Collaborative Monitoring of the Spiny Lobster in the Channel Islands Marine Protected Areas

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Abstract

The California spiny lobster fishery (*Panulirus interruptus*) is among the ten most economically valuable fisheries in California coastal waters. The Santa Barbara regional lobster fishery contributed one-third of California lobster fishery revenue for 1984 – 2003. The northern Channel Islands currently contribute the majority (54%) of Santa Barbara's lobster fishery revenue. Yet, there has been little cooperative fishery-related research on spiny lobster in the past few decades. Recently, twelve marine protected areas (MPAs), which aim to sustain, conserve, and protect marine life populations, were instituted in the region through a collaborative process between governmental agencies, fishermen, and community representatives. Our primary focus is to understand how these MPAs will affect the future of the commercial spiny lobster fishery. Collaborating with local lobster trappers and state and federal agencies, we designed a protocol to assess lobster population demographics and behavior between reserves and unprotected areas outside of the reserves. Our protocol will provide key information about ecological effects of MPAs and help evaluate their effectiveness as a fisheries management tool. Our group has also developed a historical baseline of lobster catch for the northern Channel Islands' fishing grounds from 1999 – 2003 commercial fishing seasons. Using commercial lobster logbooks, we increased the spatial resolution and quality of catch data. Historical catch data will improve our understanding of lobster populations and provide a quantitative baseline for future monitoring efforts.

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a four-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

ADVISOR

ADVISOR

DEAN

May 17, 2005

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Figure 1: Lobster Group Project Team at Wrigley Marine Science Center – USC. Left-to-right (upper): Christina, Sofia, Matt Iacchei (USC), Patrick Robinson (USC), Darren; Left-to-right (lower): Sarah, Katie.

Executive Summary

California's marine fisheries policies strive to encourage growth of commercial fisheries while protecting ecosystems. To further these policies, the California Fish and Game Commission implemented several no-take marine reserves within the Channel Island National Marine Sanctuary (CINMS) in April 2003. This region is a major fishing ground for California spiny lobster (*Panulirus interruptus*), and the lobster industry has shown considerable concern about how these MPAs may affect their fishery.

Our project's purpose is to measure juvenile and adult spillover from the marine reserves at CINMS into lobster fishing grounds. Our main objective is to collaboratively develop methods to collect, organize, and analyze lobster fishery data both inside and outside the marine reserves through a long-term monitoring plan. To achieve our objective, we have selected an optimal study area, focused on three key aspects – collaboration, a pilot study, and logbooks – and provided recommendations.

I. Background

The biological and economic failure of traditional single-species, quota-based management of fisheries is well documented and widely acknowledged. While a number of alternatives currently exist, development of a fishery management system that promotes sustainability, reduces uncertainty, and fosters collaboration among stakeholders (e.g., lobster trappers, managers, and researchers) remains a high priority. One approach with some promise is the establishment of marine reserves, such as those located in CINMS. While non-fishery benefits such as enhancing biodiversity and ecosystem function are well-recognized and widely studied, the potential fishery benefits of reserves are the subject of much debate and little empirical research.

The northern Channel Islands provide habitat that supports several economically important fisheries. The twelve recently implemented marine protected areas (MPA – a type of marine reserve) within CINMS include a portion of important lobster fishing grounds. Existing MPA monitoring programs mainly evaluate ecosystem impacts of MPAs and thus address few fishery-specific objectives. However, the MPAs located within CINMS provide the opportunity for no-fishing zones required for comprehensive fishery stock assessment models.

We hope that future collaborators will synthesize data from our project with knowledge of local lobster trappers and other related data to develop future monitoring strategies and management recommendations for the lobster fishery. Furthermore, we envision that monitoring and collaboration between stakeholders will continue based upon the project results and availability of future funding for collaborative research and monitoring in marine reserves.

