Chapter 18a. Assessment of Sculpin stocks in the Gulf of Alaska

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18a.0 Executive Summary

The following appendix summarizes the information currently known about sculpins (Families: Cottidae, Hemitripteridae, Psychrolutdiae, and Rhamphocottidae) in the Gulf of Alaska (GOA). It should be noted that in 2007 the catch of sculpins (938 t) increased about 65% from 2006 (573 t) and in 2008 sculpin catch increased an addition 43% to 1652 t. This catch increase is the result of larger catches of sculpins in the shallow water flatfish fishery. 2008 is the first year that observers identified sculpins to species.

The following appendix summarizes the information currently known about sculpins (Families: Cottidae, Hemitripteridae, Psychrolutdiae, and Rhamphocottidae) in the Gulf of Alaska (GOA).

Summary of Major Changes

1. 2008 is first year that sculpin species are identified to species in the fishery observer data.
2. Sculpin catch within the GOA fisheries is updated for with 2007 and 2008 data as of October 3rd, 2008
3. Biomass estimates from the GOA are presented for selected sculpin species from triennial and biennial Alaska Fisheries Science Center (AFSC) bottom trawl surveys
4. Information on total sculpin catch by target fishery and gear type is available for 2007.
5. Length frequencies of the 4 most abundant sculpin species are presented from AFSC survey data of the GOA.

Region	M	Exploitable biomass (mt)	F_{ABC}	ABC (mt)	F_{OFL}	OFL (mt)
GOA	0.19	30,836	0.1425	4,394	0.19	5,859

16.4.1 Introduction

Description, scientific names, and general distribution

Sculpins are a group of benthic-dwelling predatory teleost fish, that include 46 species in Alaskan waters. Sculpin species have been identified in the AFSC surveys since 2001. During AFSC surveys of the Gulf of Alaska, only 39 of 46 listed species of sculpins have been identified. It is not clear whether the other 7 species do not exist in the GOA or they just haven't been captured and identified. Sculpin diversity remains high in the GOA and many of these species are also found in the Bering Sea (Table 18a.1). Considered as a species complex, sculpins are broadly distributed throughout the shelf and slope regions of the Gulf of Alaska occupying all benthic habitats and depths. In this assessment, we mainly focus on large sculpin species from the genera *Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus* where observers from the North Pacific Groundfish Observer Program have recently begun to identify sculpin catch to genus. .

Management units

Sculpins are managed as part of the GOA Other Species complex. This means that their catch is reported in aggregate as "other" along with the catch of skates, sharks, and octopi and squid (GOA). Because catch is officially reported within the Other Species complex, independent estimates of sculpin catch were made for each year using observer data. In the GOA, the TAC of other species has been established as 5% of the sum of the TACs for all other assessed target species in the GOA Fishery Management Plan (FMP). The North Pacific Fishery Management Council is currently preparing a plan amendment to break the Other Species comples into its component parts. Sculpins are currently non-targets in the GOA, so future catch of sculpins may depend solely on the TAC and spatial temporal limitations placed on target fisheries. Life history characteristics indicate that sculpins as a group might be managed separately and catch could be constrained efficiently within a spatial context.

Reproductive Ecology

Recent studies on the reproductive biology of top 5 sculpin species in the Eastern Bering Sea Shelf area have given us much needed information of sculpin life history in Alaska. Prior to those studies much of the reproductive biology information comes from studies in the western North Pacific. Sculpins lay adhesive eggs in nests, and many exhibit parental care for eggs (Eschemeyer et al, 1983). Markevich (2000) observed the sea raven, *Hemitripterus villosus*, releasing eggs into crevices of boulders and stones in shallow waters in Peter the Great Bay, Sea of Japan. This type of reproductive strategy may make sculpin populations more sensitive to changes in benthic habitats than other groundfish species such as pollock, which are broadcast spawners with pelagic eggs. In the western Pacific, great sculpins *Myoxocephalus polyacanthocephalus* are reported to have late ages at maturity (5-8 years, Tokranov, 1985) despite being relatively short-lived (13-15 years), which suggests a limited reproductive portion of the lifespan relative to other groundfish species. Fecundity for the great sculpin off East Kamchatka waters ranged from 48,000 to 415,000 eggs (Tokranov, 1985). In contrast, preliminary information on reproduction for bigmouth sculpin (*Hemitripterus bolini*) in the Gulf of Alaska shows fecundity averaged 2283 eggs per female (Morgan Busby, AFSC, personal comm.).The diversity of sculpin species in the Gulf of Alaska suggests that each sculpin population might react to similar environmental changes (whether natural or fishing induced) in different ways. Within each sculpin species, observed spatial differences in fecundity, egg size, and other life history characteristics suggest local population structure (Tokranov, 1985).

