CASTING A WIDE NET: SIMULATED FISHING ALONG THE COAST OF CENTRAL CALIFORNIA

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Previous research has highlighted the significant relationship between marine fishing and cultural phenomena, including subsistence choices, paleocoastal migrations, and the growth of complexity. Understanding how past peoples exploited local fisheries is an important pursuit, as fishing is a broad subsistence strategy that includes a variety of techniques associated with different fish taxa, marine environments, and overall caloric return rates. Results of seven netting simulations using a 30-ft. beach seine are used here to compare and contrast mass capture with single procurement techniques in terms of return rates and popular optimization models. In addition, we use these experimental data as a platform to discuss risk minimization, population demographics, micro-nutrients, and technological investment within fishing cultures.

THE EXPERIMENT

Our net fishing experiments included seven individual simulations involving multiple net-drags in both estuary and open sandy beach marine habitats within Monterey Bay. Fish were successfully captured during each simulation. However, there were individual net drags that resulted in failure, as well as captured taxa that do not produce an archaeological signature or are absent in the local archaeological record. In addition, some taxa captured during our netting experiments may have been easily procured using other subsistence strategies, such as hand capture. For these reasons, taxa such as bay pipefish (*Syngnathus leptorhyncus*), marine gastropods, multiple species of crabs, kelp, and other edible flora and fauna were not included in our calculations.

Each net fishing simulation was conducted at high tide, unless otherwise specified. Crews of two to 10 persons assisted in the experiments, with two crew members operating the net and the remainder aiding in gathering captured taxa or recording data. The net was brought into the water from the shore to depths not exceeding 5 ft. and was then extended to its full 30-ft. length while being dragged through the water and keeping close to the ground, bringing the ends together as we neared the shore to prevent fish from escaping. Also worthy of note is that nearly every time we conducted a simulation, children would find us and gather around to help pick fish out of the net. The children actually made a quantifiable difference in the gathering time.

During each simulation, we recorded the netting time, number and type of fish, and total weight of captured taxa in grams. Captured prey items were removed from the net, identified and sorted into taxonomic categories, and weighed prior to release. Please note that "time" includes netting time, recorded from the moment the net entered the water, and time spent gathering the fish from the net. It does not include time between drags, which was spent moving to other locations along the shore and weighing/measuring the fish. Time for failed drags was not recorded. The time of each net drag was affected by multiple factors, including ocean and weather conditions, number of crew members, and our overall inexperience operating a beach seine.

THE INDIVIDUAL TRIP DATA

Our first experiment in February at New Brighton Beach, a sandy open beach environment, was spent learning how to manipulate the net optimally (Table 1). The time spent per drag was longer than during future experiments due to fewer crew members.

Table 1. Results for February 1, 2013, New Brighton Beach, Aptos, California.

Drag No.	Species Caught	Weight (g)	Time (min.)*
1	Topsmelt (*Atherinops affinis)*	240	6:00
2	Perch (Embiotocidae)	160	6:00
3	--	--	6:00
4	--	--	6:00
Total		400	24:00

* Times for this initial experiment are average estimations and not exact.

Table 2. Results for February 15, 2013, New Brighton Beach.

Drag No.	Species Caught	Weight (g)	Time (min.)
1	Topsmelt (*Atherinops affinis)*	10	2:35
2	Perch (Embiotocidae)	18	2:13
3	--	--	--
4	--	--	--
5	--	--	--
6	Topsmelt (*Atherinops affinis)*	21	2:40
7	--	--	--
8	Topsmelt (*Atherinops affinis)* Perch (Embiotocidae) Kelp greenling (*Hexagrammos decagrammus*)	95	4:08
9	Perch (Embiotocidae)	36	1:10
10	--	--	--
11	Topsmelt (*Atherinops affinis)*	65	3:23
12	Perch (Embiotocidae)	18	2:34
Total		263	18:42

Table 3. Results for March 3, 2013, Elkhorn Slough.