Thus, our report focuses on the four key aspects of our project:

Collaboration (Chapter 2)	Collaboration between stakeholders, and its role in long-term monitoring.
Pilot Study (Chapter 3)	A detailed pilot study to assess lobster population demographics and behavior.
Logbooks (Chapter 4)	A historical baseline of catch data using landmarks in our study area.
Recommendations (Chapter 5)	Policy and practical advice for resource managers and other stakeholders.

II. Collaboration

Our project emphasizes cooperation between the lobster fishery, the scientific community, and government agencies. A solid alliance will improve quantitative evaluation of reserve effects on the lobster fishery. Through firsthand experience with the collaborative process and an extensive literature review, we identify common benefits to collaboration, including open communication, trust, and resource sharing. By involving agencies, industry, and scientists in the visioning process, development of a pilot study, and collection of preliminary data, we have set a basis for continued collaboration in monitoring spiny lobster populations in the northern Channel Islands. Collaboration may lead to data for future use by trappers and scientists as they strive towards a larger goal of generating a spiny lobster fishery management plan, a management tool of the Marine Life Management Act.

Collaboration is essential to the success of fishery-related projects, as well as a cornerstone of this project. It not only provides a forum to combine knowledge and experience from all parties involved but also yields informative results for each stakeholder when objectives are met. Each party involved in this collaborative monitoring project has unique skills and expertise to offer: Resource agencies provide policy guidance and access to historical logbook data; lobster trappers provide technical fishing expertise, and cultural realities; and researchers provide scientific and statistical guidance.

The model for collaboration outlined in our project is a helpful framework that brings together members from the lobster industry, agency representatives, and academic researchers in future research. Ineffective communication based on past experiences, societal roles, and cultural misunderstandings often exists between agencies, scientists, and fishermen. For example, in the case of the Channel Islands, the relationship between agencies, scientists, and the fishing industry soured during the MPA design process as ineffective communication resulted in tension and mistrust. We recognize that trust and relationship-building can promote positive interactions between these parties, and so our project focuses on these dynamics.

III. Pilot Study

One of our project's primary deliverables is the design of a pilot study for a long-term monitoring program to understand lobster population demographics and behavior, including juvenile and adult spillover between marine reserves and fished areas, in the northern Channel Islands. Over the long-term, this information will help resource managers evaluate the effects of marine reserves as an ecosystem-based management tool. In addition to providing ecological refuges for many species, marine reserves represent the only truly unfished areas. Researchers are able to compare characteristics of specific populations over time between control sites (fished areas) and treatment sites (marine reserves).

Stakeholders will use pilot study data to estimate juvenile and adult size distribution and abundance, sex ratios, and reproductive characteristics, thereby providing baseline demographic population data useful in future lobster fishery assessment models. We recommend statistically analyzing these data through a nested 3-way analysis of variance (ANOVA). These results should refine the necessary number of sample sites and replicates for long-term monitoring. The pilot study will further test data collection methods and assess the need for changes in sampling methodology.

The sampling regime we propose is based upon a *mark-recapture* method that will allow for direct comparison of individual juvenile and adult lobster growth and movement over time. Standardized study sites located within, near and far from marine reserves at Santa Rosa, Santa Cruz and Anacapa Islands were chosen based upon local trapper knowledge of the most suitable lobster habitats. Specific trap locations within these sites are placed according to a *stratified random sampling* design. We recommend two sampling periods during the closed season for commercial lobster fishing with cooperation by local lobster trappers through paid charter using standard trapping equipment and bait techniques.

IV. Analysis of Commercial Logbooks

To provide a picture of lobster population size and growth in the northern Channel Islands before the implementation of the reserves, we analyzed historical catch data found in the DFG commercial lobster logbooks. These data had been relatively unexplored because the DFG had not digitized trap locations in these records due to the lack of standardized nomenclature. We revisited 5 seasons (1999-2003) of logbook paperwork and recorded trap locations for *catch* and *catch performance*, or the average number of lobsters per trap, by island landmark.

