

Coastal Intertidal Fish Inventory

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Background

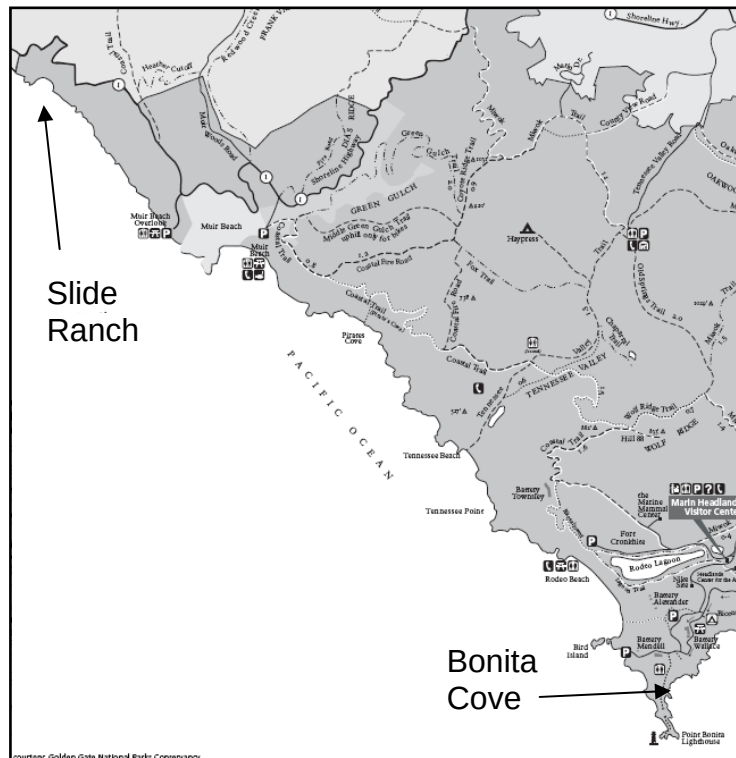
In 2002 the National Park Service (NPS), the Point Reyes National Seashore (PRNS), the San Francisco Bay Area Network of Parks and San Francisco State University entered into a Cooperative Agreement to conduct educational and scientific research (Task Agreement No. J8530020077). The agreement was the result of a desire to conduct an “inventory” of marine intertidal organisms, particularly fish, in the PRNS and the Golden Gate National Recreation Area (GGNRA). We have found no published surveys of the intertidal fish fauna of this area, but Yoshiyama (1981) and Grossman (1982, 1986) published on extensive collections of intertidal fishes along the San Mateo county coast and at Dillon Beach (respectively). This joint agreement was intended to provide the NPS with the appropriate knowledge to fulfill its mission to preserve and protect the resources in the PRNS and the GGNRA by providing basic information on the species composition and distribution of intertidal fish within its boundaries.

Methods

Four sites, each visited only once, were selected to conduct this study. Two sites were located within the GGNRA: Bonita Point (N 37.49, W 122.32) and Slide Ranch (N 37.52.163, W 122.35.746) (Figure 1), and two were in the PRNS: Santa Maria Creek (N 38.00.764, W 122.51.003) and Bolinas Point (N 37.54.224, W 122.43.732) (Figure 2). Sites were selected based on location and recommendations from Ben Becker of NPS and

Darren Fong of the GGNRA. We sampled during the extreme low tide series of July 20-23, 2005, which allowed for maximum reef exposure and collection time.

Figure 1. Sampling sites within the GGNRA



After assessing each site upon arrival we would begin our survey at the lowest point on the reef. This allowed us to sample the lowest pools in advance of the incoming tide. We then worked our way up the reef from lower to higher pools. We recorded the depth, length and width for each pool sampled and its distance from average sea level height at the given time. If the pool was deep, water was bailed out using a bilge pump and buckets. Once the water level was reduced, CO₂ was pumped into the pools to sedate the fish for easier capture. The fish were then caught using dip nets of various sizes. In some pools, an attempt to net fish was conducted before bailing. After collection, the

pools were immediately refreshed by adding seawater. Yoshiyama (1981) and Grossman (1982, 1986) employed similar methods in tidepools, but utilized the anesthetic quinaldine, which is more effective than CO₂ gas in helping to reveal cryptic species (Gibson 1999). Quinaldine is no longer legal to use in scientific studies in California.

Figure 2. Sampling sites within the PRNS.



Some of our sites included stretches of reef without well-defined pools, but which included boulder fields that often provide good intertidal fish habitat. We sampled these areas by laying a 30-m transect and examining the area within one half meter of each side of the transect. Rocks were overturned and crevices explored by hand, in addition to using nets, in an effort to catch as many fish as possible. It was not possible to use CO₂ gas to slow the movements of fish in this habitat.

Fish removed from the pools were placed in a bucket of fresh seawater for later identification. Once pools from the low tide area were sampled, we would move up to the

middle of the reef, repeat the process and then move to the highest part of the reef. Miller and Lea (1972) and Eschmeyer (1983) were used to identify all fish, which were also measured to total length (TL). Voucher specimens were collected of species from each site to be sent to the California Academy of Sciences. These fish are preserved in alcohol in case later genetic work is desired. All other fish were returned to the tidepools once they were identified and measured.

The potential for discovering additional species at each site was assessed by computing the relationship between cumulative number species observed and the cumulative of pools or transects sampled. To do this, the order of samples within a site was either permuted to all possible combinations of sequence (Slide Ranch), or the order of samples was randomized 50 times (Bollinas Point and Santa Maria Creek). For each permutation or randomization, the cumulative number of species observed was tabulated for the sequence of samples. Finally, the mean cumulative number of species was calculated for the samples in the first, second, third, etc., position, and plotted against cumulative number of samples. An asymptote in the cumulative number of species would indicate adequate sampling of overall species composition at each site. To further address the diversity of species sampled, the species composition observed in this study was compared with more extensive sampling efforts by Yoshiyama (1981) to the south of the GGNRA, along the San Mateo County coast, and by Grossman (1982) at Dillon Beach, just to the north of the PRNS.

Results

GGNRA

Bonita Cove

We sampled Bonita Cove, in the Marin Headlands of the GGNRA (Figure 1), on July 20, 2005, and found only three fish, all of which proved to be the saddleback sculpin, *Oligocottus rimensis*. This species was found at only one other site, Slide Ranch. Three pools were sampled at Bonita Cove, adjacent to the trestle that marks the site of the historic U.S. Lifesaving Service launch site. These pools are not natural, but are the result of the design of the abandoned tracks. The pools are made of concrete that rests on basalt outcroppings. There are abundant spaces in these pools where water, algae, and invertebrate animals collect. We sampled at low, intermediate and high elevation pools relative to the water line. To the west of these pools and across a rocky beach, there is a cobble/boulder field that also provides a moderately rich intertidal habitat. We sampled here using a 30 meter band transect, but no fish were found in this region of Bonita Cove; all three of the sculpins found at this site were found in the man-made pools.

The sizes of the three sculpins found in Bonita Cove ranged from 67 to 73 mm.