Drag No.	Location	Species Caught	Weight (g)	Time (min.)
1	Parsons		--	--
2	Wildlife Blind	--	--	--
3	South Marsh	--	--	--
4	South Marsh	Staghorn sculpin (*Leptocottus armatus*)	25	4:30
Total			25	4:30

The second trip took us back to New Brighton Beach, and with a larger crew we were able to do more drags and significantly reduce the dragging/processing time (Table 2).

Our third trip was to Elkhorn Slough, as we were especially interested in comparing sandy beach return rates with estuarine environment return rates (Table 3). Elkhorn Slough is also in Monterey Bay, with the river mouth opening into the ocean by Moss Landing beach. This trip was largely unsuccessful, and we only caught specimens during one of the drags. The water in the slough was low, and much of our time was spent wading through deep mud. This also made drags difficult, as the crew members would sink and get stuck while trying to pull in the net.

Our May return trip to New Brighton Beach was on an extremely windy day, with wave swells 4-6 ft. high, strong currents, and in an area with high kelp levels (Table 4). After only two very challenging drags and no identifiable species caught, we ended for the day.

Our trip to Elkhorn Slough on May 19 yielded the highest return rates of the project (Table 5). The water levels were higher than during our previous trip, and small schooling fish were abundant. We

Table 4. Results for May 5, 3013, New Brighton Beach.

Drag No.	Species Caught	Weight (g)	Time (min.)
1	Unidentified	3	3:37
2	Unidentified	3	4:00
Total		6	7:37

Table 5. Results for May 19, 2013, Elkhorn Slough.

Drag No,	Location	Species Caught	Weight (g)	Time (min.)
1	Whistlestop	Silverside (Antherinidae) Staghorn Sculpin (*Leptocottus armatus*)	2,190	4:09
2	Whistlestop	Bat Ray (*Myliobatis californica*)	6,000	1:15
3	Main Channel	Silverside (Antherinidae) Staghorn Sculpin (*Leptocottus armatus*) Flatfish (Pleuronectiformes)	88	5:00
4	Main Channel	Silverside (Antherinidae) Staghorn Sculpin (*Leptocottus armatus*) Flatfish (Pleuronectiformes)	990	12:00
Total			9,268	22:24

Table 6. Results for September 2, 2013, Elkhorn Slough-Whistlestop.

Drag No.	Species Caught	Weight (g)	Time (min.)
1	Staghorn Sculpin (*Leptocottus armatus*)	29	4:22
2	Staghorn Sculpin (*Leptocottus armatus*) Unidentified	54	3:47
3	Silverside (Antherinidae)	520	4:26
4	Silverside (Antherinidae) Staghorn sculpin (*Leptocottus armatus*) Midshipman (*Porichthys notatus*)	29	5:27
Total		632	18:02

Table 7. Results for September 2, 2013, Moss Landing.

Drag No.	Species Caught	Weight (g)	Time (min.)
1	--	--	--
2	Perch (Embiotocidae)	9	1:25
3	--	--	--
4	Perch (Embiotocidae)	84	3:40
Total		92	5:05

also caught a bat ray (*Myliobatis californica*) in the net, which accounted for the majority of the total grams caught.

We returned to Whistlestop in Elkhorn Slough on September 2 (Table 6) and once again saw high numbers of small schooling fish, as well as more staghorn sculpin.

After netting in Elkhorn Slough, we did a few drags along the open beach at Moss Landing (Table 7). The area targeted during this simulation was a wind-swept, steep-sloping shoreline with significant wave surge. The tide level was not recorded during this simulation.

Table 8. Comparisons of taxa caught at Elkhorn Slough with MNT-228 and SLO-15.