In our project, catch data resolution is important for monitoring because it is the basis for comparison between reserves and fished areas. However, the current block-level catch data is an order of magnitude less than the resolution needed for reserve monitoring. For example, imagine trying to find out how many people lived in Santa Barbara when you only knew how many people lived in California! In the Channel Islands National Marine Sanctuary, the 12 marine reserves have a mean area of 16.3 square miles whereas the 12 Department of Fish and Game (DFG) blocks in our study area have a mean area of 137.4 square miles. Therefore, we seek to improve the historical baseline dataset by analyzing at the landmark level so that catch data can be compared between locations inside and outside of marine reserves.

These landmarks cover areas both inside and outside of marine reserves for the northern Channel Islands (e.g., Anacapa Island, Santa Cruz Island, and Santa Rosa Island). Although the size of the fishing areas identified by local landmark names is variable and imprecise, they are considerably smaller than the DFG blocks. We developed a *gazetteer*, a standardized list of names and their locations, from these landmark names.

Our analysis of catch data reveals that while catch performance by landmark appears to vary during the lobster season (i.e., from October to March), the annual mean catch performance for our study area in the northern Channel Islands appears relatively stable. This suggests varying efforts in trapping each season by the commercial lobster trappers, and seasonal oceanographic changes, particularly on Santa Cruz Island and Santa Rosa Island. Our deliverables include a historical baseline of catch and catch performance with improved spatial resolution, a landmark gazetteer, and an analysis of the economic value of the catch (Appendix K).

V. Recommendations

Our recommendations for future research involve collaborative fisheries work, monitoring spiny lobster populations inside and outside of marine reserves in CINMS, and steps to improve data quality from DFG logbooks. They include the following:

Collaboration

Future researchers should form a Steering Committee with representatives from each participating stakeholder party. Researchers should formalize leadership roles and research agreements through written contracts to ensure responsibilities are clear to everyone involved.

Pilot Study

In addition to the detailed pilot study methodology we provide in Chapter 3, we recommend ground-truthing proposed sample sites to confirm presence of suitable lobster habitat and identify variability between sites. Researchers should also use NOAA, PISCO and NPS monitoring datasets to create habitat maps for further sample site refinement.

Analysis of Commercial Logbooks

The DFG should make three changes to improve the quality and use of data from commercial lobster logbooks: 1) Publish our historical baseline data and annual lobster logbook reports as public resources; 2) Adopt the landmark gazetteer to improve the spatial quality of catch data; 3) Investigate GPS-based logbook data collection methods to improve spatial resolution and accuracy.

The goal of the long-term monitoring plan is to provide quantitative information about lobster population size, growth rates, fertility patterns, and juvenile and adult spillover between marine reserves and fished areas. We recommend the monitoring plan be implemented as soon as possible and continue into the future to collect time-series data on population and individual growth rates, changes in fertility, and movement patterns. Consistent long-term monitoring will supply researchers, trappers, and resource managers with this essential fishery information required by the Marine Life Management Act.

VI. Summary

To measure the effects of MPAs on the lobster fishery in the northern Channel Islands, we introduce a pilot study methodology for long-term monitoring of lobster population demographics and behavior. Our goal is to provide a ready-to-implement pilot study; therefore we elaborate in detail on our pilot study's procedures, siting methods, and statistical analyses. We also provide a historical baseline of catch data based on landmarks, and recommendations to our stakeholders. Our historical baseline of catch data provides a basis for comparing catch data with pilot study data and is also useful for other analyses that require improved spatial resolution. We offer some analyses of our own as examples.

Resource managers, trappers, and researchers should work together to refine this monitoring plan and gather and assess data. The resulting information will help to evaluate impacts of the Channel Islands MPAs on lobster fishery yields and contribute to an evaluation of lobster fishery sustainability for the State's management goals.

