18d. Gulf of Alaska sculpins

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Executive Summary

The year 2010 was an "off" year for the biennial AFSC trawl survey in the Gulf of Alaska (GOA). Because no new biological data area available, this document would typically consist of only an executive summary. However in 2010, the North Pacific Fishery Management Council passed amendment 87 to the GOA Fishery Management Plan, which separated the Other Species complex into its constituent species groups. Thus, GOA sculpins will now be managed as an independent complex with its own harvest specifications and the authors were requested to provide a full assessment for the 2011 fishing season.

Summary of changes

1. Sculpin catch and retention data within the GOA fisheries from 2003-2009 have been updated and partial 2010 data (as of October 10, 2010) has been added.
2. The approach to harvest recommendations and the choice of an appropriate value for instantaneous natural mortality (*M*) has been changed. Estimates of *M* from recent life history studies on sculpins in the Bering Sea/ Aleutian Islands (BSAI) management area have been used to make recommendations for GOA sculpins. In addition, as is done for BSAI sculpins, the *F* for the sculpin complex is based on a weighted average of *M*s for those species where recent data are available.

Summary of results

	last year		**this year**	
quantity/status	*2010*	*2011*	**2011**	2012
sculpin complex average mortality rate*	*0.19*	*0.19*	**0.22**	0.22
specified/recommended Tier	*5*	*5*	**5**	5
biomass	*33,307*	*33,307*	**33,307**	33,307
F_{OFL} (*F=complex mortality rate*)	*0.19*	*0.19*	**0.22**	0.22
max F_{ABC} (maximum allowable = 0.75 *x* F_{OFL})	*0.14*	*0.14*	**0.17**	0.17
specified/recommended F_{ABC}	*0.14*	*0.14*	**0.17**	0.17
specified/recommended OFL (t)	*6,328*	*6,328*	**7,328**	7,328
specified/recommended ABC (t)	*4,746*	*4,746*	**5,496**	5,496
Is the stock being subjected to overfishing?	*no*		**no**	
(for Tier 5 stocks, data are not available to determine whether the stock is in an overfished condition)				

* *The sculpin complex mortality rate is a biomass-weighted average of the instantaneous natural mortality rates for the four most abundant sculpins in the GOA: bigmouth, great, plain, and yellow Irish lord. The complex mortality rate may change as new survey data become available. See "results" section for more detail.*

Introduction

Description, scientific names, and general distribution

Sculpins are a group of benthic-dwelling predatory teleost fishes, that include 46 species in waters off the coast of Alaska. Sculpins have been identified to species 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 (Table 1). It is not clear whether the other 7 species exist in the GOA. Sculpin diversity is high in the GOA and many of these species are also found in the Bering Sea (Table 1). 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* which observers from the North Pacific Groundfish Observer Program have recently begun to identify sculpin catch to genus.

Management units

Historically, sculpins have been managed as part of the GOA Other Species complex, which also includes sharks, octopus and squid. A single TAC was specified for the entire Other Species complex. In response to the requirements for annual catch limits contained within the reauthorization of the Magnuson Stevens Fishery Conservation and Management Act, the NPFMC reviewed the management of other species in the GOA. The NPFMC passed amendment 87 to the GOA FMP that requires that sculpins be managed as separate complex and that Annual Catch Limits (ACLs) would be established annually by the SSC starting in 2011. Sculpins are currently non-targets in the GOA, so the catch of sculpins depends solely on the TAC and spatial temporal limitations placed on target fisheries. Vulnerability analyses indicate that the individual species in the sculpin complex have a wide range of vulnerabilities to overfishing (largely as a result of differences in life history and thus productivity). These results suggest that the composition of the sculpin complex should be examined and the creation of two or more separate sculpin complexes be considered.

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 respond differently to environmental changes (whether natural or fishing induced). 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 2. With the exception of data for bigmouth sculpins, all fecundity and maturity data in Table 2 are from outside GOA region.

Fishery

There are no directed fisheries for sculpin species in the GOA at this time. Sculpins, in 2009, constituted about 43% of the total GOA Other Species complex catch. Prior to 2005, when skates were still included in the complex, they were 7-19% of the other species catch (Table 3). Retained catch of sculpin species in the GOA has increased recently from 7% in 2003 to 18% in 2009 (Table 3; 2010 data are incomplete and not shown). Sculpins are caught incidentally by a wide variety of fisheries. Based on data from the NMFS AKRO the main fisheries that catch sculpins are the flatfish, Pacific cod, and IFQ halibut fisheries (Table 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. After increasing from 583 t in 2006 to 1,943 t in 2008, the total sculpin catch declined to 1,374 t. The 2010 catch as of October 10, 2010 is 854 t. These patterns are largely the result of variability in the catch of sculpins by the shallow-water flatfish target fisheries (Table 4).