FROM SITE MNT-228	FROM SITE SLO-165	FROM OUR CATCH AT ESTUARY
Silversides / Anchovy	Silversides / Herring	Silversides / Anchovy
Rays	Rockfish	Staghorn sculpin
Perch	Rays	Flatfish
Sardine	Perch	Bat ray
Stickleback	Staghorn sculpin	Plain fin midshipman
Staghorn sculpin		

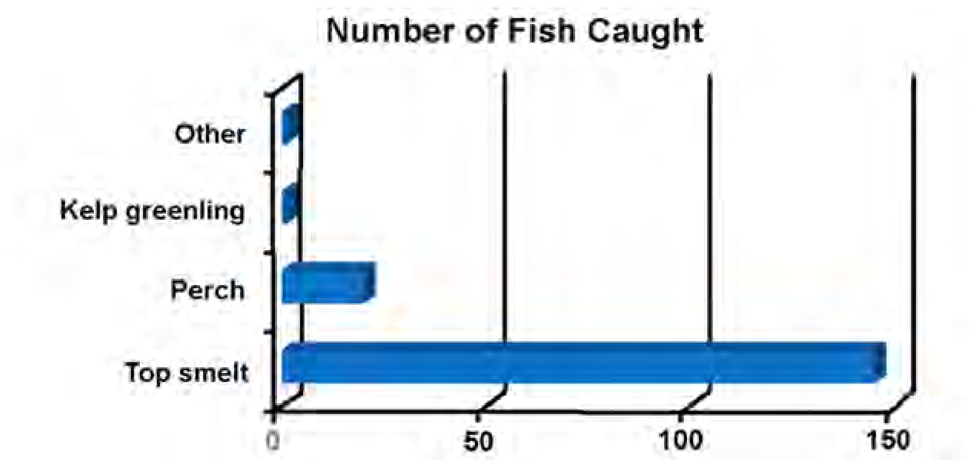

Figure 1. Taxa from sandy beach environments.

DATA FROM ALL EXPERIMENTS

Comparing the Data

We closely compared the identified species we caught with ichthyofaunal record assemblages of nearby areas, specifically sites in Monterey and San Luis Obispo, as shown in Table 8.

Fish by Environment Type

Figure 1 displays the type of prey captured on sandy beaches, and Figure 2 displays taxa caught in estuary environments. Top smelt (*Atherinops affinis*) constituted the majority of fish caught at the sandy beach, while anchovies/silversides (Antherinidae) were the most numerous in the estuary environment.

Return Rates

Figure 3 displays the results of each fishing method type in terms of how many grams we caught per hour, compared to the results of previous experimental research conducted by Dustin McKenzie that measured return rates associated with hook-and-line single procurement fishing methods (McKenzie 2007). Seine netting in an estuary environment provided the highest return rates, but netting in both sandy beach and estuary environments yielded higher return rates than hook-and-line fishing strategies.

Grams by Fish Species

Figure 4 illustrates the weights caught by fish species. The bat ray (*Myliobatis californica*) offered the bulk amount of weight, despite only a single specimen having been caught. Anchovies and