Thus, we stress the importance of collaboration between the fishing community, agencies, and researchers to meet the objectives of this project. Our collaborative model provides a basis for collaborative fisheries research, which is not only important for monitoring but also essential for innovative approaches to fisheries management. Our pilot study would benefit from this model, and we hope an implementation of our pilot study would subscribe to it.

Chapter 1: Introduction

A promising field of natural resource management, ecosystem-based management, strives to protect biodiversity using the best available scientific knowledge by integrating biological, social, and economic factors into a collaborative management approach. Ecosystem-based management primarily focuses on comprehensive studies and participation from all stakeholders involved with management of natural resources, with the understanding that sustainability of the resource is a long-term goal for future use (MDNR, 2005). An application of ecosystem-based management, serving to protect biodiversity in coastal and open ocean ecosystems and preserve vital and unique marine habitats, is the use of marine reserves (Gell & Roberts, 2003). Specifically, marine reserves in the Channel Islands National Marine Sanctuary (CINMS), a type of Marine Protected Area (MPA), have the most restrictions on resource uses, such as banning all commercial and recreational fishing in the designated waters.

Marine reserves in CINMS are an example of ecosystem-based management, as the reserves safeguard the physical and biological environment from anthropogenic influences and were designed through a process involving various community members. Marine reserves have many benefits to offer, including ecosystem services such as protecting habitat from physical anthropogenic disturbances, providing relatively pristine and intact ecosystems to study, limiting commercial and recreational fishing activities, maintaining a sustainable fishery, and allowing for the opportunity of spillover of fished species into waters surrounding marine reserves (Babcock et al., 1999). Marine reserves can also serve as a reference point in experimental designs for monitoring processes to further understand complex and dynamic marine ecosystems (Kauman et al., 2004). For the purpose of our project, we take the approach of designing a collaborative monitoring plan to test fishery-specific goals of Marine Protected Areas in CINMS.

In our introductory chapter, we introduce the history and background of the Channel Islands National Marine Sanctuary. We also discuss project objectives, as well as identify project deliverables. There are three specific areas of study outlined in this chapter that we investigated to accomplish our project goals, which include: establishing a network of support for future collaboration, designing a pilot study for long-term monitoring of the spiny lobster, and synthesizing a historical baseline of spiny lobster catch data for future monitoring purposes.

I. Channel Islands National Marine Sanctuary

The waters surrounding the Channel Islands of Southern California contain both natural and cultural resources which have socio-economic, ecological, and historical value to fishermen, tourists, researchers, and local residents. The Channel Islands National Marine Sanctuary (2) was designated a federal marine sanctuary in September 1980 to protect its marine and coastal resources as delineated under the National Marine Research and Sanctuaries Act passed in 1972 (CINMS, 2004). CINMS is one of thirteen national sites that is part of NOAA's National Marine Sanctuary Program (NMS, 2005). The boundaries of CINMS extend from the mean high tide line to six nautical miles offshore of the northern Channel Islands (CINMS, 2004).