In 2002-2003, the observer program of AFSC initiated a species identification project to address 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, the sea raven (*H. villosus*), has never been identified in any of the GOA trawl surveys conducted by AFSC. Therefore, 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 the vast majority of all sculpin catch in the GOA region (Table 5).

The observer catch composition data in Table 5 show that in 2007, *Hemilepidotus* spp. (the Irish lords) made up 65% of the sculpin total observed catch. *Hemitripterus* spp. (bigmouth sculpin) constituted approximately 18% of the total sculpins. In 2008, the first year observers identified the top 5 species of sculpins to species, shows that *Hemilepidotus jordani* (yellow Irish lord) were 62% of all sculpin catch in the GOA, followed by Irish lord unidentified. In 2009 the catch percentage of *H. jordani* was lower but still the largest fraction of sculpin catch. *Myoxocephalus* species make up only a small part of GOA sculpin catches (Table 5). These results indicate that the species composition of the incidental sculpin catch does not parallel the species composition of the sculpin population as estimated by the AFSC groundfish survey: bigmouth sculpins were 7.7% of the 2009 survey sculpin biomass estimate, whereas they constituted 15.3% of the 2009 catch; *Myoxocephalus* spp. were 26.5% of the survey estimate compared to 8.8% of the catch; and miscellaneous sculpins were 3.9% and 12.8% of the survey estimate and catch, respectively. Irish lords were the only group that was represented approximately equal in the survey and in the catch: 61.9% and 63.1%, respectively.

Data

Survey data

Biomass estimates

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 6). Trends in biomass were available for only selected sculpin species for the period 1984-2000 due to difficulties with species identification and survey priorities. Species-specific biomass estimates are available for the 2001-2009 surveys. Almost 95% of the sculpin biomass is comprised of the larger sculpin species in the GOA. Yellow Irish lord is the most abundant (~46% of the sculpin biomass), followed by the genera *Myoxocephalus* at ~27% and bigmouth sculpin at ~22% of the sculpin biomass (Table 7 and Figure 1).

Biomass trends show that the bigmouth sculpin declined between 1984 and 2001, but has remained relatively stable since then (Figure 1). Yellow Irish lord biomass has increased over the last three surveys, which has resulted in an increase in total sculpin biomass (Table 7 and Figure 2). The coefficients of variation (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 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 on every biennial survey since 2003: yellow Irish lord, plain sculpin, great sculpin and bigmouth sculpin (Figure 3). These length compositions have remained fairly stable during this period. 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. 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	2009
yellow Irish lord	917	1034	1044	2573
plain sculpin	81	126	176	153
great sculpin	208	201	209	304
bigmouth sculpin	81	61	51	64

Analytic Approach

Sculpins in the GOA are managed under Tier 5, where OFL = M * average survey biomass and ABC = 0.75 * M * average survey biomass. Average biomass was calculated as the average of the last 4 GOA trawl survey estimates (Table 6). In the past, harvest recommendations for GOA sculpins were made using an estimate of M based on data from the western Bering Sea in the Russian literature. In 2008, life history studies of sculpins in the eastern Bering Sea and Aleutian Islands were completed and the results of those studies are now used to make harvest recommendations for sculpins in the BSAI. In 2009, the BSAI Plan Team recommended that M values based on age-based catch-curve analysis be used wherever possible. In addition, separate ABC and OFL calculations were made for each species where recent M estimates were available and the individual values were aggregated to create sculpin-wide harvest recommendations. In effect, this means that for the BSAI a weighted average of species-specific Ms is

applied to the aggregate sculpin biomass, with the proportional average biomass of each species providing the weights.

We recommend that harvest recommendations for sculpins in the GOA be made using the values of M now in use for the BSAI sculpin complex. Those M estimates are both more recent and closer in geographical distance than the M values used previously. We also recommend that GOA harvest recommendations be based on the application of a biomass-weighted average M to the total sculpin complex biomass.

Results

Recent estimates of M are available for four of the sculpin species in the GOA sculpin complex: yellow Irish lord, great sculpin, bigmouth sculpin, and plain sculpin (Table 8). Together, these 4 species comprise 96% of the estimated GOA sculpin biomass (Table 7). A biomass-weighted average M was calculated according to the following table:

species	average biomass	*M*	weighted contribution to *M*	weighted average *M*
yellow Irish lord	17,239	0.17	0.09	0.22
great	7,140	0.28	0.06	
bigmouth	4,398	0.21	0.03	
plain	3,038	0.40	0.04	

The weighted average M of 0.22 was used to make the following harvest recommendations. The lowest species-specific M is 0.17, so the recommended FABC was calculated as 0.75*0.17=0.13.