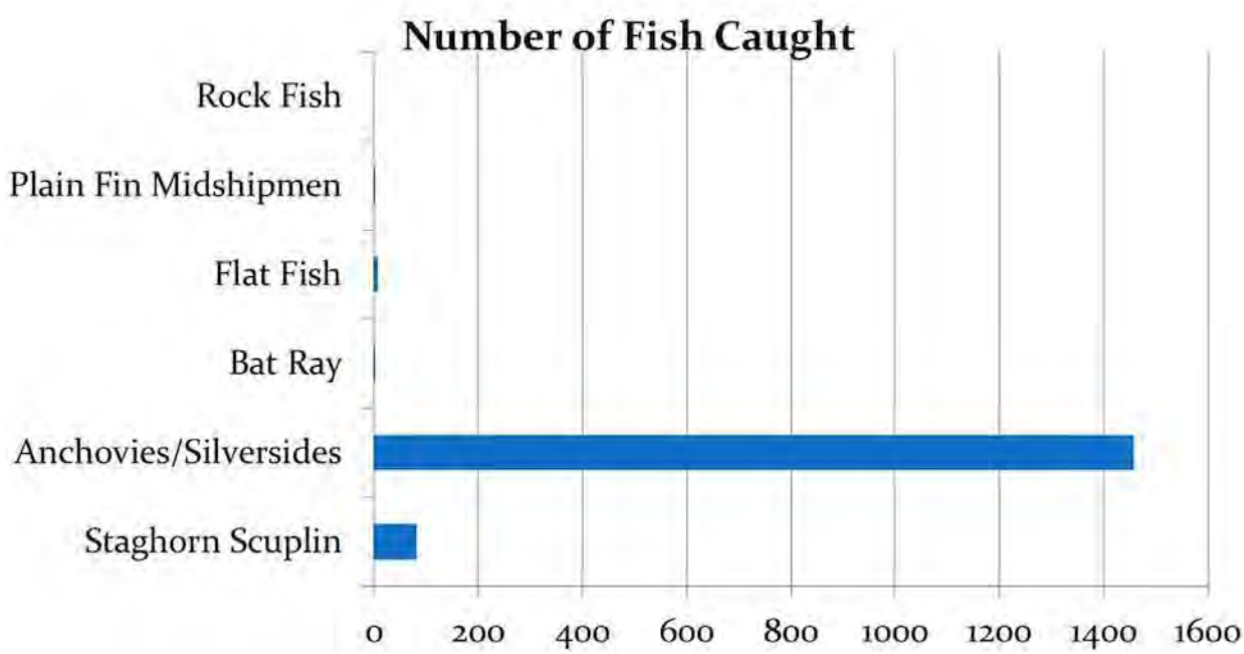

Figure 2. Taxa from estuarine environments.

silversides (Antherinidae) were the next most significant contributors by total weight, and were also the highest overall in terms of number caught.

INTERPRETATIONS

Our simulations indicated that, when compared to other environments, estuaries are optimal patches for foragers employing mass capture strategies such as seines. Net fishing is conducive to the exploitation of estuary environments due to reduced wave energy and paucity of ocean floor obstructions such as kelp or reefs, which may cause nets to snag. Heightened biodiversity associated with estuary habitats also increases the optimality of net fishing in these environments. Our numbers suggest that estuaries are also more productive than sandy beaches due to the fact that many species found in estuaries are present all year long and may be relied upon across all seasons as dependable resources. Coupled with a high biodiversity, this makes exploitation of resources readily available with little caloric expenditure.

While Optimal Foraging Theory (OFT) has been the dominant model used for interpreting foraging strategy, it generally interprets human foraging behavior as a process driven by maximization, discounting other possible forager interests (Lacher et al. 1982). Our research is perhaps best framed within dynamic state variable modeling (DSVM), a nuanced approach to interpreting data that considers the implications of prey capture on multiple levels. As stated in Cristie Boone's dissertation,

> Dynamic state variable modeling (DSVM) suggests that probability of successful prey capture, mortality risk in a patch, and energy expenditure are very important in a forager's prey choices. The model predicts that foragers preferentially exploit predictable, easily acquired resources, even those with relatively lower rates of return [Boone 2012:ix-x].

This approach allows consideration of a host of factors that could potentially influence interpretive results in archaeological research.

The currency of choice for looking at return rates has traditionally been the calorie. However, multiple environmental and/or seasonal factors may cause foragers to make subsistence choices to