Slide Ranch

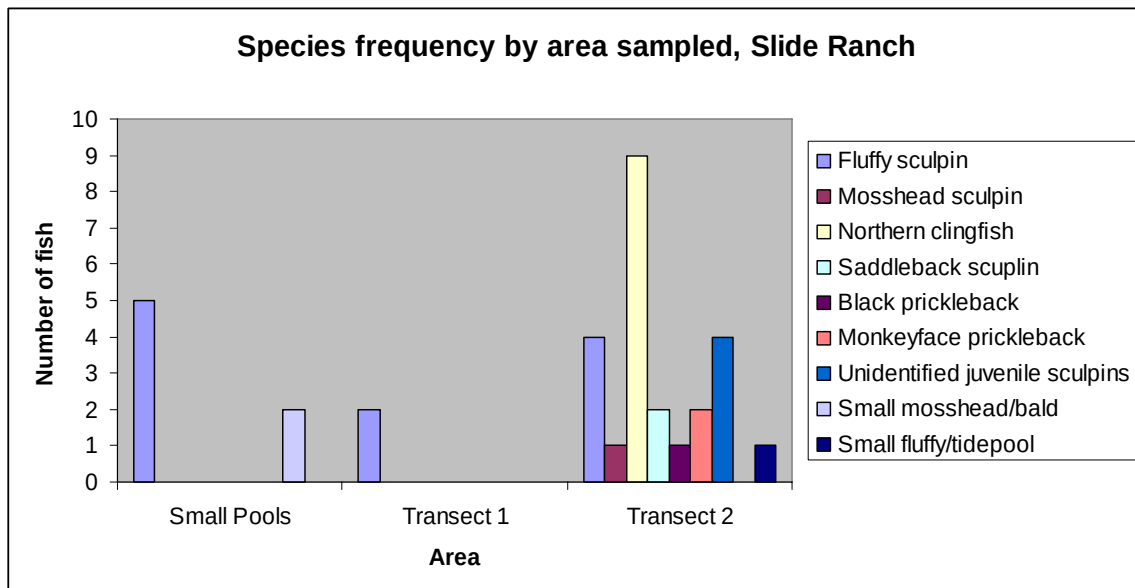
The second site in the GGNRA was sampled on July 23, 2005 at Slide Ranch, just south of the town of Stinson (N 37.52.163, W 122.35.746). The two most abundant species of fish found here were the fluffy sculpin (*Oligocottus snyderi*) and the northern clingfish (*Gobiesox maeandricus*) (Table 1). More species (6) were identified at this site than at any other site. The northern clingfish and black prickleback were found only at this site, and mosshead sculpin and monkeyface prickleback were found at other sites.

Table 1. Species collected at Slide Ranch.

Common names	Scientific names	# Collected	Percentages
Fluffy sculpin	<i>Oligocottus snyderi</i>	11	34.4
Northern clingfish	<i>Gobiesox maeandricus</i>	9	28.1
Saddleback sculpin	<i>Oligocottus rimensis</i>	2	6.25
unidentifiable juvenile sculpin		3	9.4
Monkeyface prickleback	<i>Cebidichthys violaceus</i>	2	6.3
Mosshead sculpin	<i>Clinocottus globiceps</i>	1	3.1
Black prickleback	<i>Xiphister atropurpureus</i>	1	3.1
Juv. fluffy/tidepool sculpin	<i>Oligocottus sp.</i>	1	3.1
Juv. mosshead/bald sculpin	<i>Clinocottus sp.</i>	2	6.25
Total		32	

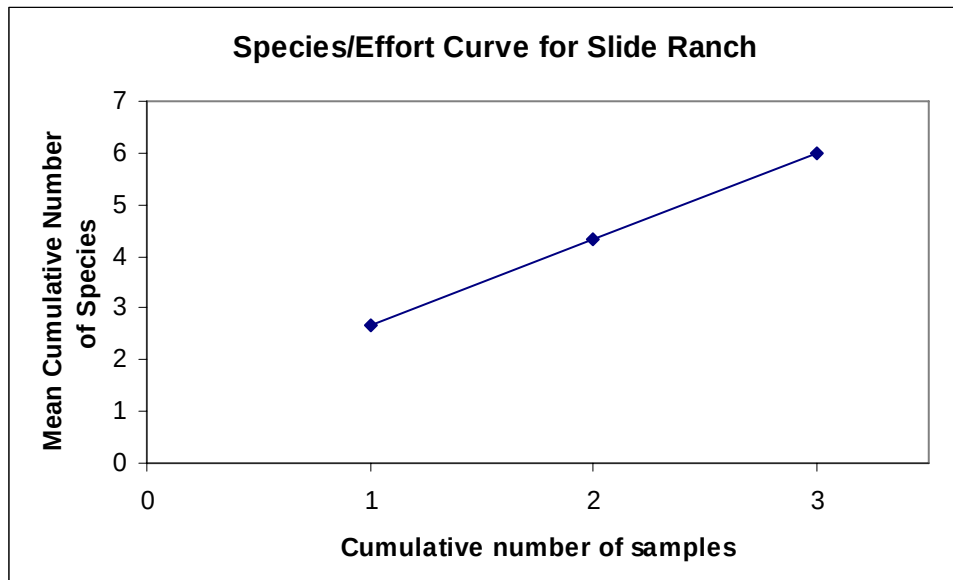
Slide Ranch offered few true tidepools from which to sample. The intertidal zone consisted primarily of a boulder field adjacent to sandy regions, strewn with a high density of kelp and other algae. We sampled some small pools here and laid two 30-meter transects at different elevations relative to the waterline. The second, higher transect yielded far more fish than any of the other samples (Figure 3).