Life history (GOA-specific)

Information such as depth range, distribution, and maximum length has been collected for several years for many species during surveys. There are no GOA-specific age and growth, maturity data for sculpins identified in this management region. Known life history characteristics for selected sculpin species in

the GOA are presented in Table 18a.2. With the exception of bigmouth fecundity all fecundity and maturity data in Table 18a.2 are from outside GOA region.

18a.2 Fishery

There is no directed fishing for any sculpin species in the GOA at this time. Sculpins, in 2008, constitute about 75% of the GOA Other Species catch. Prior to 2005 when skates were still included in the complex they were 7-21% of the other species catch (Table 18a.3). Sculpins are caught incidentally by a wide variety of fisheries. Based on data from the NMFS AKRO the main fisheries are the trawl fisheries for flatfish, Pacific cod, and rockfish, and Pacific cod pot fishery (Table 18a.4). It is unclear which sculpin species were commonly taken in GOA groundfish fisheries prior to 2004, because observers did not regularly identify animals in these groups to species. Retained catch of sculpin species in the GOA has increased from 7% in 2003 to 19% in 2007 (Table 18a.5)

In 2002-2003, the observer program of AFSC initiated a species identification project prompted by the need to gather basic population data for groups in the Other Species complex. Beginning in January 2004, sculpin catch was identified to genus for the larger sculpin species: *Hemilepidotus, Myoxocephalus, and Hemitripterus.* Several species of *Hemilepidotus* and *Myoxocephalus* have been identified from surveys. In Alaskan waters, *Hemitripterus* probably represents only one species, the bigmouth sculpin (Stevenson 2004). Another member of this genus that may occur in Alaskan waters, the sea raven (*H. villosus*), has never been identified in any of the GOA trawl surveys conducted by AFSC. It is reasonable to assume that all sculpins identified by observers as *Hemitripterus* sculpins were bigmouth sculpins. According to total catch figures for 2007 from the NMFS Alaska Regional Office (AKRO), the aforementioned large sculpin genera contributed nearly 92% of all sculpin catch in the GOA region Table 18a.6.

Table 18a.6 shows that in 2007, *Hemilepidotus* spp. make up 64% of the sculpin total observed catch. *Hemitripterus* spp. (bigmouth sculpin) makes up about 18% of the total observed catch of sculpins. Beginning in 2008, observers identified to all sculpin species species. In 2008, the first year observers identify the top 5 species of sculpins to species, shows that *Hemilepidotus jordani* makes up 61% of all sculpin species in the GOA, followed by Irish Lord unidentified.

18a.3 Survey

Biomass trend

Aggregate sculpin biomass in the GOA shows no clear trend, and should probably not be used as an indicator of population status for a complex with so much species diversity (Table 18a.7). Trends in biomass were available for only selected sculpin species for the period 1984-2005 due to difficulties with species identification and survey priorities. Species specific biomass estimates are available for the 2001, 2003, 2005 and 2007 surveys. The species composition of the sculpin complex as estimated by bottom trawl surveys of the GOA demonstrates the diversity of this complex. Almost 95% of the sculpin biomass is dominated by the larger sculpin species in the GOA: yellow Irish lord (*Hemilepidotus jordani*) being the most common (~45.5% of the sculpin biomass), followed by the genera *Myoxocephalus* at ~27% and bigmouth sculpin (*Hemitripterus bolini*) at ~22% of the sculpin biomass (Table.18a.8).

Biomass trends show that the bigmouth sculpin declined between 1984 and 2001, but remains stable over the last 2 surveys (Figure 18a.1). Sculpins that show an increase since 1984 are the plain sculpin, and yellow Irish lord, spinyhead, great and darkfin sculpins show no real trend in biomass through the years (Figure 18a.1). The coefficient of variations (CVs) for the survey biomass estimates of 7 out of 12 sculpins species are below 0.3, suggesting that the GOA survey is doing an adequate job assessing the biomass of the more abundant species (Table 18a.8).

Length frequency

Length measurements (fork length, FL in mm) have been collected for a variety of sculpin species during AFSC surveys. The four most abundant species from the GOA survey have been measured annually since 2003: yellow Irish lord, plain sculpin, great sculpin and bigmouth sculpin (Figure 18a.2). Year by

year analysis shows that the length composition by species is consistent. One interesting observation is that the surveys tend to catch bigmouth sculpins on the higher side of the length range, similar to the length observations of bigmouth from the eastern Bering Sea (EBS) shelf survey. Although little information is known about bigmouth sculpin life history, this may suggest that the younger or smaller bigmouth sculpins occur in areas not sampled well by the surveys.