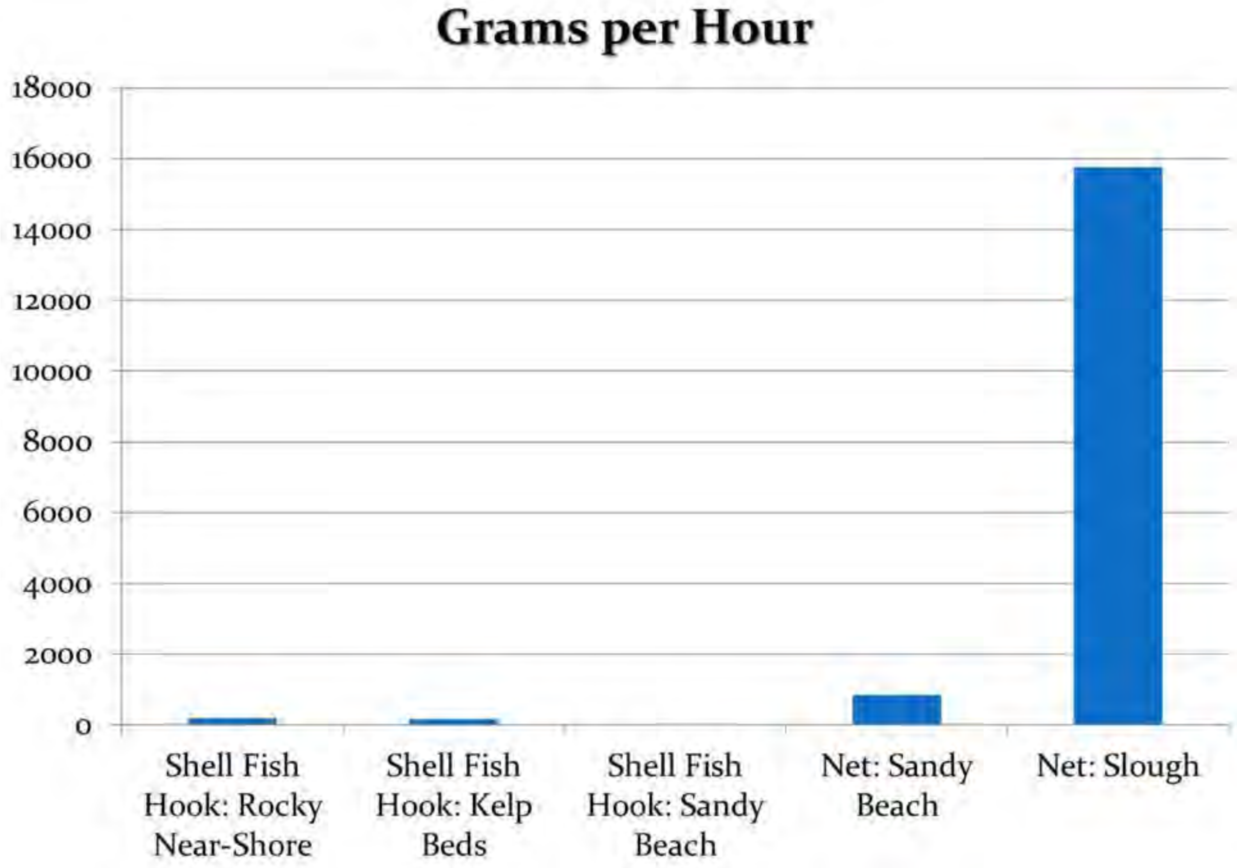

Figure 3. Grams per hour of single procurement versus mass procurement.

maximize currencies other than calories. For example, terrestrial game is thin in winter and has leaner meat. Our data suggest that the high fat content of small schooling fish and ease of capture may have provided an incentive for individuals to engage in mass capture strategies in estuary environments, thereby providing much-needed fat during times of terrestrial game scarcity. For women, net fishing may have offered a dependable source of fat to feed offspring and meet the caloric requirements of their children. Our data suggest that the reliability of netting is better for provisioning offspring when compared to subsistence pursuits that are more prone to failure, such as single procurement strategies focused on large-bodied prey. Not only is this useful for women provisioning offspring, but children can be productive in the provisioning process. As mentioned previously, when conducting netting simulations at public beaches, children showed up off the beach to help us pick fish out of the net, providing significant reduction on overall handling costs.