Figure 3. Collections in different sampling units at Slide Ranch



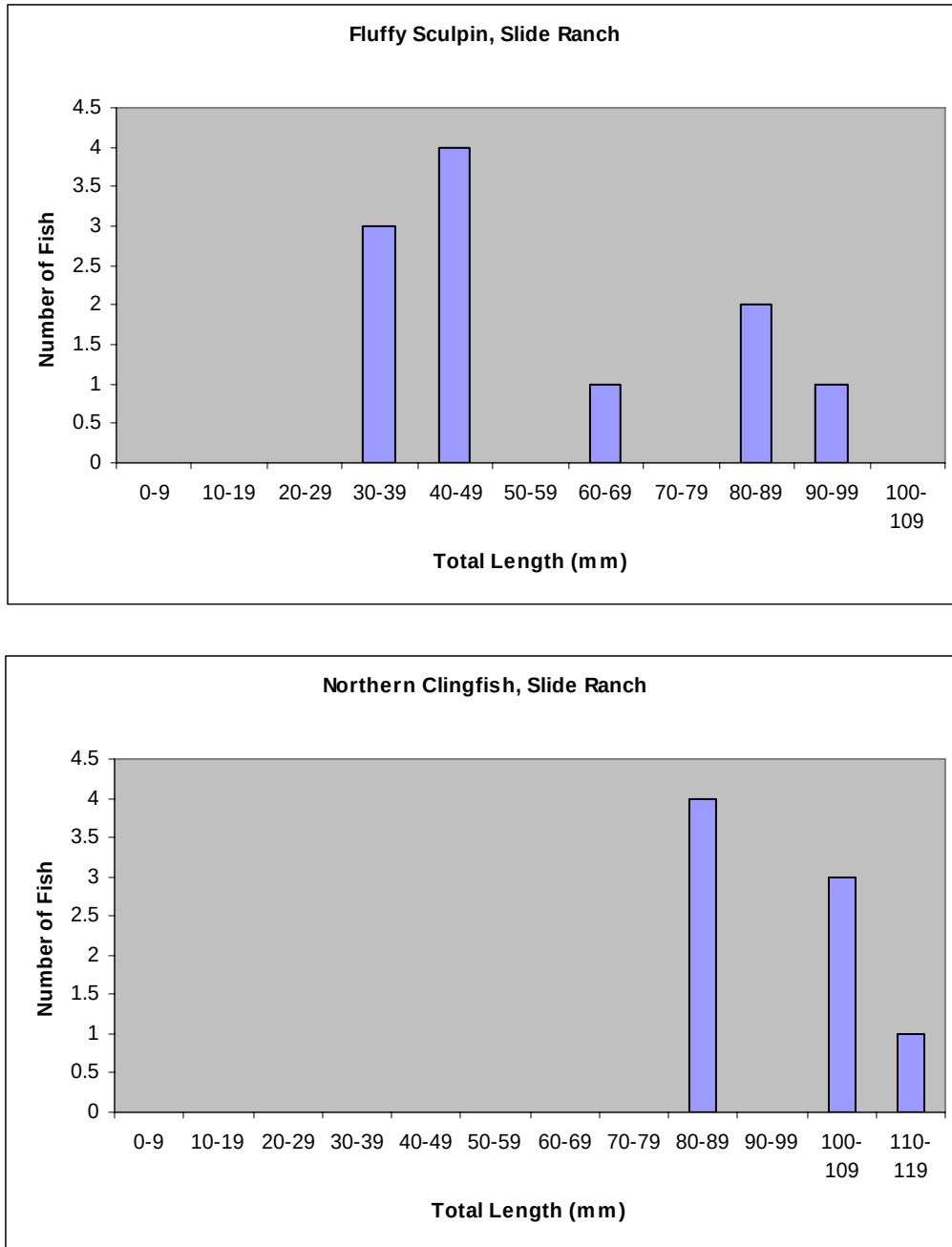
This may be due to a variety of factors other than an increase in fish density. The area was somewhat easier to sample, and we managed to refine our technique for hunting fish in boulder fields by the last transect. This technique involved grabbing fish by hand before they could slither away under adjacent boulders. We saw many more fish than we were able to catch at this site. Due to the particularly difficult topography of the site, fish were able to wriggle and disappear under rocks and into algae. The dissimilarity of the sampling sites, and the increased sampling success in Transect 2 led to species-effort relationship that did not reach an asymptote (Figure 4).

Figure 4. Relationship between mean cumulative number of species collected and number of units sampled at Slide Ranch (N = 6 permutations of sample order).



The size of the clingfish found at Slide Ranch ranged from 72-98 mm, while the size of fluffy sculpins ranged from 20-80 mm (Figure 5). A larger and smaller size mode of fluffy sculpin indicates the presence of two year classes of fish.

Figure 5. Sizes of fluffy sculpin and northern clingfish samples at Slide Ranch.



PRNS

Bolinas Point

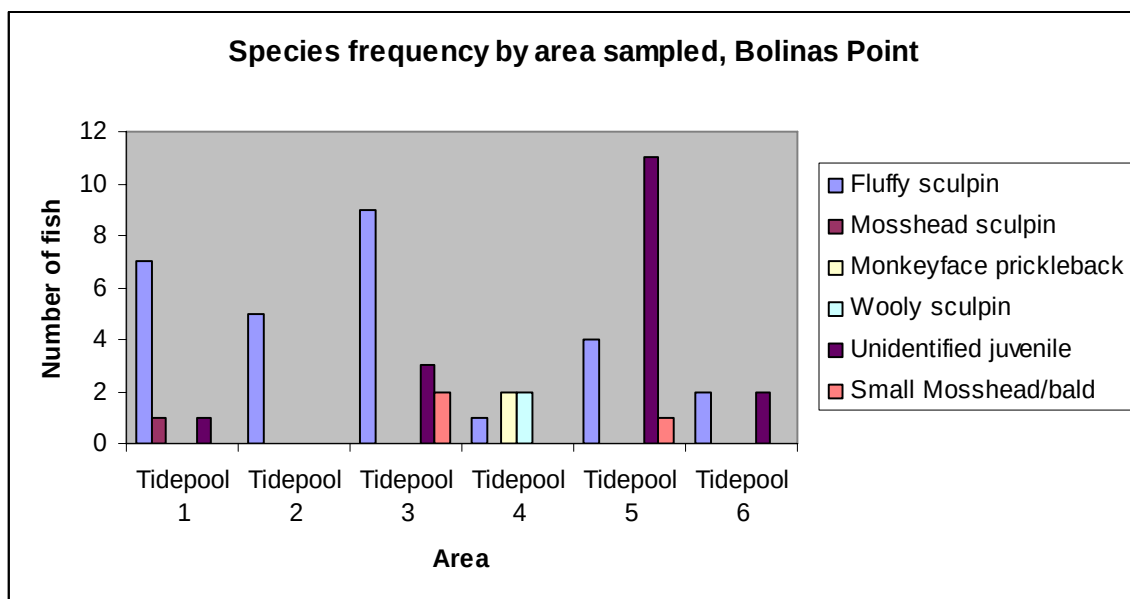
The two sites sampled in the PRNS were Bolinas Point and Santa Maria Creek (Figure 2). The intertidal region at Bolinas Point consists of a large shale reef with a great deal of relief. Six pools were sampled, two at the lowest exposed point on the shelf, two midway up and two close to the high end of the rocky reef. On July 21, 2005, when we sampled Bolinas Point, the fluffy sculpin (*O. snyderi*) dominated the species assemblage of fishes on the reef (Table 2). A number of other species co-occurred with *O. snyderi*, but in considerably fewer numbers. *O. snyderi* occurred in every sample (Figure 6). A single adult mosshead sculpin was observed in tidepool 1. Small individuals that could not be positively identified as either mosshead or bald sculpin because these species cannot be distinguished at sizes smaller than 35 mm (Miller and Lea 1972) were found in two additional pools, distributed throughout the intertidal zone. Since no other bald sculpin were positively identified in this study, these small specimens were probably also mosshead sculpins. Wooly sculpin and monkeyface prickleback were also observed at this site, and at one other site each.

Table 2. Species collected at Bolinas Point

Common names	Scientific names	# Collected	Percentages
Fluffy sculpin	<i>Oligocottus snyderi</i>	28	52.8
Unidentified juvenile sculpin		17	32.1
Mosshead sculpin	<i>Clinocottus globiceps</i>	1	1.9
Monkeyface prickleback	<i>Cebidichthys violaceus</i>	2	3.8
Wooly sculpin	<i>Clinocottus analis</i>	2	3.8
Juvenile Mosshead/bald sculpin	<i>Clinocottus globiceps/recalvus</i>	3	5.7
	Total	53	

Another pool, “Tidepool 5”, at the highest point on the reef, held a large number of unidentifiable juvenile sculpins. These sculpins dominated the assemblage of this pool, which was unique among all of the pools at this site in that it was characterized by surf grass. While our data are not extensive enough to indicate a trend, they offer some suggestion that small juvenile sculpins have a preference for surf grass, and for pools located higher up on the reef, as evidenced by their distribution at both Bolinas (Figure 6) and at Slide Ranch.