Sample sizes for length frequency analysis for GOA:

Species	2003	2005	2007
Yellow Irish Lord	917	1034	1044
Plain sculpin	81	126	176
Great sculpin	208	201	209
Bigmouth sculpin	81	61	51

18a.4 Analytical Approach

For the purpose of this assessment the analytical approach consisted of evaluating natural mortality and comparing with survey biomass. The following methods were employed to evaluate natural mortality with life history parameters: Alverson and Carney 1975, Pauly 1980, Charnov 1993, Hoenig 1983, , Rikhter and Efanov 1976. Little information was available for sculpin stocks in the GOA FMP area, so M was estimated using the methods as applied to data for Russian sculpin species. Considering the uncertainty inherent in applying this method to sculpin species and stocks not found in the GOA, as well as that great and plain sculpin are the most abundant in the GOA and have estimates of M in the literature, we elected to use the lowest estimate of M, 0.19, which is one of the estimates for great sculpin (Table 18a.9). Choosing the lowest estimate of M is considered conservative because it will result in the lowest estimates of ABC and OFL under Tier 5.

18a.5 ABC and OFL recommendations for 2009-2010

The sculpin assemblage represents 40 species of which 16-20 have shown up in the AFSC surveys since 1993 (Table 18a.1). Because their life history is so different from sharks, squid and octopi, we recommend a sculpin level ABC and OFL. There is a reliable biomass time series for the sculpin complex, and in recent years, reliable estimates of biomass for each species within the complex. We feel that our conservative estimate of M is the best available for managing this species complex until further information is available.

Currently, we recommend a Tier 5 approach be applied to the sculpin complex within the GOA as long as the catch remains incidental and no target fishery develops. We further recommend using an average of the 6 most recent survey biomass estimates to capture recent biomass trends. Applying the M estimate of 0.19 to the average survey biomass estimates, we calculate an ABC of 0.75 * 0.19 * (30,836) = 4,394 mt for the GOA. Using the same method to calculate OFL, 0.19 * (30,836) = 5,859 mt for the GOA. Tier 6 options for sculpin management are not recommended.

In the unlikely event that target fisheries develop for some sculpin species, we recommend that each targeted sculpin species be managed separately, and that directed fishing only be allowed when sufficient life history information becomes available to make reasonable species specific estimates of productivity. Given that the most probable targeted sculpin species would be the most abundant, managing as single species may not be problematic under the current TAC setting regime if the species was being identified to species level by the observer program. If a targeted species of sculpin is one with a low abundance thus low TACs then alternative management strategies such as closed areas should be considered.

18a.6 Ecosystem Considerations

18a.6.1 Ecosystem Effects on Stock

Little is known about sculpin food habits in the GOA, especially during fall and winter months. Limited information indicates that in the GOA the larger sculpin species prey on shrimp and other benthic invertebrates, as well as some juvenile walleye pollock (Figure 18a.3). In the GOA the main predator of large sculpins are Pacific halibut, pinnipeds, small demersal fish and sablefish (Figure 18a.3). Other sculpins in the GOA feed mainly on shrimp and benthic crustaceans (Figure 18a.4). Other sculpins are mainly preyed upon by Pacific cod and is the main source of mortality (Figure 18a.4). Source of above information from Aydin et al. (2007).

18a.6.2 Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that affect the stocks within this complex (see Table 18a.4) is given in the respective fisheries SAFE chapter. The GOA Sculpin complex is not a targeted fishery, therefore reference to the effects of the fishery on the ecosystem will be described in those chapters of the fisheries that catch sculpins incidentally.

Ecosystem effects on *Sculpin complex*

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Zooplankton	Stomach contents, ichthyoplankton surveys, changes mean wt-at-age	No affect	Probably no concern
a. Predator population trends			
Marine mammals	Fur seals declining, Steller sea lions increasing slightly	No affect	Probably no concern
Birds	Stable, some increasing some decreasing	No affect	Probably no concern
Fish (Pollock, Pacific cod, halibut)	Stable to increasing	Affects not known	Probably no concern
b. Changes in habitat quality			
Temperature regime	None	Affects not known	Unknown
Winter-spring environmental conditions	None	Probably a number of factors	Unknown
Production	Fairly stable nutrient flow from upwelled BS Basin	Inter-annual variability low	No concern

***Targeted fisheries* effects on ecosystem (see relative chapters)**

18a.6.3 Data gaps and research priorities

Severe data gaps exist in sculpin species life history characteristics, spatial distribution and abundance in Alaskan waters. Most importantly no data on maximum age exists for the four main sculpin species in the GOA. Therefore, collections for age data on Yellow Irish lord, Great sculpin, bigmouth sculpin and plain sculpin are needed from the GOA. It is essential that we continue to improve species identifications as well as collecting life history information from the fisheries. Over 90% of all sculpins caught in the fisheries of the GOA in 2004 were from the genera *Myoxocephalus*, *Hemitripterus*, and *Hemilepidotus*. Collecting seasonal food habits data (with additional summer collections) would help to clarify the role of both large and small sculpin species within the GOA ecosystem. These data are necessary in deciding creative management strategies for non-target species.