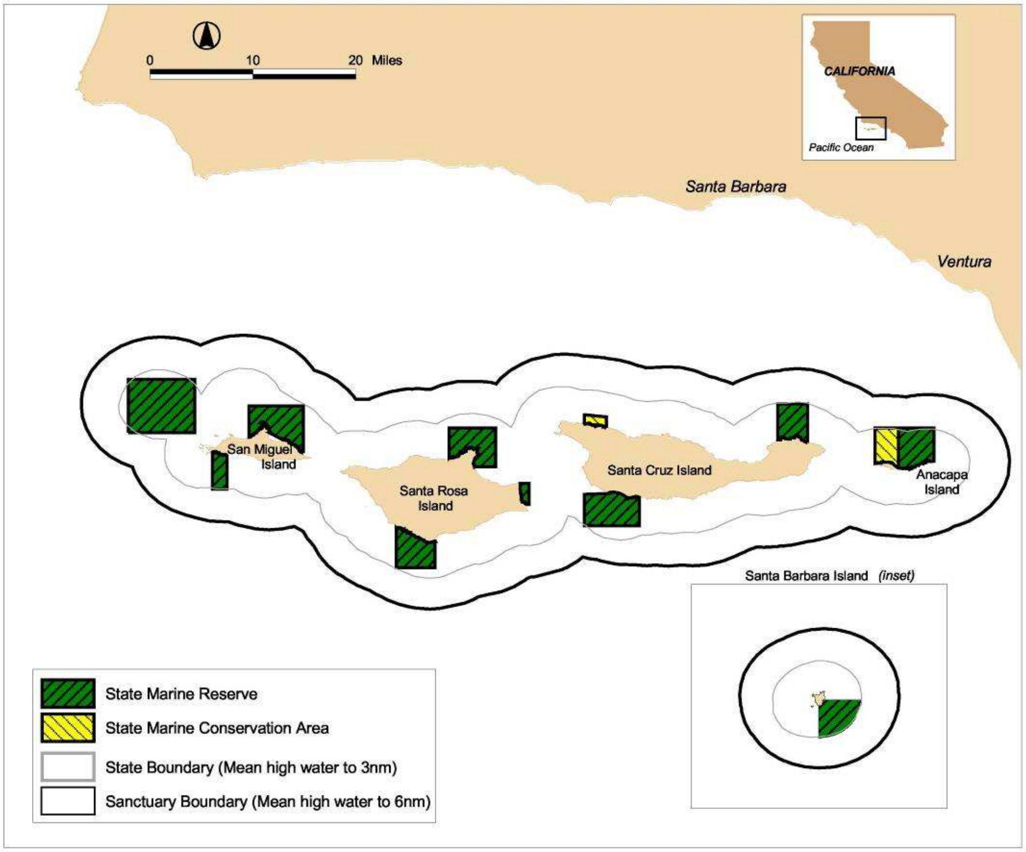


Figure 2: The Channel Islands National Marine Sanctuary and the 12 state MPAs. The outer line surrounding the Channel Islands is the Sanctuary boundary. Source: Channel Islands National Marine Sanctuary, 2005.

A. Location of the Northern Channel Islands

CINMS encompasses a 1,658 square mile area around the northern Channel Islands that is located approximately 14 to 24 miles west of Ventura, California, around a latitude of 34 degrees North and a longitude of 120 degrees West (CINMS, 2004). The northern Channel Islands (3) include Anacapa Island, Santa Cruz Island, Santa Rosa Island, and San Miguel Island, and they reside just south of Point Conception in the Southern California Bight. Santa Barbara Island (2) is often shown with the northern Channel Islands, but it is technically a southern Channel Island. The northern Channel Islands are the visible peaks of a large underwater mountain range that forms the Santa Barbara Channel (4).

Figure 3: Picture of northern Channel Islands from space. Source: (Raquel, 2005).

Figure 4: Side view of northern Channel Islands. This is a side view of the northern Channel Islands looking northward toward Santa Barbara, CA. Source: (Raquel, 2005).

B. Physical and Biological Characteristics

The northern Channel Islands lie within a convergence between northern-flowing warmer water from the California Countercurrent, or Davidson Current, and southern-flowing colder water from the California Current (Figure 5). This convergence in oceanographic conditions has significant effects on the biology of the region, especially in terms of productivity and biodiversity. Northern currents and upwelling within the region deliver relatively high levels of nutrients to surface waters surrounding the islands that support high levels of primary production, including large kelp forests of giant kelp (*Macrocyctis pyrifera*). High levels of phytoplankton, zooplankton, and nekton (e.g., squid) production help to support transient and resident species of whale, including Grey, Blue, Humpback, and several species of beaked whales, as well as large populations of common and bottlenose dolphin, harbor seals, and sea lions. Warm waters from the south provide conditions suitable for southern species, including Garibaldi, the endangered Giant Black Sea Bass, and spiny lobsters. The convergence of coastal current systems form meso- and small-scale eddies and gyres that have varied and complex effects on biological and geochemical processes throughout the CINMS region (Figure 5).