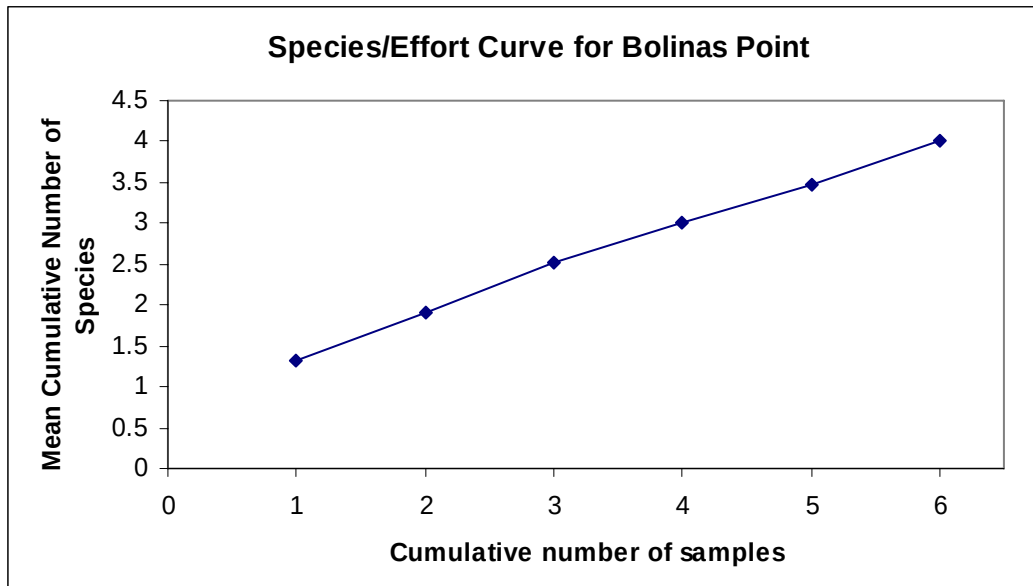
Figure 6. Collections in different sampling sites at Bolinas Point.



The species-effort relationship for Bolinas Point showed no indication of reaching an asymptote (Figure 8). This suggests that the sample of 6 tidepools was inadequate to characterize the species composition on the reef. Had the juvenile mosshead or bald sculpins been included in among the mosshead sculpins, perhaps the relationship would have showed a greater tendency to reach an asymptote. However, the appearance of two

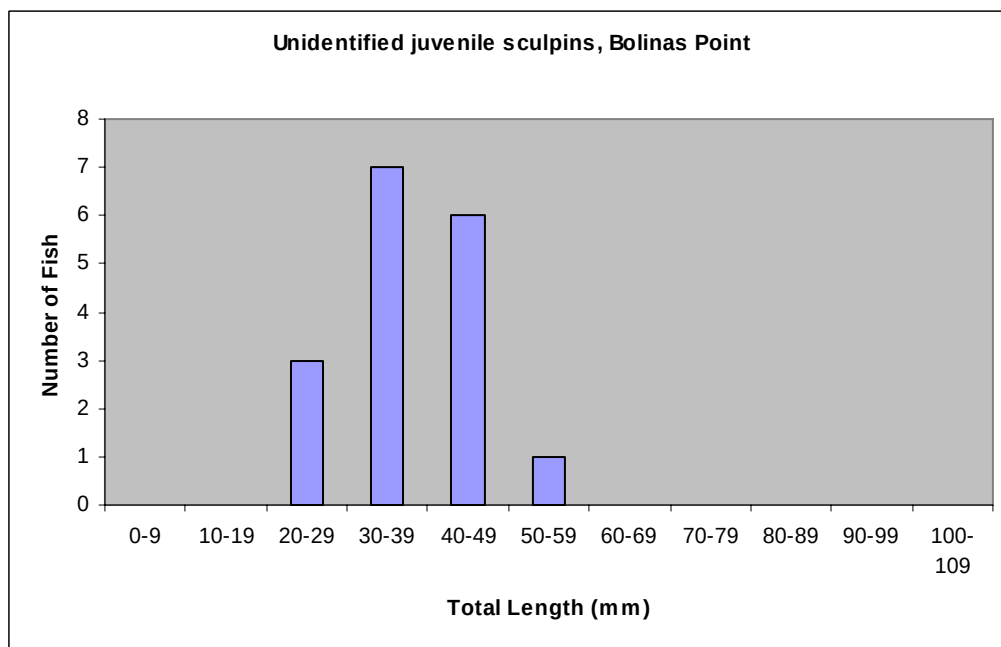
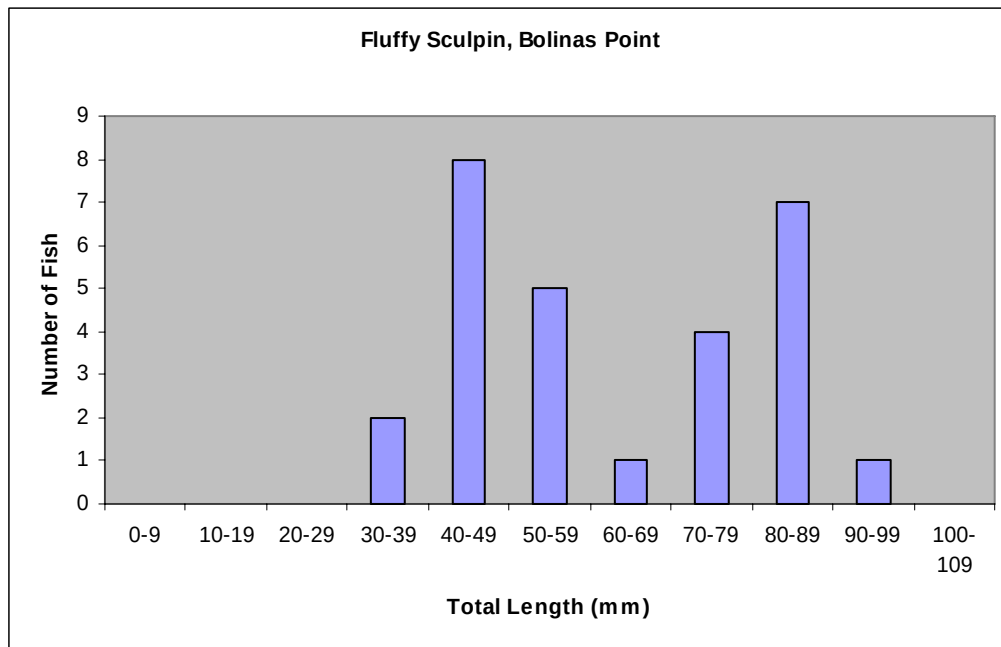
species (wooly sculpin and monkeyface prickleback) in only one sample supports the inadequacy of sampling.

Figure 8. Relationship between cumulative number of species collected and number of pools sampled at Bolinas Point (N = 50 randomizations of sample order).