18a.7 Summary

Below are the recommendations for ABC and OFL for a GOA sculpin complex for 2009-2010.

Region	M	Exploitable biomass (mt)	F_{ABC}	ABC (mt)	F_{OFL}	OFL (mt)
GOA	0.19	30,836	0.1425	4,394	0.19	5,859

18a.7 Literature Cited

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Table 18a.1. Sculpin species observed during the years 1993-2005 on the Gulf of Alaska bottom trawl surveys.

Family	Scientific name	Common name	96	99	01	03	05
Cottidae	*Artediellus pacificus*	Pacific hookear sculpin		x			
	Artedius lateralis	Smoothhead sculpin					
	Bolinia euryptera	Broadfin sculpin					x
	Enophyrs bison	Buffalo sculpin					
	Enophrys diceraus	Antlered sculpin		x	x		
	Gymnocanthus galeatus	Armorhead sculpin	x	x	x	x	x
	Gymnocanthus pistilliger	Threaded sculpin	x		x	x	x
	Hemilepidotus hemilepidotus	Red Irish Lord	x	x	x	x	x
	Hemilepidotus jordani	Yellow Irish Lord	x	x	x	x	x
	Hemilepidotus papilio	Butterfly sculpin	x	x			
	Hemilepidotus spinosus	Brown Irish lord				x	
	Hemilepidotus zapus	Longfin Irish lord		x		x	x
	Icelinus borealis	Northern sculpin	x	x	x		x
	Icelinus burchami	Dusky sculpin		x		x	
	Icelinus filamentosus	Threadfin sculpin					
	Icelinus tenuis	Spotfin sculpin	x			x	
	Icelus spatula	Spatulate sculpin		x	x		
	Icelus spiniger	Thorny sculpin	x		x	x	x
	Icelus uncinalis	Uncinate sculpin		x			
	Jordania zonope	Longfin sculpin					
	Leptocottus armatus	Pacific staghorn sculpin		x	x		x
	Microcottus sellaris	Brightbelly sculpin					
	Myoxocephalus jaok	Plain sculpin	x	x	x	x	x
	Myoxocephalus polyacanthocephalus	Great sculpin	x	x	x	x	x
	Myoxocephalus verrucocus	Warty sculpin			x		
	Paricelinus hopliticus	Thornback sculpin		x			
	Radulinus asprellus	Slim sculpin				x	
	Rastrinus scutiger	Roughskin sculpin					x
	Thecopterus aleuticus	Whitetail sculpin					
	Thyriscus anoplus	Sponge sculpin	x				x
	Triglops forficatus	Scissortail sculpin	x	x	x	x	x
	Triglops macellus	Roughspine sculpin	x	x	x	x	x
	Triglops metopias	Crescent-tail sculpin				x	
	Triglops pingelii	Ribbed sculpin	x	x	x	x	x
	Triglops septicus	Spectacled sculpin	x	x	x	x	x
Hemitripteridae	*Blepsias bilobus*	Crested sculpin			x		
	Hemitripterus bolini	Bigmouth sculpin	x	x	x	x	x
	Nautichthys oculofasciatus	Sailfin sculpin	x		x	x	
	Nautichthys pribilovius	Eyeshade sculpin	x				
Psychrolutidae	*Dasycottus setiger*	Spinyhead sculpin	x	x	x	x	x
	Eurymen gyrinus	Smoothcheek sculpin	x	x	x		x
	Malacoccottus zonurus	Darkfin sculpin	x	x	x	x	x
	Malacocottus kincaidi	Blackfin sculpin					
	Psychrolutes paradoxus	Tadpole sculpin	x	x	x	x	x
	Psychrolutes phrictus	Blob sculpin					x
Rhamphocottidae	*Rhamphocottus richardsoni*	Grunt sculpin	x	x	x	x	x

Table 18a.2. Selected life history information available for selected GOA sculpin species.