2011-2012 harvest recommendations for the GOA sculpin complex	
sculpin complex biomass	33,307
complex *M*	0.22
F_{OFL}	0.22
maximum permissible F_{ABC}	0.17
recommended F_{ABC}	0.17
OFL	7,328
maximum permissible ABC	5,496
recommended ABC	5,496

Ecosystem Considerations

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 4). In the GOA the main predator of large

sculpins are Pacific halibut, pinnipeds, small demersal fish and sablefish (Figure 4). Other sculpins in the GOA feed mainly on shrimp and benthic crustaceans (Figure 5). Other sculpins are mainly preyed upon by Pacific cod and is the main source of mortality (Figure 5). Source of above information from Aydin et al. (2007).

Fishery Effects on the Ecosystem

Analysis of ecosystem considerations for those fisheries that affect the stocks within this complex (see Table 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)**			

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.

Literature Cited

Alverson, D.L., and M.J. Carney. 1975. A graphic review of the growth and decay of population cohorts. J. Cons. Int. Explor. Mer 36:133-143.

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. NOAA Tech Memo.178 298pp.

Charnov, E.L. 1993. Life history invariants some explorations of symmetry in evolutionary ecology. Oxford University Press Inc., New York. 167p.

Eschmeyer, W.N., E.S. Herald, and H. Hammann, 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Co., Boston: 336 pp.

Gaichas, S.K., D. Courtney, T. TenBrink, M. Nelson, S. Lowe, J. Hoff, B. Matta and J. Boldt. 2004. BSAI Squid and Other species stock assessment. In Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska Region. North Pacific Fishery Management Council, 605 W. 4th Ave., Suite 306, Anchorage, AK 99501.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82: 898-903.

Markevich, A. 2000. Spawning of the sea raven *Hemitripterus villosus* in Peter the Great Bay, Sea of Japan. Russian Journal of Marine Biology 26(4): 283-285.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. Int. Explor. Mer 39(2):175-192.

Rikhter, V.A., and V.N. Efanov. 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res. Doc. 76/VI/8. Serial N. 3777. 13p.

Roff, D.A. 1986. The evolution of life history parameters in teleosts. Can. J. Fish. Aquat. Sci. 41:989-1000.

Stevenson, D.E. 2004. Identification of skates, sculpins, and smelts by observers in North Pacific groundfish fisheries (2002-2003). U.S. Dept. Commer., NOAA Tech. Memo. NMFS-AFSC-142, 67p.

Tokranov, A.M., 1985. Reproduction of great sculpin, *Myoxocephalus polyacanthocephalus* (Cottidae) in Kamchatka waters. J. Ichthyol. 24(4):119-127.

Table 1. Sculpin species that have been observed during AFSC GOA bottom trawl surveys.

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

Table 2. Life history information available for selected GOA sculpin species. "O" designates data was obtained from individuals of that species outside the GOA region.

Species	common name	maximum length (cm)		maximum age		fecundity (x1000)	age at 50% maturity
		O	GOA	O	GOA		
Myoxocephalus joak	plain	75	59	15		25.4 - 147	5 - 8
M. polyacanthocephalus	great	82	72	13		48 - 415	6 - 8
M. verrucosus	warty	78				2.7	
Hemitripterus bolini	bigmouth	83	86			2.3	
Hemilepidotus jordani	yellow Irish lord	65	50	13		25 - 241	6 - 7
H. papilio	butterfly	38					
G. pistilliger	threaded	27		13		5 - 41	
G. galeatus	armorhead	46	28	13		12 - 48	
Dasycottus setiger	spinyhead	45	22	11			
Icelus spiniger	thorny	17					
Triglops pingeli	ribbed	20		6		1.8	
T. forficate	scissortail	30	28	6		1.7	
T. scepticus	spectacled	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.

Table 3. GOA total sculpin complex catch, retention rate, total Other Species catch, and sculpin percentage of Other Species catch, 1997-2010*. *Source: AKRO Catch Accounting System except for retention rate, which was estimated from fishery observer data obtained from the AFSC Fishery Monitoring and Analysis program.*

Year	Sculpin complex total catch	retention rate	Other species total catch	Percent of Other Species catch
1997	898		4,823	19%
1998	526		7,422	7%
1999	544		3,788	14%
2000	940		5,455	17%
2001	587		3,383	17%
2002	919		8,162	11%
2003	629	7%	6,266	10%
2004+	701	9%	1,705	41%
2005	626	16%	2,513	25%
2006	583	16%	3,881	15%
2007	960	19%	3,035	32%
2008	1,925	14%	2,967	65%
2009	1,374	18%	3,188	43%
2010*	854	n/a	1,724	50%

+ Beginning in 2004, skates were removed from Other Species complex.

