been less than 8 mt/year from 1988 to 1995. Age/size at 50 percent recruitment is unknown. Most of the bycatch occurs on the outer continental shelf (100 to 200 m depth), chiefly north of the Alaska Peninsula from Unimak Island. To Port Moller and northwest to the Pribilof Islands; also around Kodiak Island and many of the AI.

Relevant Trophic Information

Octopus are eaten by pinnipeds (principally Steller sea lions, and spotted, bearded, and harbor seals) and a variety of fishes, including Pacific halibut and Pacific cod (Yang 1993). When small, octopods eat planktonic and small benthic crustaceans (mysids, amphipods, copepods). As adults, octopus eat benthic crustaceans (crabs) and molluscs (clams).

Approximate Upper Size Limit of Juvenile Fish (in cm): Unknown

Habitat Narrative for *Octopus* spp.:

Egg/Spawning: Occurs on shelf; eggs are laid on bottom, maybe preferentially among rocks and cobble.

Young Juveniles: Are semi-demersal; are widely dispersed on shelf, upper slope.

Old Juveniles and Adults: Are demersal; are widely dispersed on shelf and upper slope, preferentially among rocks, cobble, but also on sand/mud.

Additional Information Source

NMFS, Alaska Fisheries Science Center, Sarah Gaichas.

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SPECIES: *Octopus dofleini*, *O. gilbertianus*

Life Stage	Duration or Age	Diet/Prey	Season-Time	Location	Water Column	Bottom Type	Oceanographic Features	Other
Eggs	U (1 to 2 months?)	NA	spring-summer?	U (IS, MS?)	D	R, G?	U	Euhaline waters
Young juveniles	U	zooplankton	summer-fall	U (IS, MS, OS, USL?)	D,SD	U	U	Euhaline waters
Older Juveniles and Adults	U (2 to 3 years? for *O. gilbertianus*; older for	crustaceans, molluscs	all year	IS, MS, OS, USL	D?	R, G, S, MS	U	Euhaline waters