Species	Common Name	Maximum Length (cm)		Maximum Age		Fecundity (x1000)	Age at 50% Maturity
		Outside GOA	GOA	Outside GOA	GOA		
Myoxocephalus joak	Plain sculpin	75	59	15		25.4 - 147	5 - 8
M. polyacanthocephalus	Great sculpin	82	72	13		48 - 415	6 - 8
M. verrucosus	Warty sculpin	78				2.7	
Hemitripterus bolini	Bigmouth sculpin	83	86			2.3	
Hemilepidotus jordani	Yellow Irish lord	65	50	13		25 - 241	6 - 7
H. papilio	Butterfly sculpin	38					
Gymnocanthus pistilliger	Threaded sculpin	27		13		5 - 41	
G. galeatus	Armorhead sculpin	46	28	13		12 - 48	
Dasycottus setiger	Spinyhead sculpin	45	22	11			
Icelus spiniger	Thorny sculpin	17					
Triglops pingeli	Ribbed sculpin	20		6		1.8	
T. forficate	Scissortail sculpin	30	28	6		1.7	
T. scepticus	Spectacled sculpin	25		8		3.1	

References: AFSC; Panchenko 2002; Panchenko 2003; Tokranov 1985; Andriyashev 1954; Tokranov 1988a; Tokranov 1988b; Tokranov 1995; Tokranov and Orlov 2001; Busby, AFSC, personal comm.
Notes: Estimate of Natural mortality (M) is the lowest estimate of M derived from several methods as presented in Gaichas et al. (2004); blanks indicate no life history data found.

Table 18a.3. GOA total catch of other species (including skates) and sculpin complex 1997-2007*. Source: Catch Accounting system, AKRO.

Year	Other species total catch	Sculpin complex total catch	Percent of other species catch
1997	4,823	898	19%
1998	7,422	526	7%
1999	3,788	544	14%
2000	5,455	940	17%
2001	3,383	587	17%
2002	8,162	919	11%
2003	5,132	632	12%
2004	3,399	697	21%
2005*	2,347	612	26%
2006	3,425	573	16%
2007	2,800	938	33%
2008**	2,208	1,652	75%

*Skates removed from Other species complex

**2008 data as of October 3rd 2008 – increase due to high catch in Shallow Flatfish target fishery and Pacific Cod Hook and Line, Non-Pelagic Trawl and Pot target fisheries…

Table 18a.4. Catch (mt) of large sculpins and other sculpins in the Gulf of Alaska by target fishery and gear type from 2007. *Source: NMFS AK regional office catch accounting system. Note: Large sculpin category is analogous to sculpin species in the genera Hemilepidotus, Hemitripterus and Myoxocephalus.*

2007
Gulf of Alaska

Large Sculpins

Target fishery	Gear type			
	Bottom Trawl	Pelagic Trawl	Pot	Longline
Pacific Cod	35	1	229	162
Shallow Flatfish	319	-	-	-
Rockfish	27	-	-	-
Arrowtooth	33	-	-	-
IFQ Halibut	-	-	-	22

Other Sculpins

Target fishery	Gear type			
	Bottom Trawl	Pelagic Trawl	Pot	Longline
Shallow Flatfish	52	-	-	-
Pacific Cod	3	-	3	1
Rockfish	4	-	-	-
IFQ Halibut	-	-	-	5

Table 18a.5. Sculpin retained and discarded catch (mt) for the GOA for 2003-2007. *Source: NMFS AK Region catch accounting system.*

Sculpins

	Retained	Discarded	Total	Percent Retained
GOA				
2003	54	697	751	7%
2004	58	600	658	9%
2005	89	455	544	16%
2006	94	481	576	16%
2007	162	695	856	19%

Table 18a.6. Extrapolated total catch (mt) of *Hemilepidotus* spp., *Hemitripterus* spp., *Myoxocephalus* and sculpin unidentified, based on observer data. *Source: AK Region Catch Accounting System;NMFS AFSC Fishery Monitoring and Assessment Program*

Gulf of Alaska	**2007 Sculpin catch (tons)**	**% of GOA sculpin**	**2008* Sculpin catch (tons)**	**% of GOA sculpin**
Hemitripterus spp.**	166	18%		
H. bolini			144	9%
Hemilepidotus spp.	608	65%	336	20%
H. hemilepidotus			<1	<1%
H. jordani			1,028	62%
Myoxocephalus spp.	88	9%		
M. verrucosus			<1	<1%
M. jaok			<1	<1%
M. polyacanthocephalus			125	7%
Sculpin unidentified§	76	8%	18	1%

*Data reported through 10/2008

**Hemitripterus spp. probably represents only one species (big mouth sculpin).

§ Sculpin unidentified is analogous to the Other sculpin category in the catch accounting system. Therefore percentages are used to get total sculpin catch from sculpins in the Large Sculpin category are different than above.

Table 18a.7 Sculpin complex biomass estimates based on NMFS bottom-trawl surveys, 1984-2007.

Year	Biomass	CV
1984	40,954	0.08
1987	31,328	0.11
1990	25,556	0.18
1993	25,371	0.12
1996	31,313	0.26
1999	30,783	0.11
2001	30,418	0.28
2003	26,514	0.09
2005	33,519	0.09
2007	32,468	0.11

Table 18a.8. Sculpin complex biomass (mt) from the 1996-2007 GOA trawl survey.