* 2010 data as of October 10, 2010. Retention rate not reported for 2010 due to incomplete data.

Table 4. Total GOA sculpin catch (t) by target fishery, 2003-2010. *Source: AKRO Catch Accounting System.*

target fishery	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010***
arrowtooth flounder	16	7	19	36	38	16	16	12
deep flatfish	2	2	0	0	0	0	0	0
flathead sole	4	10	3	1	0	16	3	3
IFQ_halibut	54	43	30	14	33	141	177	53
other target	6	0	0	0	0	0	11	0
Pacific cod	381	431	320	361	444	745	562	567
rex sole	27	19	11	7	8	4	31	6
rockfish	24	58	27	32	31	23	34	62
sablefish	1	2	17	4	7	2	20	1
shallow flatfish	113	129	200	125	376	963	514	146
pollock	1	0	0	2	22	15	5	3

* 2010 data are as of October 10, 2010.

Table 5. Estimated species composition of GOA incidental sculpin catches, 2007-2010, based on fishery observer data. *Source: NMFS AFSC Fishery Monitoring and Analysis Program.*

	proportion of catch			proportion of 2009 survey biomass
	2007	**2008**	**2009**	
Hemitripterus* spp.*	**18.0%**	7.8%	**15.3%**	**7.7%**
H. bolini		7.8%	15.3%	7.7%
***Hemilepidotus* spp.**	**65.0%**	**78.6%**	**63.1%**	**61.9%**
Hemilepidotus unidentified		16.4%	24.8%	
H. hemilepidotus		<1%	<1%	
H. jordani		61.7%	37.8%	61.9%
***Myoxocephalus* spp.**	**9.0%**	**11.5%**	**8.8%**	**26.5%**
Myoxocephalus unidentified		<1%	2.3%	
M. verrucosus		<1%	<1%	0%
M. jaok		<1%	<1%	6.3%
M. polyacanthocephalus		10.0%	6.2%	20.2%
miscellaneous sculpins§	**8.0%**	**3.4%**	**12.8%**	**3.9%**

** Hemitripterus spp. probably represents only one species (bigmouth sculpin).
§ Miscellaneous sculpins includes unidentified sculpins as well as darkfin, scissortail, and longfin Irish lord.

Table 6. Sculpin complex biomass estimates (t) based on NMFS bottom-trawl surveys, 1984-2007.

year	biomass (t)	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
2009	40,726	0.11

Table 7. GOA trawl survey biomass estimates (t) for individual sculpin species, 1996-2009, with 2009 CV.

species	biomass							CV
	1996	**1999**	**2001***	**2003**	**2005**	**2007**	**2009**	**2009**
crested	-	-	6	-	-	-	-	-
spinyhead	278	271	690	608	463	422	410	0.14
antlered	-	-	1	-	-	-	-	-
armorhead	13	15	60	78	28	58	216	0.22
threaded	3	-	21	<1	2	-	2	0.70
yellow Irish lord	17,804	20,255	20,945	12,064	15,952	15,720	25,219	0.16
butterfly	<1	1	-	-	-	-	-	-
bigmouth	4,246	3,983	3,471	5,767	5,543	3,126	3,154	0.19
thorny	1	-	1	<1	<1	<1	<1	-
Pacific staghorn	-	1	2	-	14	-	8	0.63
darkfin	477	371	335	607	944	790	614	0.22
plain	1,015	1,692	932	1,220	3,912	4,456	2,562	0.30
great	7,326	3,913	3,540	6,037	6,574	7,734	8,215	0.18
warty	-	-	339	-	-	33	-	-
scissortail	60	47	62	94	23	30	111	0.49
spectacled	90	233	12	40	105	96	68	0.83
total	**31,313**	**30,782**	**30,417**	**26,515**	**33,560**	**32,468**	**40,726**	**0.11**

* The 2001 trawl survey did not cover the eastern GOA, so those numbers are not directly comparable.

Table 8. List of available natural mortality information for sculpins. Values are from Ormseth and TenBrink 2009.