Seine nets would have taken a significant amount of time and energy to construct. The expense of the item in both these dimensions is increased when taking into account management over time, as damages resulting from various environmental factors would require some form of continuous maintenance. During our collection of data, fishing in storm conditions in a sandy beach environment caused net damage that consequently took 3 hours to repair. However, if the net is used in reliable high-return areas, the benefit may exceed the cost of time spent on initial manufacturing and subsequent upkeep. In the context of fishing, the high rate of return from net fishing as compared with hook-and-line or other single procurement methods could potentially provide nutrients for a larger group of people (i.e., a family), a consideration that could offset the cost of maintenance.

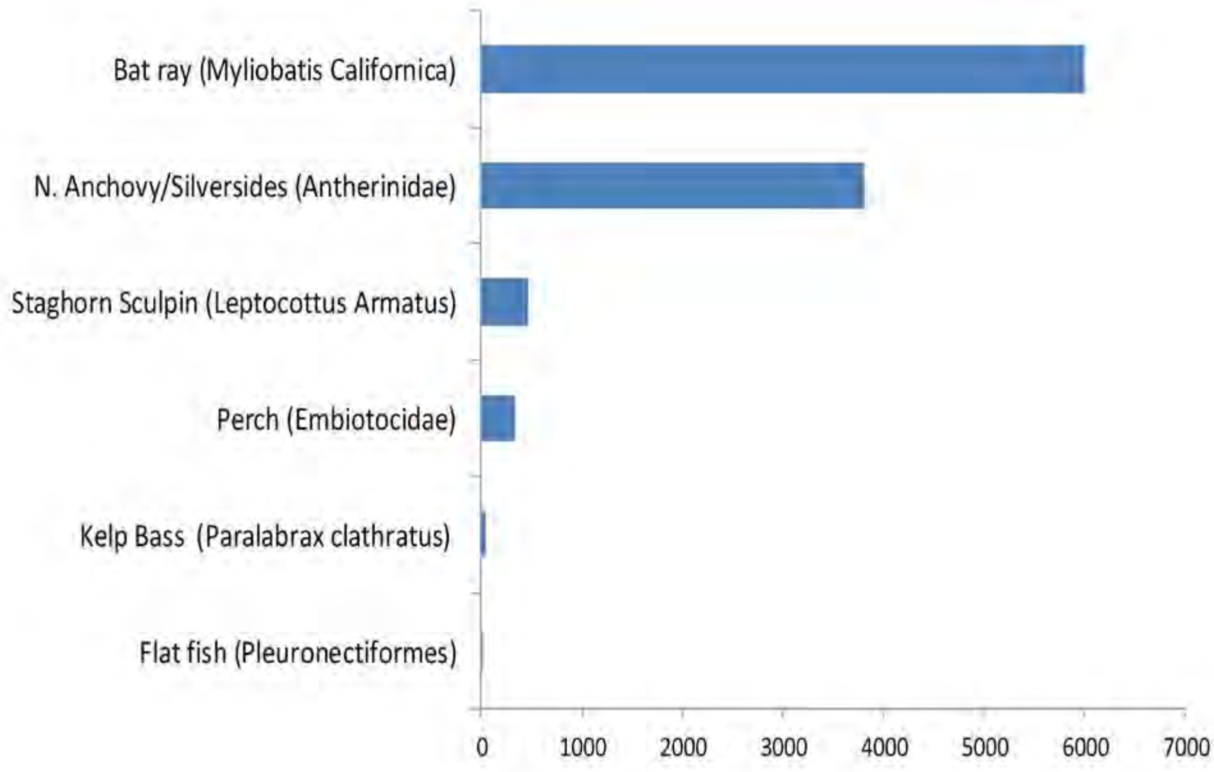

Figure 4. Taxa, by total grams.