Species	Common Name	Biomass						CV
		1996	1999	2001	2003	2005	2007	2007
Blepsias bilobus	Crested sculpin	-	-	6	-	-	-	-
Dasycottus setiger	Spinyhead sculpin	278	271	690	608	463	422	0.15
Enophrys diceraus	Antlered sculpin	-	-	1	-	-	-	-
Gymnocanthus galeatus	Armorhead sculpin	13	15	60	78	28	58	0.28
Gymnocanthus pistilliger	Threaded sculpin	3	-	21	<1	2	-	-
Hemilepidotus jordani	Yellow Irish lord	17,804	20,255	20,945	12,064	15,952	15,720	0.15
Hemilepidotus papilio	Butterfly sculpin	<1	1	-	-	-	-	-
Hemitripterus bolini	Bigmouth sculpin	4,246	3,983	3,471	5,767	5,543	3,126	0.22
Icelus spiniger	Thorny sculpin	1	-	1	<1	<1	<1	0.98
Leptocottus armatus	Pacific staghorn sculpin	-	1	2	-	14	-	-
Malacocottus zonurus	Darkfin sculpin	477	371	335	607	944	790	0.19
Myoxocephalus jaok	Plain sculpin	1,015	1,692	932	1,220	3,912	4,456	0.50
Myoxocephalus polyacanthocephalus	Great sculpin	7,326	3,913	3,540	6,037	6,574	7,734	0.19
Myoxocephalus verrucosus	Warty sculpin	-	-	339	-	-	33	1.00
Triglops forficata	Scissortail sculpin	60	47	62	94	23	30	0.27
Triglops scepticus	Spectacled sculpin	90	233	12	40	105	96	0.58
	Total	31,313	30,782	30,417	26,515	33,560	32,468	0.11

Table 18a.9. List of available natural mortality information for sculpins.

Species	Area	Sex	Hoenig	Rikhter & Efanov	Alverson & Carney	Charnov
Arctic staghorn sculpin	W. Bering Sea	*males*	0.53			
	W. Bering Sea	*females*	0.47			
				0.41		
Common staghorn sculpin	Kamchatka	*males*	0.32	0.32		
	Kamchatka	*females*	0.25	0.26		
Red Irish Lord	Puget Sound		0.70			
Threaded sculpin	E. Bering Sea	*males*	0.42		0.36	0.65
		females	0.47		0.58	0.40
Armorhead sculpin	Kamchatka	*males*	0.38			
	Kamchatka	*females*	0.32			
Great sculpin	Kamchatka	*males*	0.47	0.32		
	Kamchatka	*males*		0.26		
	Kamchatka	*females*	0.32	0.22		
	Kamchatka	*females*		**0.19**		
Plain sculpin	Sea of Japan	*males*	0.35	0.41		
	Sea of Japan	*males*		0.32		
	Sea of Japan	*females*	0.28	0.26		
	Sea of Japan	*females*		0.22		