Due to their distance from the mainland and proximity to the open sea, waters surrounding Santa Rosa Island are typically 3-5^{o} F colder than the waters of eastern-most Anacapa Island. The islands are more exposed to waves and currents on their southern sides than their more protected northern sides. These differences in temperature, ocean swell and current have an effect on biological productivity and species composition around the islands.

There are three main biogeographical regions surrounding the northern Channel Islands, consisting of the Oregonian bioregion, the Californian bioregion, and the Transition bioregion (MRWG, 2000). The Oregonian bioregion consists of San Miguel Island, northern Santa Rosa Island, and northern Santa Cruz Island which are bathed by the California Current and support biotic communities similar to those of central and northern California, Oregon, and Washington. The eastern tip of Santa Cruz Island and Anacapa Island are generally surrounded by more temperate waters and represent the Californian bioregion. Southern Santa Rosa Island, southern Santa Cruz Island, and Santa Barbara Island make up a "Transition" bioregion between the cooler and warmer waters (MRWG, 2000).

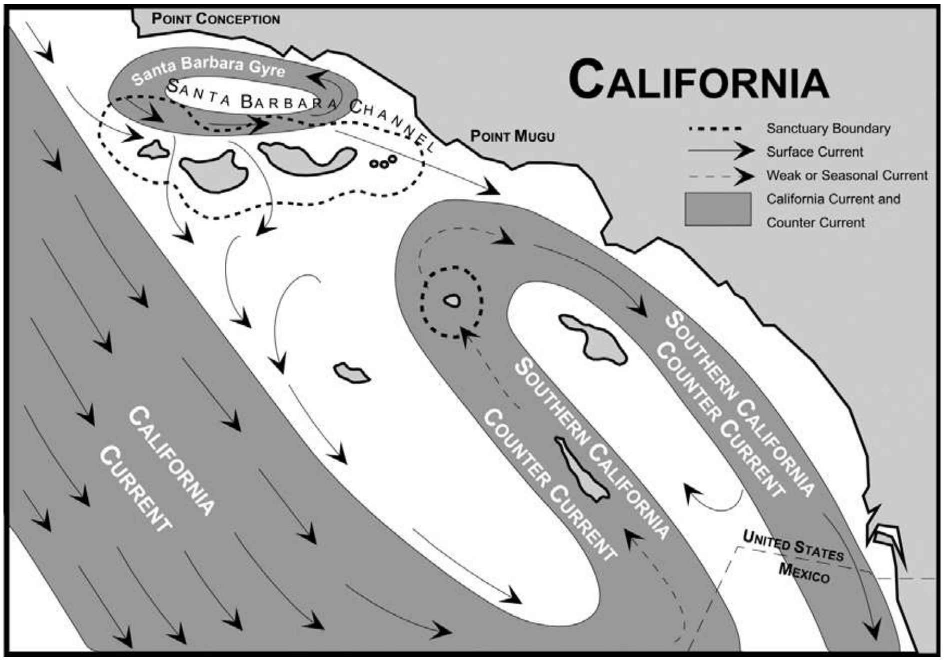


Figure 5: Oceanographic Currents within the Southern California Bight. Source: (CINMS, 2002).

II. Marine Protected Areas

Marine reserves serve many purposes; the primary purpose for modern fishery management is to provide complete and permanent protection from fishing in sensitive and biologically diverse habitats (Roberts et al., 2005). Commercial and recreational fishing activities have economic and cultural benefits, but to manage fisheries in a sustainable manner requires gathering more scientific information in new ways than currently exists (Kauman et al., 2004). The idea of marine reserves as a fisheries management tool has recently re-emerged with mounting relevance in ecosystem-based management, and observations from previously established marine reserves have noted incidental fisheries benefits (Gell & Roberts, 2003).