Based on projections by Bettinger and Ugan, nets would have taken a significant amount of time to construct (Bettinger et al. 2006; Ugan et al. 2003). The time investment in net construction and the gathering of required plant resources could potentially make nets wealth items. This might lead to the ownership of a net becoming a signifier of status, and the possibility of net acquisition as a way to increase status. In addition to the value of the net itself, wealth items such as nets can be used to generate surpluses and thus enter into systems of reciprocity, creating greater wealth. Ethnographic observations suggest that nets may have been passed down from generation to generation, both as a result of the prestige associated with a wealth item such as a net, and due to the functionality of passing a net down rather than constructing a new one (Greg Castro, personal communication 2014).

CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

While OFT is a beneficial model to help us understand past subsistence strategies, exploration of foraging activities may be improved by allowing for more nuanced modeling of the relationships between the environment and the hunter-gatherers. Our work supports the use of DSVM, due to the numerous and variable factors that were encountered and discovered through our hands-on experimental research. The application of DSVM to subsistence-related experimental projects can help to elucidate the complex subsistence behaviors associated with the mass capturing of small schooling fish. The importance of these data is clear when considering the ubiquitous nature of small schooling fish in faunal assemblages throughout coastal California (see Figure 5 for examples).

The presence of small schooling fish in site assemblages speaks to their importance as prey, although geographical, social, and environmental factors may have as much to do with this presence as the fish themselves. Imagining that hunter-gatherers all made the same subsistence decisions despite geographical, environmental, and cultural differences is a faulty assumption. Because fishing takes place