Species	Area	Sex	Hoenig	Jensen	Charnov	catch curve	SAFE *M*
yellow Irish lord	EBS	M	0.17	0.41	0.45	0.17	0.17
	EBS	F	0.15	0.47	0.51	0.17	
	AI	M	0.21	0.23	0.27	0.17	
	AI	F	0.16	0.27	0.31	0.17	
great sculpin	EBS	M	0.28	0.39	0.43	0.25	0.28
	EBS	F	0.25	0.27	0.3	0.31	
bigmouth sculpin	EBS	both	0.21	0.21	0.24	n/a	0.21
plain sculpin	EBS	M	0.28	0.38	0.42	0.39	0.4
	EBS	F	0.26	0.27	0.55	0.41	

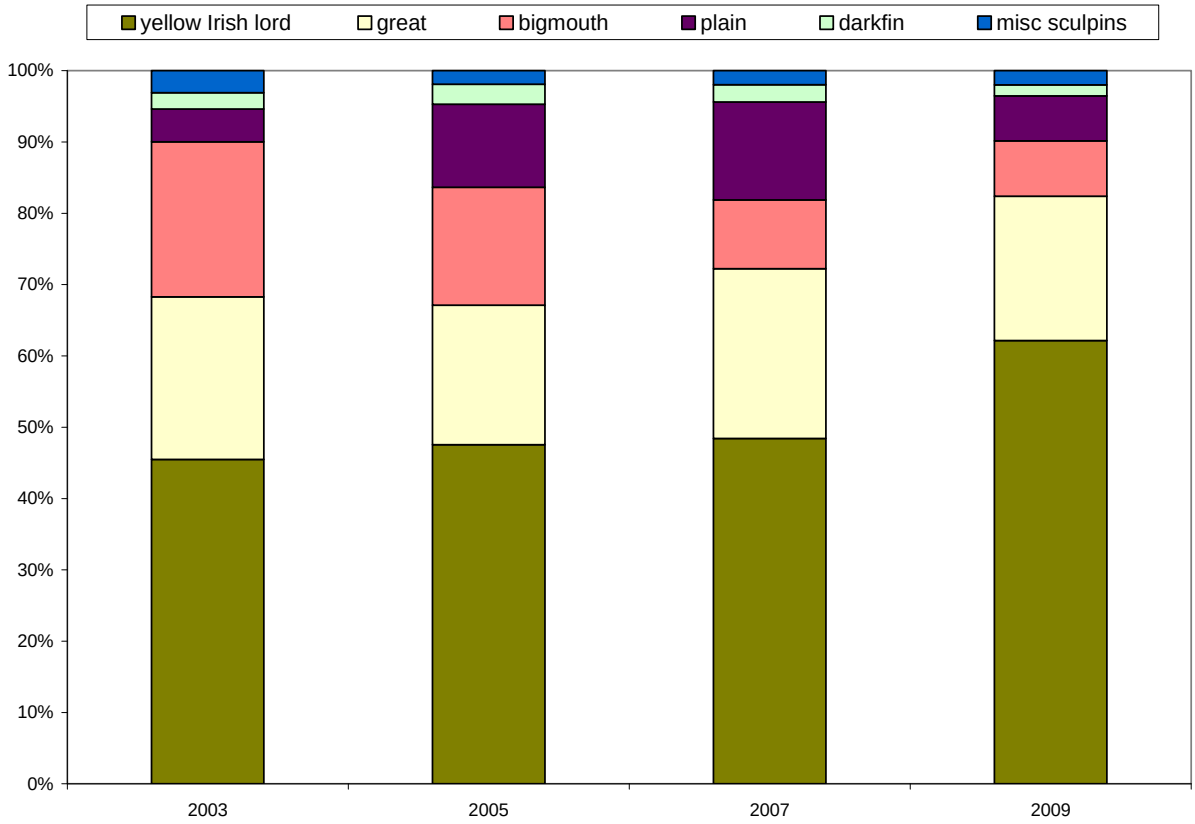

Figure 1. Species composition of the sculpin complex in the GOA. Data are from the 2003-2009 AFSC GOA bottom trawl surveys.