Sizes of fluffy sculpins at Bolinas Point ranged from 25-80 mm. The two modes in size probably represent first and second year fish. The unidentified juveniles which were found to be relatively common at Bolinas ranged from 11-35 mm (Figure 7).

Figure 7. Total lengths of fluffy sculpins and unidentified juvenile sculpins at Bolinas Point.



Santa Maria Creek

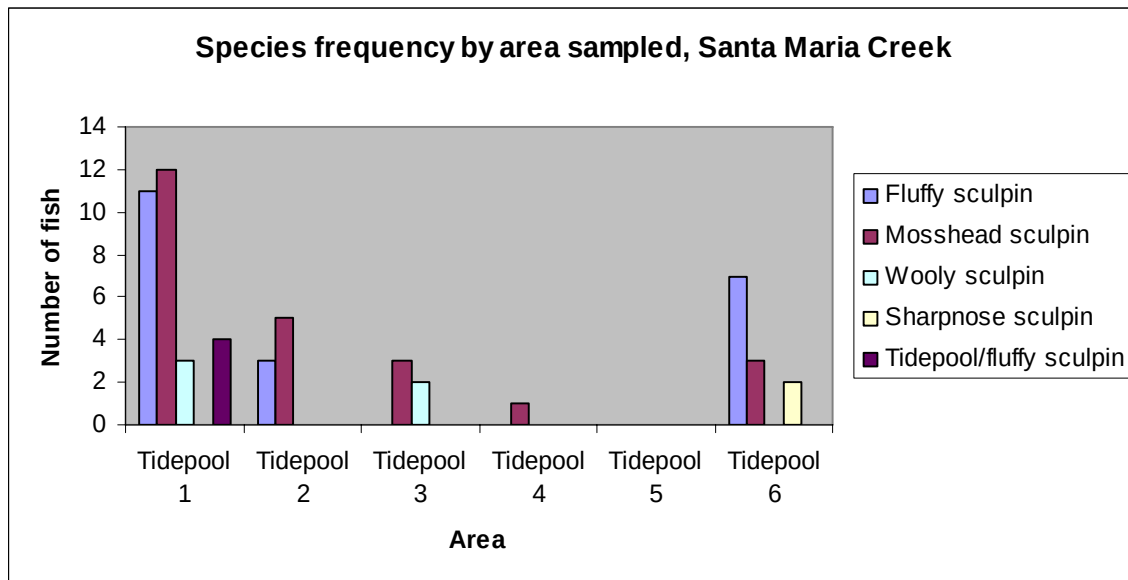
We sampled Santa Maria Creek, which is a large sandy beach punctuated by three rocky outcrops, on July 22, 2005. Tidepools were present on top of the outcrops, and we sampled from five pools situated atop two of these outcrops. The sixth sample was from a pool on the landward (high tide) side of the rocks. The pool was created by a recess in the sand and it had an algal cover of *Ulva*.

Santa Maria creek was dominated by two species, the mosshead sculpin, *C. globiceps*, and the fluffy sculpin, *O. snyderi*. (Table 3). All of the other sites were clearly dominated by just one species, usually the fluffy sculpin. One species, the sharpnose sculpin, *C. auticeps*, was found only at this site. The wooly sculpin was also found here, as well as at Bolinas Point. Finally, a greater number of individual fish was found at Santa Maria Creek than at any other site, but most of these were found in one pool, "Tidepool #1" (Figure 9), which also had the greatest diversity of any of the pools at this site.

Table 3. Species collected at Santa Maria Creek.

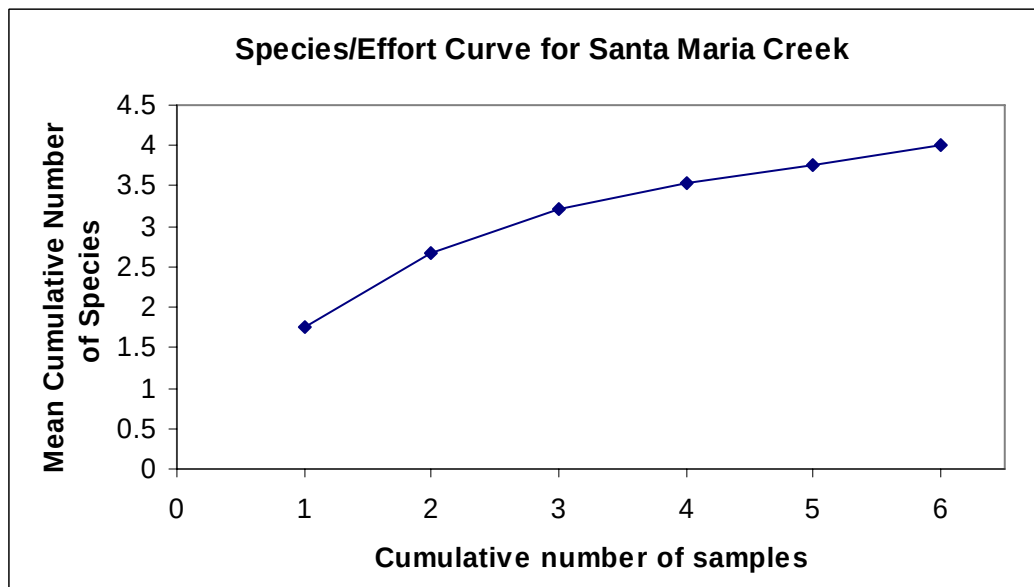
Common names	Scientific names	# Collected	Percentages
Fluffy sculpin	<i>Oligocottus snyderi</i>	21	37.5
Mosshead sculpin	<i>Clinocottus globiceps</i>	24	32.1
Wooly sculpin	<i>Clinocottus analis</i>	5	8.9
Tidepool / Fluffy sculpin	<i>Oligocottus maculosus/snyderi</i>	4	7.1
Sharpnose sculpin	<i>Clinocottus auticeps</i>	2	3.6
	Total	56	

Figure 9. Species collected in different tidepools at Santa Maria Creek.