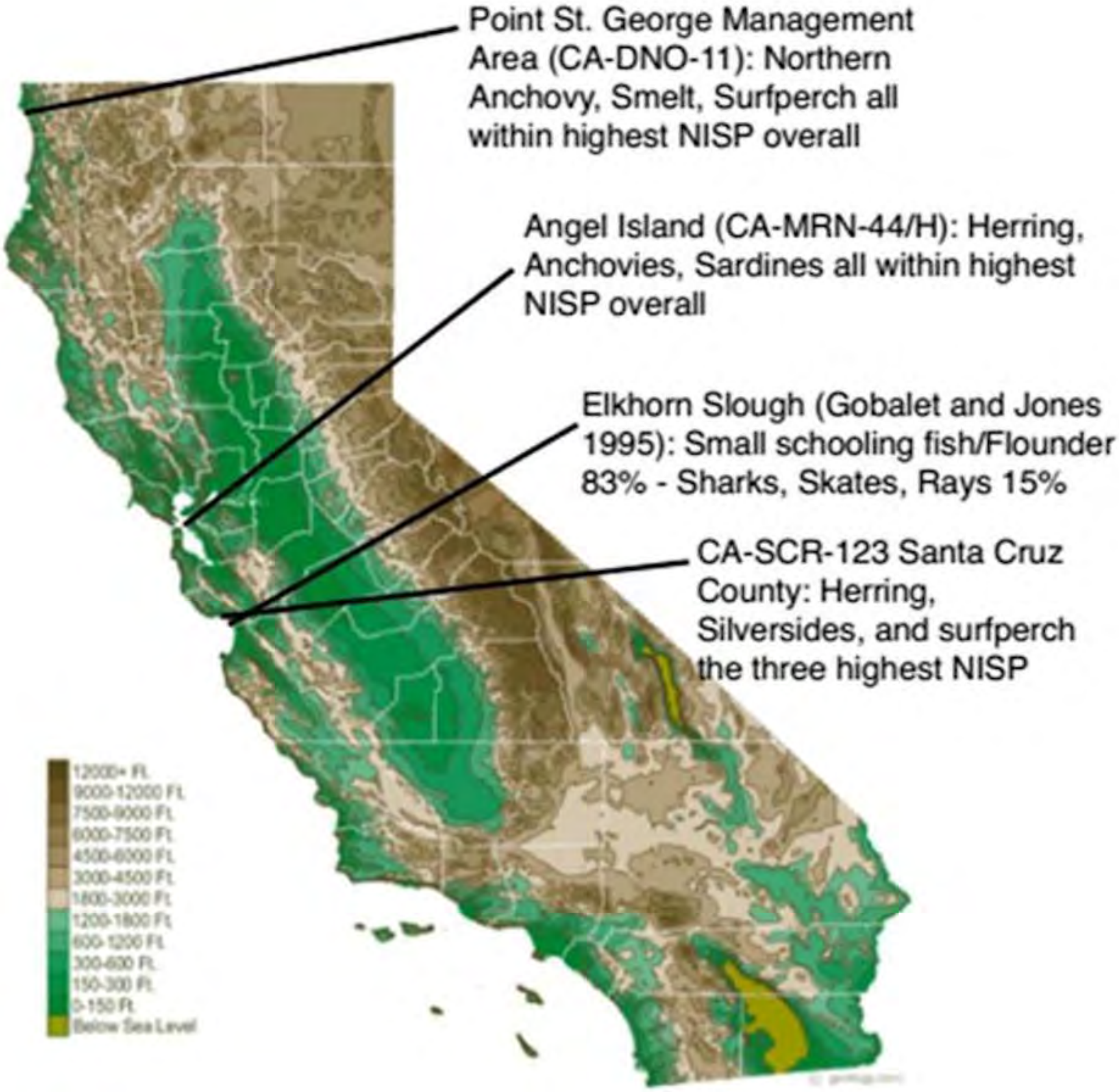

Figure 5. Coastal California faunal assemblages with small schooling fish.

in a very unpredictable environment (Acheson 1981), associated decisions will vary in relation to geography, access, environment, seasonality, and a host of other factors. Cultural components may come into play, such as incorporating net maintenance and curation into traditions such as songs or stories (Gregg Castro, personal communication 2014). These social and environmental factors produce complicated relationships that may have elevated the dietary importance of small schooling fish, despite their low caloric return per unit. It is possible that the overall productivity of the California coast gave local populations surplus time to engage in a variety of non-procurement activities, including the development of costly technologies such as nets. The sheer amount of time spent by coastal hunter-gatherers to develop and construct nets suggests that targeting small fish was an important subsistence activity, regardless of whether social, environmental, or geographical factors were the primary driving force.

According to ethnographic data, women's and children's foraging efforts have often been underrepresented in archaeological findings, and children are able to reach adult efficiency faster in fishing than in intertidal foraging (Bird and Bird 2002; Bird et al. 2009). This shows that gender roles and other social factors provide examples of the many facets that can play into the decision to engage in a particular foraging activity such as netting. Through exploring the relationship between social, environmental, and geographical factors that come into play in decisions around foraging choices, a complex view emerges of how these decisions are formed through these different factors. This means that a more complex form of modeling may allow a holistic view of how these factors interrelate to influence decisions to target a specific prey.

The development and use of nets raises questions about the relationship between fishing and the development of sedentism and cultural complexity. It may not be too great a stretch to imagine that technology such as nets, which require large investments of time and effort, could become prestige or wealth items. These wealth items could very well have contributed to social hierarchy formation or the ability to organize and become sedentary. Further research into this theme may draw upon ethnographic research in the same vein as exploring the manner in which net curation activities may be incorporated into traditions and cosmology.

Micro-nutrients, high success rates, social and gender factors, and mass capture ability all highlight the importance of examining the role of small schooling fish in prehistoric coastal subsistence strategies. To examine these strategies successfully, models such as DSVM that allow for multiple factors and relationships to influence diet breadth choices must be accepted. There is also a need for further experimental research to examine complicated foraging behaviors using a hands-on approach. Research such as Cristie Boone's and our own is necessary to better understand the coastal subsistence strategies of the past. The results presented here should be explored in greater detail, as their implications regarding complex subsistence choices extend beyond the geographical and cultural boundaries of California.

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