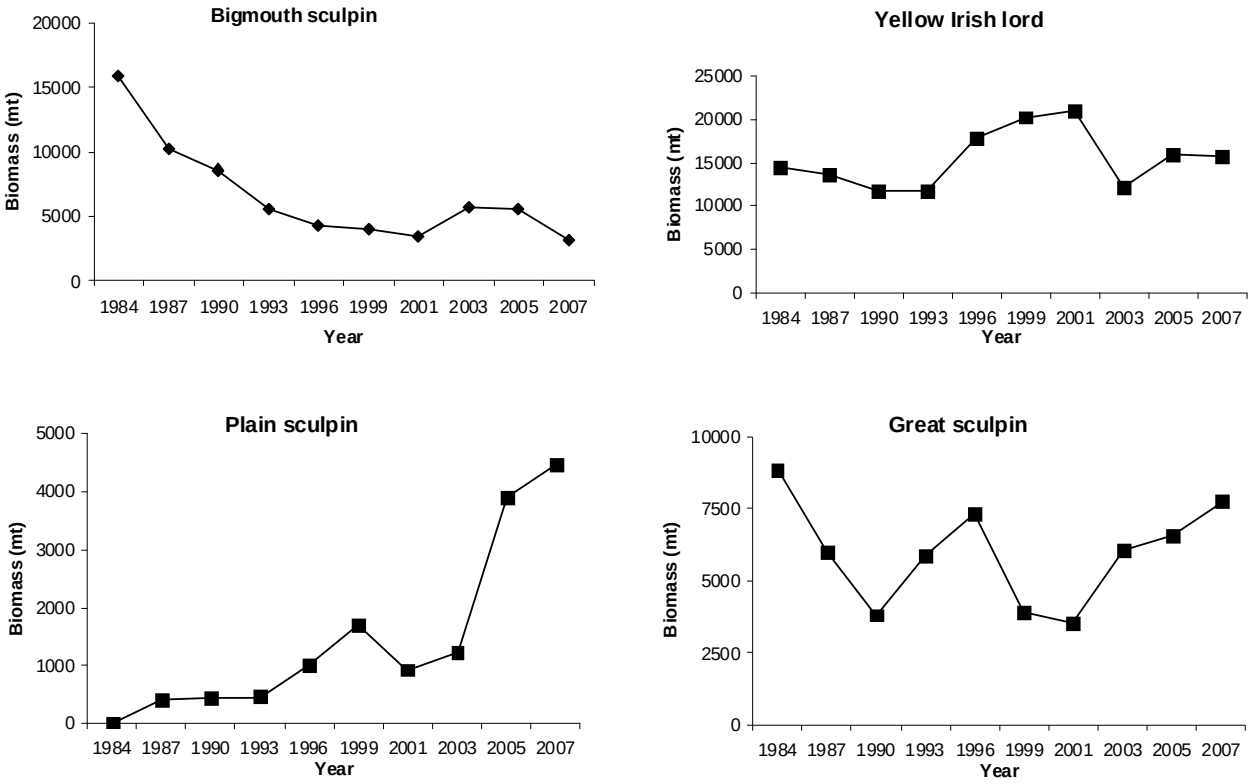


Figure 18a.1. Biomass time series from GOA bottom trawl surveys for selected sculpin species, 1984-2007.

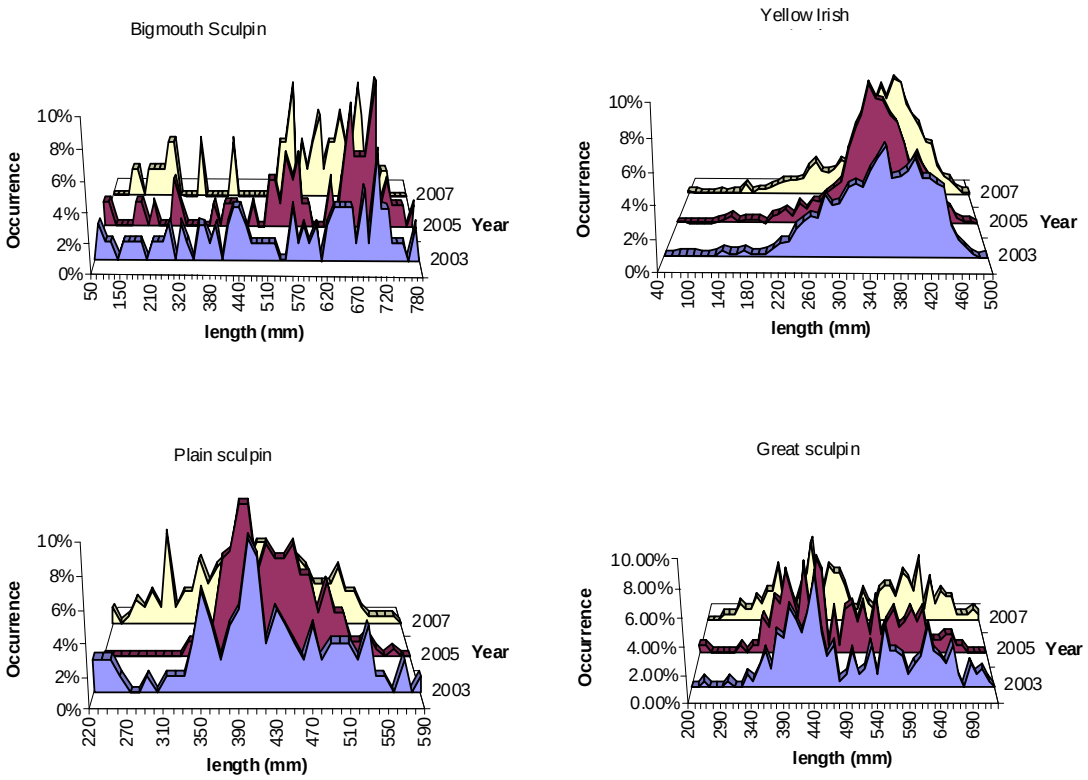
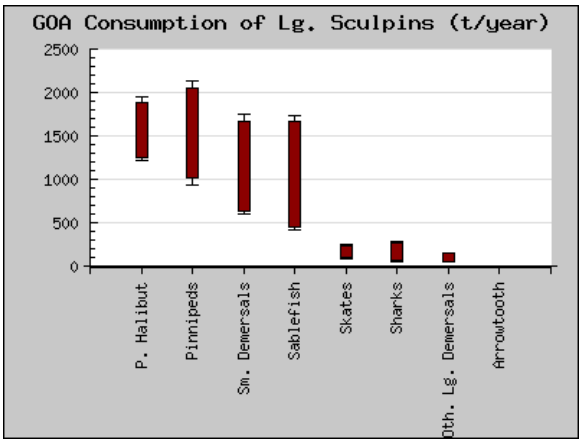
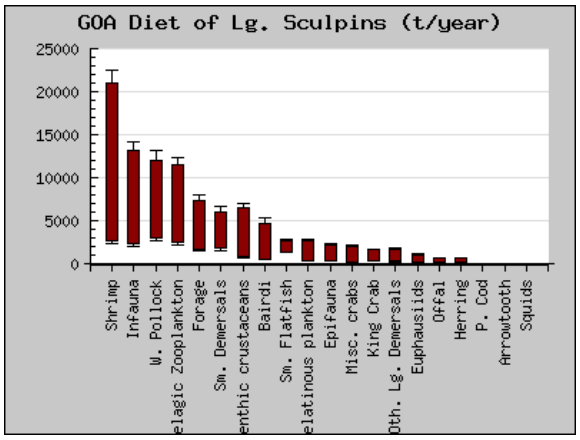