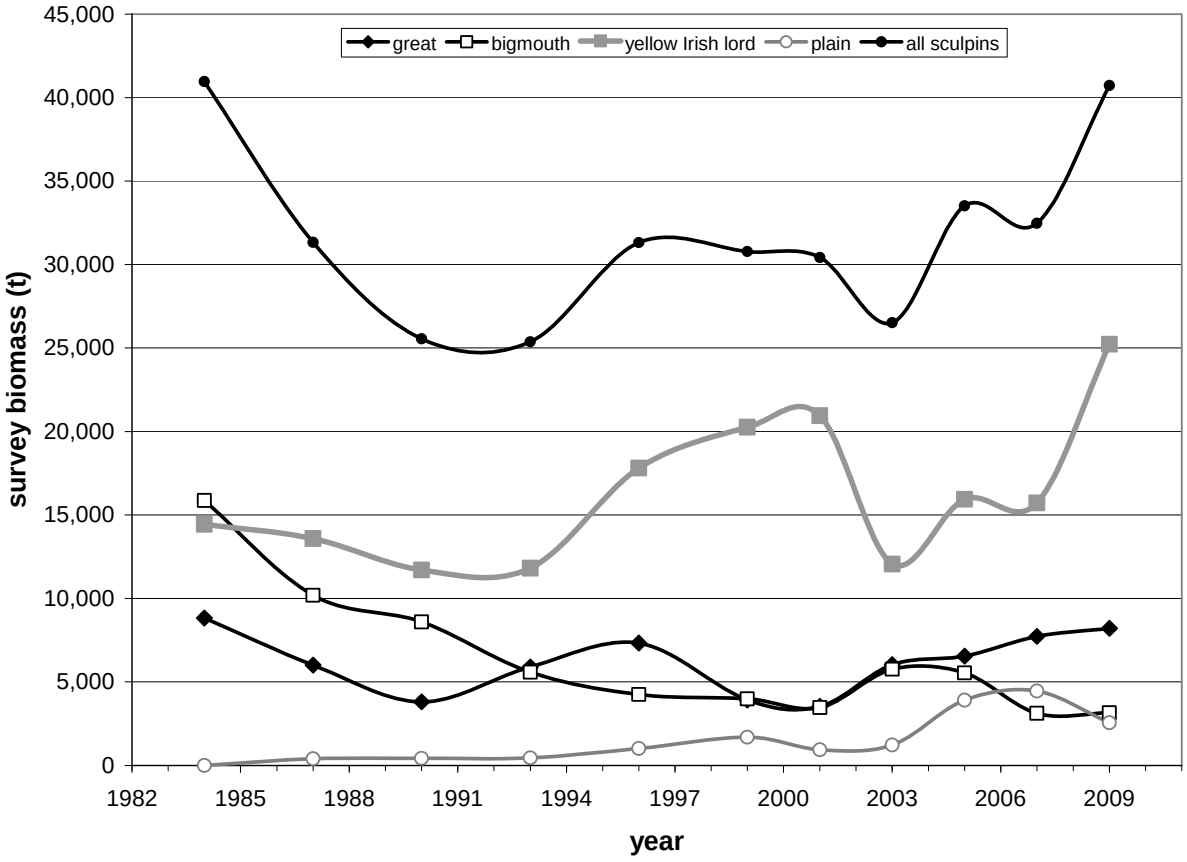

Figure 2. Time series of trawl survey biomass estimates for selected sculpin species and all sculpins combined in the GOA, 1984-2009.