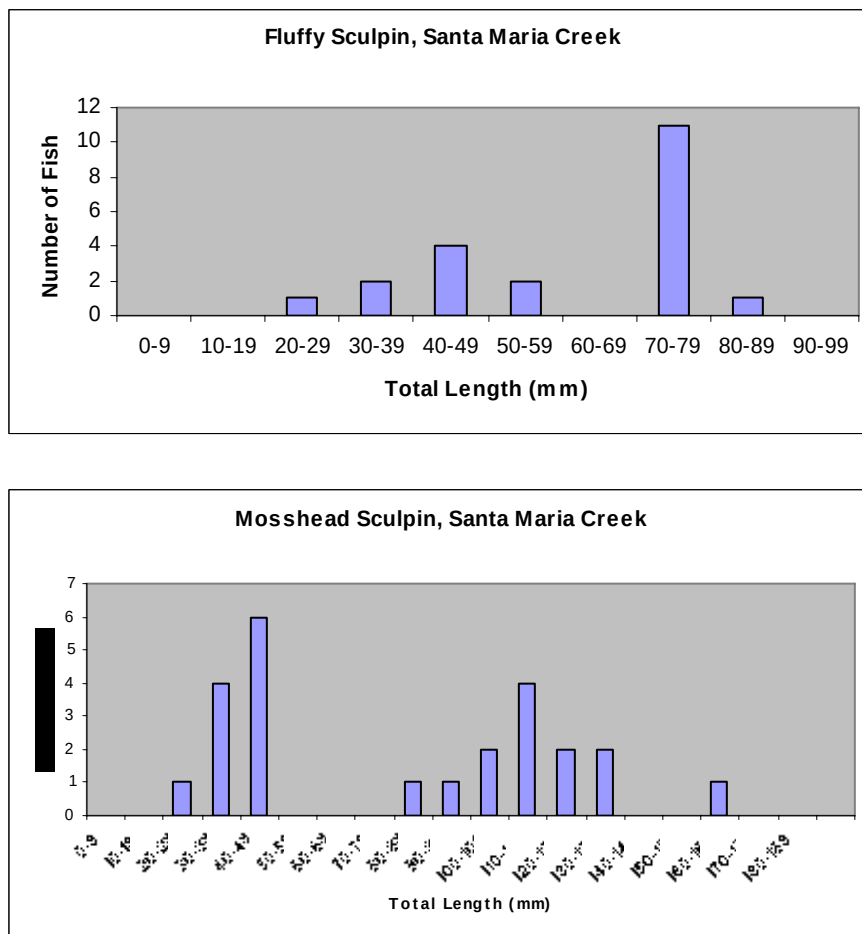
The cumulative species-area relationship for samples at Santa Maria Creek was the closest of all sites to reaching an asymptote, perhaps because of the low diversity seen in some of the pools at this site (Figure 11).

Figure 11. Relationship between cumulative number of species collected and number of pools sampled at Santa Maria Creek (N = 50 randomizations of sample order).



The fluffy sculpins found at Santa Maria Creek ranged in size from 29-85 mm, probably representing first and second year fish (Figure 11). Mosshead sculpins ranged from 22-169 mm (Figure 11). The mossheads collected probably represented first, second, and third year individuals, based upon the aggregation of size classes evident even with the small number of individuals sampled. Woolly sculpins ranged in size from 101-133 mm

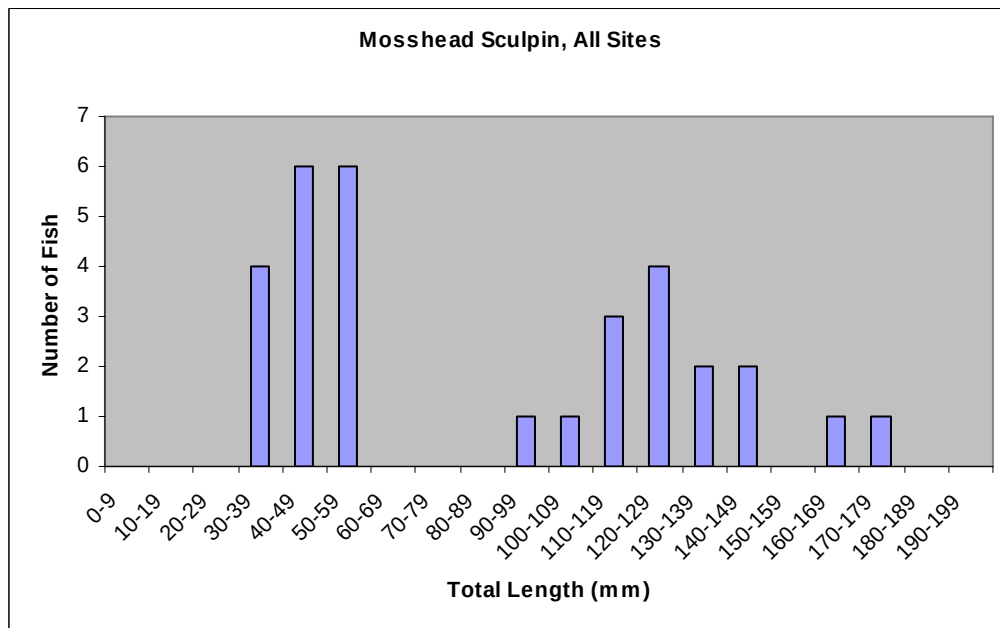
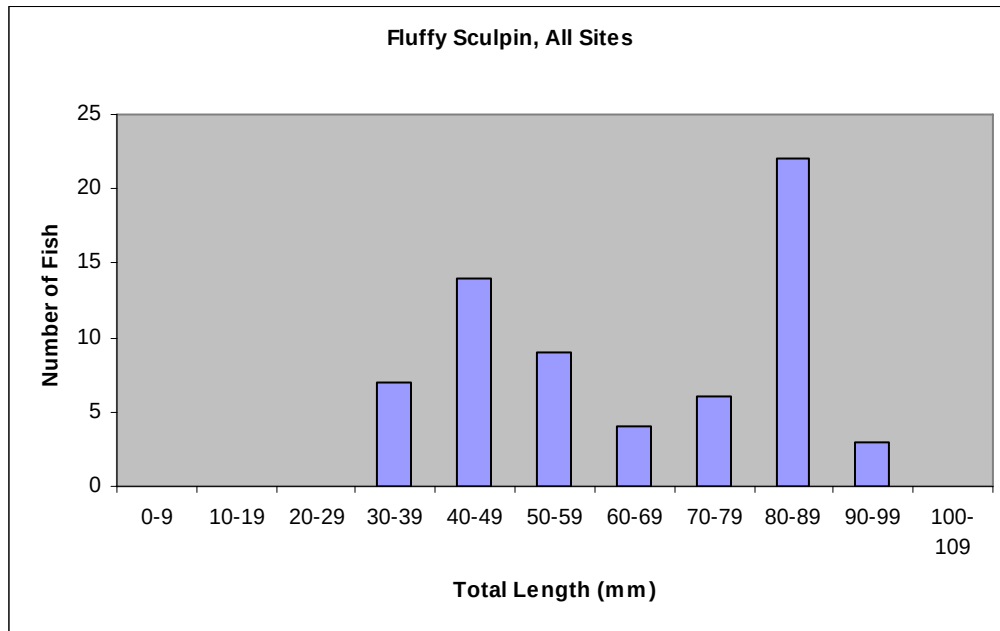
Figure 10. Length frequency distributions for two species of sculpin at Santa Maria Creek.



Aggregates Size Distributions

Fluffy and mosshead sculpins, the most abundant species sampled in our study, grouped into relatively clear size modes (Figure 12). The size-frequency distribution for fluffy sculpin shown here includes small fish identified as fluffy or tidepool sculpin, and likewise the diagram for mosshead sculpin includes the few small specimens identified as mosshead or bald sculpins. The fluffy sculpin seems to show two size modes, indicating the presence of two year classes. The mosshead sculpin occurs mainly in two year classes as well, but a third year class is may also be present. These size distributions indicate that recruitment of both of these species occurred in each of the past 2-3 years.

Figure 12. Sizes of fluffy and mosshead sculpin sampled from all sites.