Figure 18a.2. Length frequencies (fork length, FL in mm) from survey data for the 4 most abundant sculpin species in GOA.





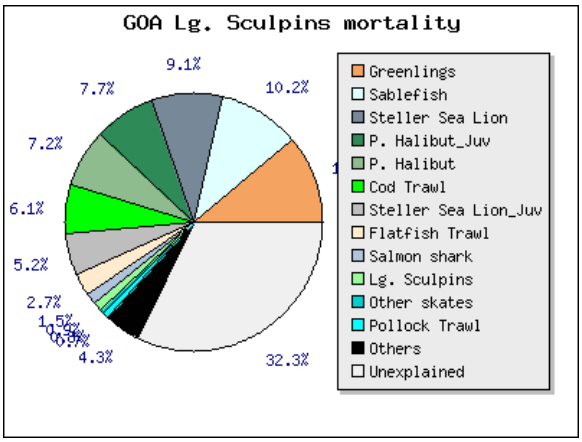
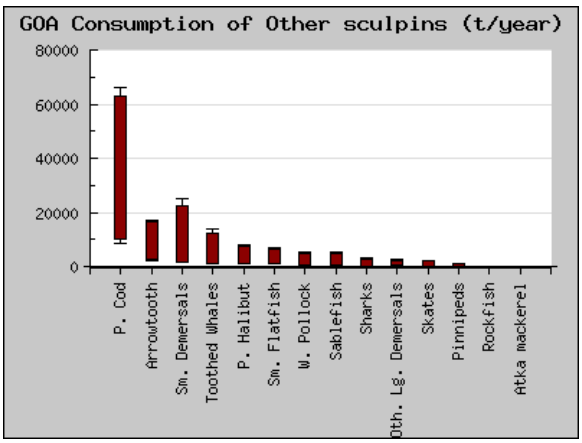
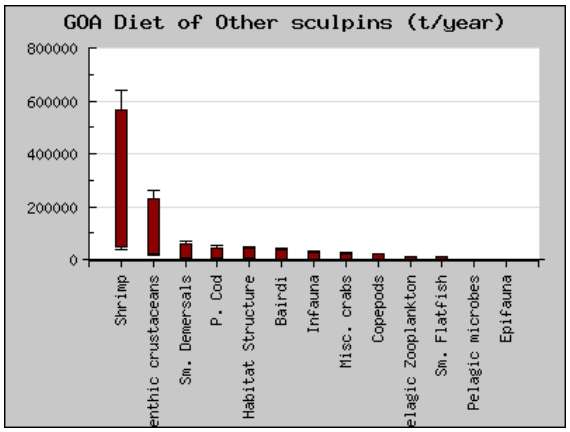


Figure 18a.3 Diet, consumption and mortality information for Large Sculpins in the GOA.





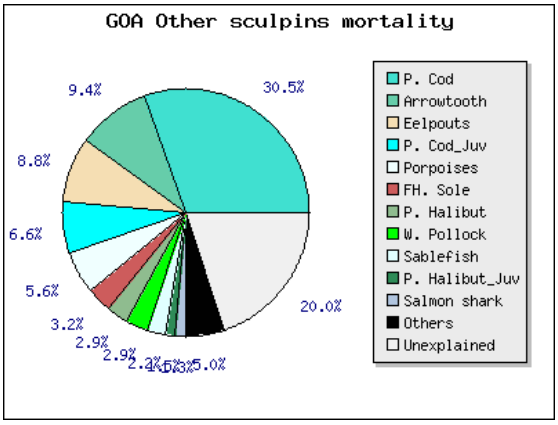


Figure 18a.4 Diet, consumption and mortality information for Other Sculpins in the GOA.