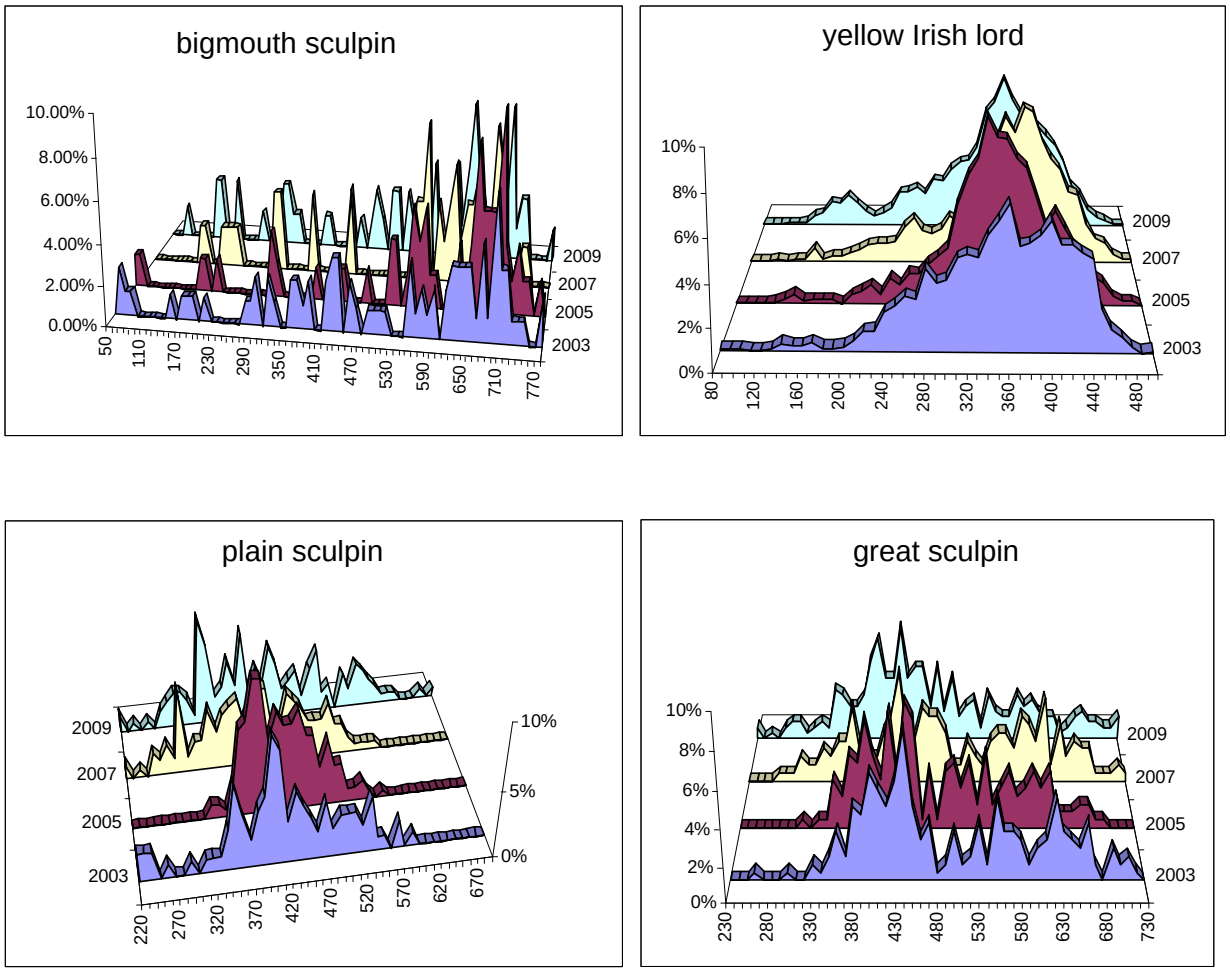

Figure 3. Length composition (fork length, FL in mm) from survey data for the 4 most abundant sculpin species in the GOA, 2003-2009.