Discussion

This survey covered four sites, each sampled during a spring tide period on one day by three marine biologists, sometimes assisted by an amateur individual, who as a group sampled as many pools and transects as possible within each site during that low-tide period. Carbon dioxide gas was used in pools to slow the movements of fish, but no anesthetic or ichthyocide was used. The survey produced a total of 8 identified species in three families (Table 4). Sculpins in the family cottidae were by far the most abundant family, and within that group the fluffy sculpin (*Oligocottus snyderi*) and mosshead sculpin (*Clinocottus globiceps*) were the most abundant species collected in the study. Three other species of sculpins were also collected. Other families represented were the pricklebacks (Stichaeidae), represented by two species, and the clingfish (Gobiesocidae), represented by one species. This survey provides a reasonable starting point for a characterization of the intertidal fishes in the GGNRA and the PRNS, but does not provide a complete inventory.

Point Bonita appeared to have a very limited population of intertidal fish, although the subtidal fish population may be substantial given the array of fishers pulling up surfperch or rockfish on any given day. We, however, found only three saddleback sculpins (*Oligocottus rimensis*) at this site, a species that was discovered at only one other site, Slide Ranch. Saddleback sculpins may generally be rare in California—they are listed in Miller and Lea (1972) as a northern species. If so, this may be a unique southern outpost for this species. Point Bonita is moderately rich in invertebrate fauna and is regularly visited by groups of school children. Whether this high foot traffic has an impact on the reef is unknown.

Slide Ranch contained an unexpectedly rich habitat that was rather distinct from any of the other sites in that its rocky intertidal began at the edge of a beach, and resembled a boulder field more than a reef. This provided a complex habitat that offered a great deal of refuge for its inhabitants. We believe that we were able to sample only a fraction of the fish that we saw for this reason. The lack of pools did not provide an opportunity to sample as we had at other sites, and the rocky boulders offered the fish we pursued ample opportunity to escape. Nonetheless, we observed a species composition that was somewhat distinct from the other sites, and thus probably reflective of the unique habitat we found here. Clingfish (*Gobiesox maeandricus*) and black prickleback (*Xiphister atropurpureus*) were found only at this site, and monkeyface prickleback (*Cebidichthys violaceus*) were found at this site as well, so these two families were better represented at this site than any of the others. The occurrence of these species contributed to the slightly greater species diversity at this site than at the other three sites. Of the fluffy sculpins that we found at this site, there were probably representatives of both first and second year fish, as in the other sites. The species/effort curve (Figure 4) generated for this site is difficult to compare to Bolinas or Santa Maria Creek, because the site was sampled largely by transects through boulder fields, rather than by discrete tidepools, but with the bulk of the specimens and species collected in only one of the sampling units (Figure 3), it appears that additional sampling would yield additional species.

Bolinas Point offered a typical rocky reef with pools that yielded four identified species. The assemblage was dominated by fluffy sculpins, but mosshead sculpins (*Clinocottus globiceps*), found at two other sites, and wooly sculpin (*Clinocottus analis*)

and monkeyface prickleback, each found at one other site, were observed here. In general, the pools at Bolinas Point appear to be quite variable in species composition (Figure 7), and as a result, the species/effort relationship did not reach an asymptote. Therefore, we would expect that additional sampling would yield additional species here.

Bolinas Point was sampled using somewhat similar methods by the research group that initiated this project (McGowan et al, unpublished data) on February 25-26, 2003. They identified only fluffy sculpins, bald sculpins (*Clinocottus recalvus*) and high cockscombs (*Anoplarchus purpurescens*). Fluffy sculpins dominated samples in both the 2003 and 2005 surveys. The 2005 survey produced more specimens (53 vs. 30), did not find bald sculpin or high cockscomb, but did report three species (wooly sculpin, mosshead sculpin, and monkeyface prickleback) that were not observed in the 2003 collections.

The collection at Santa Maria Creek was co-dominated by fluffy and mosshead sculpins, rather than by fluffy sculpins alone. It also yielded the less common sharpnose sculpin, which did not appear in any other sites, and the wooly sculpin, which was found at one other site. Sampling at Santa Maria Creek appeared produce the closest approach to an asymptote in the relationship between number of species sampled and cumulative sampling effort (Figure 11). However, the overall species diversity at this site was not high, and several of the sites sampled at this site had two, one, or no species, perhaps contributing to the appearance of an asymptote. On the other hand, one unique species was found at this site, the tidpool yielding the greatest number of individuals of any sample in this study was at this site, and there was a unique co-dominance of fluffy and mosshead sculpins here.

To summarize, fluffy sculpins seemed ubiquitous, as did mosshead sculpins to a lesser degree. Saddleback sculpins were found only at Bonita Cove and Slide Ranch in the GGNRA. Wooly sculpins were only found in the two PRNS sites, and sharpnose sculpins were found only at Santa Maria Creek. Black pricklebacks and clingfish occurred only at Slide Ranch in the boulder fields there, while monkeyface pricklebacks occurred both at Slide Ranch and at Bolinas Point. The small differences in species composition among sites suggest that there is no any major pattern in species occurrence within the region. Microhabitat probably does influence species composition. In our study, boulder fields seemed to support a greater abundance of pricklebacks and clingfish than did tidepools, and based on previous studies in the central California intertidal region (Yoshiyama 1981), tide height almost certainly influences species composition.

This study was limited to four days of collecting by 3-4 people, and did not employ fish anesthetics or ichthyocides other than carbon dioxide gas. The species/effort relationships at most sites indicated that additional species might be collected with additional effort. Therefore, this study cannot represent a complete inventory of the species expected to be found in the intertidal regions of the GGNRA and PRNS. However, more extensive work by Yoshiyama (1981) and Grossman (1982) in nearby areas can be used to predict additional species that are likely to be found within the GGNRA and PRNS (Table 4). Yoshiyama (1981) reported on 99 trips to three sites along the San Mateo County coast between Pescadero Point and Pigeon Point. He used the anesthetic quinaldine to slow the movements of fish, and to bring them from hiding places. He was assisted in the collections by an unstated number of additional individuals. These sampling efforts yielded 3703 individual fish over 30 mm standard

length (smaller fish could not be identified with certainty in the field). Grossman (1982) reported on 13 collections made over 1.5 years in a 30 m x 17 m site at Dillon Beach, Sonoma County. Grossman also used the anesthetic quinaldine, and was assisted by an unstated number of field assistants. His collections yielded 2857 individual fish. Grossman's sampling yielded over 200 individual fish per collection, while the sampling conducted by Yoshiyama and the present study both yielded 35-40 specimens per collection.

Most of the eight species collected in our study were abundant in the collections by Yoshiyama and Grossman (Table 4). In all three studies, the fluffy sculpin (*Oligocottus snyderi*) was by far the most abundant species, and sculpins were the most abundant and most speciose family. The mosshead sculpin (*Clinocottus globiceps*) and the wooly sculpin (*C. analis*) were also abundant sculpins in all three studies. The saddleback sculpin (*Oligocottus rimensis*) and the sharpnose sculpin (*C. auticeps*) were relatively more common in our study than in the other two studies, and a few common species in the other studies (the smoothhead sculpin, *Artedius lateralis*, the tidepool sculpin, *Oligocottus maculosus*, and juvenile cabezon, *Scorpaenichthys marmoratus*) were not observed in our study. We would expect these species, as well as the more uncommon species of sculpin reported in the other two studies, to be present in the intertidal zone of the GGNRA and PRNS regions. The northern clingfish (*Gobiesox maeandricus*) was common in all three studies, but somewhat more so in our study than in the other two, mostly because of large catches of this species in one sample.

“Eel blennies” (members of the families Stichaeidae and Pholididae) were better represented, both in number of individuals and in number of species, in Yoshiyama's

collection than in Grossman's or ours. The monkeyface prickleback (*Cebidichthys violaceus*) and black prickleback (*Xiphister atropurpureus*) were observed in our collections, and the high cockscomb (*Anoplarchus purpureus*) was observed in the collection by McGowan. These three species were among the 6 most common pricklebacks and gunnels collected by Yoshiyama, who, along with Grossman, also observed the rock prickleback (*X. mucosus*). Yoshiyama and Grossman also collected the penpoint gunnel (*Apodichthys flavidus*) and rockweed gunnel (*Xerperes fucorum*), though at different levels of relative abundance. We would expect all 6 of these species to be present within the GGNRA and PRNS, and for all but the rock prickleback to be relatively abundant. The occurrence of these species is highly dependent on habitat, as indicated in our collections, and also on sampling method. The use of anesthetics greatly enhances the ability to collect these species, which can be quite elusive.

Also absent in our samples but relatively abundant in the samples of Yoshiyama and Grossman were two species of kelpfish in the family Clinidae, the striped kelpfish (*Gibbonsia metzi*) and the crevice kelpfish (*G. montereyensis*). Our general experience suggests that these species are most common in deep tidpools in the lower intertidal zone, in association with algae. We would expect these species also to occur in the GGNRA and PRNS.

The tidepool snailfish (*Liparis florae*) was observed by Grossman, but not by us or by Yoshiyama. It is an unobtrusive species that we also would expect to occur in the GGNRA and PRNS.

Other species observed by Yoshiyama and Grossman but not in our study include some that occur as juveniles on a temporary and seasonal basis, such as the rockfishes

(genus *Sebastes*), which may be quite abundant in lower-level tidepools during the spring-summer recruitment season. These species and life stages also occur in the subtidal zone. Adults of some rockfishes (especially the grass rockfish, *Sebastes rastrelliger*, and the black and yellow rockfish, *S. chrysomelas*) may also occur in the deep intertidal and shallow subtidal zone, and are available to fishermen in this region. Greenlings (family Hexagrammidae, genus *Hexagrammus*) were observed by Yoshiyama and especially Grossman. These species may occur in the low intertidal and shallow subtidal zone, where they are also available to fishermen. Surfperches (family Embiotocidae) were also observed by Yoshiyama and Grossman, but not abundantly. The dwarf surfperch (*Micrometrus minimus*) and reef surfperch (*M. aurora*) are common residents of the shallow subtidal and low intertidal zone, and move into the intertidal zone at high tide. The striped seaperch (*Embiotoca lateralis*) is also a common resident of the shallow subtidal zone, and may occur occasionally in the intertidal region. It is also caught by shore fishermen. Other species of surfperch may also be expected to venture into the intertidal zone during high tides. We expect that all of these taxa observed by Yoshiyama and Grossman to be present in the intertidal region of the GGNRA and PRNS.

The samples collected in the present study cannot serve as a complete inventory of the intertidal fishes of the GGNRA and PRNS. Four days of sampling, without the use of anesthetics like quinaldine, is simply too little effort to conduct a complete inventory. However, the collections in this study did yield an assemblage of species that was similar enough to the more extensive collections by Yoshiyama (1981) and Grossman (1982) to indicate that their collections may serve as a guide to the overall assemblage of species

one might expect to find within the intertidal regions of the GGNRA and PRNS. These collections bracket the GGNRA and PRNS geographically, and are themselves generally similar to one another. Some differences between these studies may be due to the more limited spatial array of samples by Grossman, and to differences in the types of habitat sampled. These studies were carried out over 25 years ago, leaving open the possibility that they are not representative of intertidal communities today. The relatively greater occurrence of sharpnose sculpin and saddleback sculpin in our study than in the older studies could be an indication of this. However, Grossman (1982, 1986) showed that over at least the time scale of a decade, the species composition of the intertidal zone was relatively stable. C. Pfister (unpublished manuscript, University of Chicago) also found a high degree of consistency in the species composition of abundant sculpins in tidepools on the Olympic Peninsula of Washington State. Davis (2000) showed that populations of intertidal fishes may fluctuate in response to short-term climatic events, such as El Niño and La Niña years, and Polivka & Chotkowski (1998) found some variation in intertidal communities over time. In a general review, however, Gibson and Yoshiyama (1999) noted that “species abundances fluctuate, but not to the extent that resident species are very common in some years but rare in others.” Therefore, in the absence of major climatic changes, the collections by Yoshiyama (1981) and Grossman (1986), as supplemented by those conducted in this study, should provide a reasonable expectation of the species likely to be encountered in the intertidal regions of the GGNRA and PRNS.

Table. 4. Comparison of ranked abundances of intertidal fish species collected by Yoshiyama (1981), Grossman (1982), and this study.

Family Species	Yoshiyama	Grossman	This Study
Cottidae			
<i>Oligocottus snyderi</i>	1	1	1
<i>O. maculosus</i>	14	16	-
<i>O. rubellio</i>	23.5	28.5	-
<i>O. rimensis</i>	22	-	5
<i>Clinocottus analis</i>	2	8	4
<i>C. globiceps</i>	9	7	2
<i>C. recalvus</i>	19	-	-
<i>C. auticeps</i>	-	17	7
<i>Artedius lateralis</i>	5	24	-
<i>A. harringtoni</i>	-	24	-
<i>A. notospilosus</i>	-	24	-
<i>Scorpaenichthys marmoratus</i>	10	3.5	-
<i>Hemilepidotus spinosus</i>	21	-	-
<i>Enophrys bison</i>	23.5	21.5	-
<i>Ascelichthys rhodorus</i>		14	-
Hexagrammidae			
<i>Hexagrammos decagrammus</i>	15	10.5	-
<i>H. lagocephalus</i>	20	-	-
<i>H. superciliosus</i>	-	9	-
Liparididae			
<i>Liparis florum</i>	-	10.5	-
Scorpaenidae			
<i>Sebastes</i> sp.	8	-	-
<i>Sebastes rastrelliger</i>	-	5	-
<i>Sebastes melanops</i>	-	3.5	-
Embiotocidae			
<i>Micrometrus aurora</i>	17.5	-	-
<i>M. minimus</i>	-	15	-
<i>Embiotoca lateralis</i>	-	13	-
<i>Hyperprosopon ellipticum</i>	-	26	-
Gobiesocidae			
<i>Gobiesox maeandricus</i>	17.5	19.5	3
Clinidae			
<i>Gibbonsia metzi</i>	11	6	-
<i>G. montereyensis</i>	12.5	12	-
Stichaeidae			
<i>Cebidichthys violaceus</i>	4	19.5	6
<i>Anoplarchus purpureus</i>	3	21.5	-
<i>Xiphister atropurpureus</i>	6	-	8
<i>X. mucosus</i>	16	27	-
Pholididae			
<i>Xerperes fucorum</i>	7	18	-
<i>Apodichthys flavidus</i>	12.5	2	-
Paralichthyidae			
<i>Citharichthys stigmaeus</i>	-	28.5	-
Total number of specimens	3703	2857	147

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