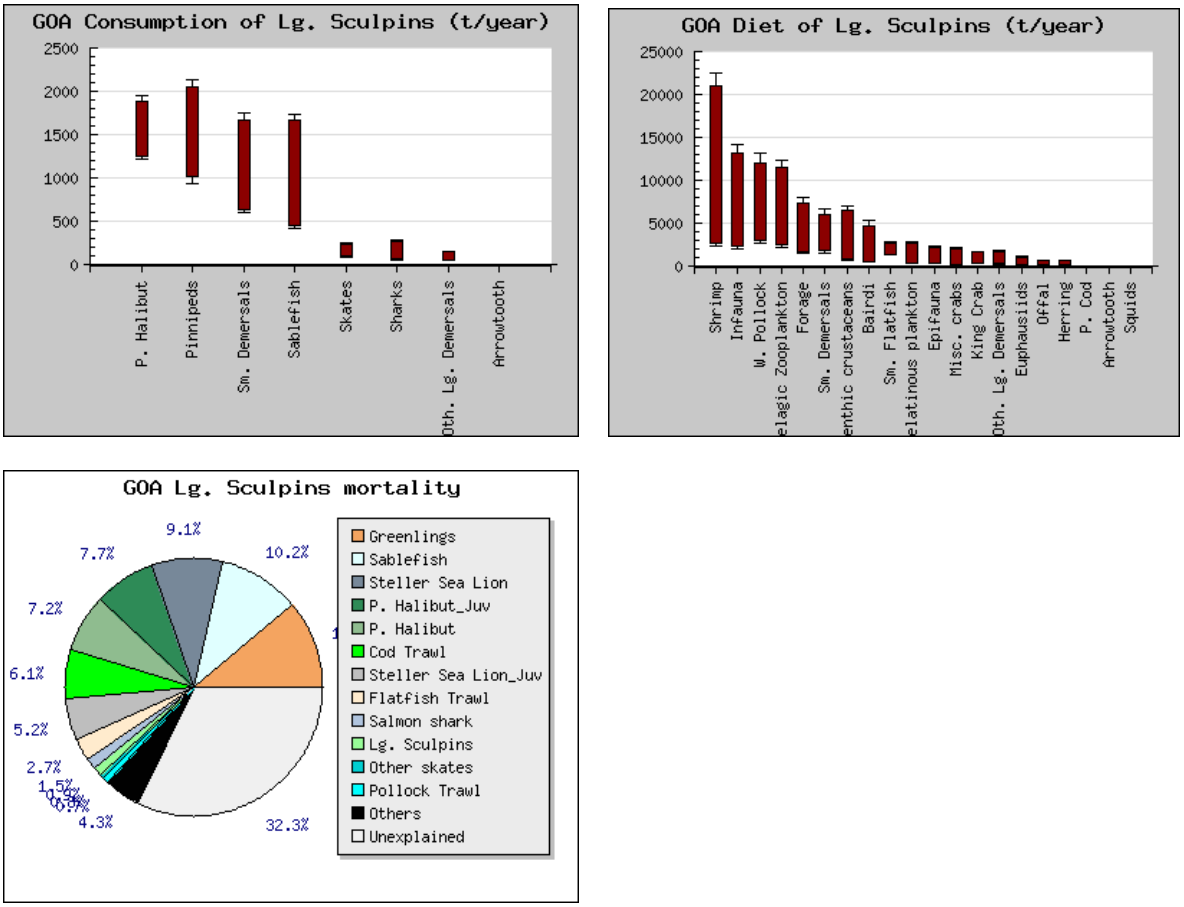

Figure 4. Diet, consumption and mortality information for Large Sculpins in the GOA.

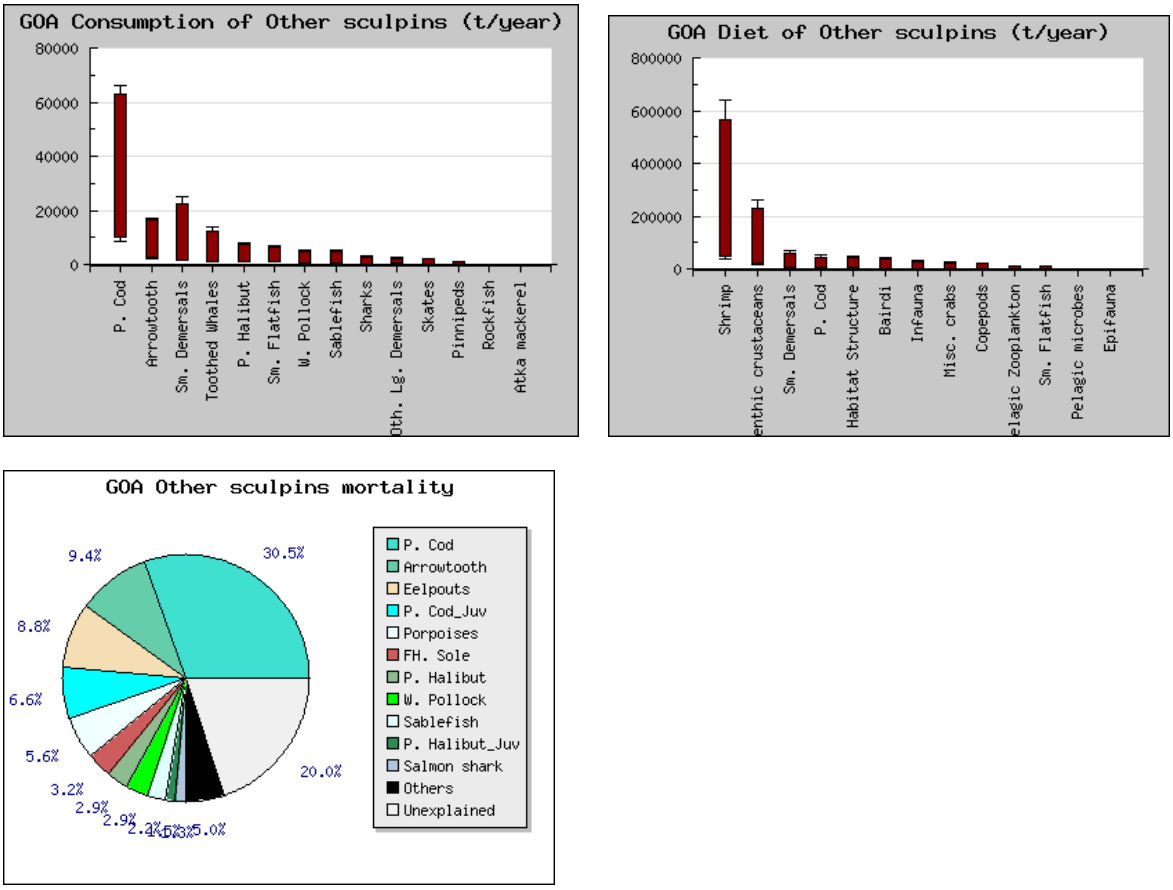

Figure 5. Diet, consumption and mortality information for Other Sculpins in the GOA.

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