California's Marine Life Management Act ("MLMA," 1998) calls for conservation and ecosystem-based management of all marine life, including species affected by commercial and recreational fishing activities, to maintain healthy and distinct ecosystems in nearshore environments ("MLMA," 1998). The MLMA emphasizes approaching ecosystem-based management from a comprehensive scientific basis rather than focusing on single species management, the traditional management approach to sustaining fisheries. However, there is still a distinct need for scientific information and data to apply such a comprehensive management approach. "Few fisheries have the legal mandate for ecosystem-based management or to apply precautionary management when information is lacking, so fishermen have little incentive to demand improved information" (Kauman et al., 2004).

California's Marine Life Protection Act ("MLPA," 1999) establishes guidance for scientific planning and designing of marine reserves. "Marine reserves, where no fishing is permitted, serve as a 'biological insurance policy' for future generations against our imperfect ability to project sustainable catch levels, our poor understanding of how fishing affects ecological relationships in the ocean, our failure to take those relationships into account in determining catch levels, and the use of increasingly destructive fishing methods" (NRDC, 2005). On May 26, 2000, President Clinton ordered the protection of significant cultural and natural resources within the marine environment by strengthening and expanding the Nation's system of Marine Protected Areas (MPAs). For the purposes of this order, the definition of an MPA is: "any area of the marine environment that has been reserved by federal, state, territorial, tribal or local laws or regulations to provide lasting protection to part or all of the natural or cultural resources therein" (Clinton, 2000).

Marine reserves are a form of ecosystem-based management because they are geographically specified, based upon scientific and local knowledge, consider multiple external influences, and strive to balance diverse societal objectives (Sissenwine & Murawski, 2004). Marine reserves allow species to interact with their natural environment and each other, while minimizing human impacts that damage ecosystems, such as habitat destruction and overfishing. The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) finds that "many animals and plants in reserves tend to live in greater numbers, grow larger, and reproduce more than their counterparts outside reserves" (PISCO, 2002). Marine reserves can provide a refuge for organisms to live and populate without human predation, and the spillover of larger organisms and dispersal of larvae, juveniles and adults to areas outside reserves can benefit local fisheries (Halpern & Warner, 2003).

A. Channel Islands Marine Protected Areas

While the boundaries of the Channel Islands National Marine Sanctuary offer protection to the marine environment from disturbances to the seafloor, multiple uses of the marine region is permitted in most areas surrounding the islands. In October 2002 the California Fish and Game Commission designated twelve marine protected areas (Figure 2) in state waters (0-3 miles) covering a 10% area of the Channel Islands National Marine Sanctuary. MPA regulations took effect on April 9, 2003 (G. Davis, 2002; DFG, 2003a). California State Marine Reserves prohibit all activities that damage, injure, take, or possess any living, geological, or cultural marine resource, except where special permission is granted for necessary monitoring, restoration, or research (DFG, 2003a).

During the MPA designation process, scientists recommended designing a minimum of one reserve in each biogeographical region (Chapter 3) in the Channel Islands. Each reserve should represent no more than 30-50% area of marine habitat in each biogeograpahical region due to constraints of risk management, experimental design, monitoring, and enforcement (Airamé et al., 2003). "A primary goal set forth by the Marine Reserves Working Group (MRWG) for establishing a network of no-take marine reserves in the Channel Islands was to ensure the conservation of ecosystem biodiversity. This goal was primarily intended to protect representative and unique marine habitats, ecological processes and populations of interest in the region" (MRWG, 2001).

Both the MLMA of 1998 and the MLPA of 1999 support the concept of ecosystem-based management, and CINMS serves to protect the natural, cultural, and historical value of its encompassing environment (CINMS, 2004). The DFG Commission established the Channel Islands MPAs to meet the following goals identified through a stakeholder-based community working group process (Ugoretz, 2002):

Ecosystem Biodiversity Goal	To protect representative and unique marine habitats, ecological process, and populations of interest.
Socio-Economic Goal	To maintain long-term socioeconomic viability while minimizing short-term socioeconomic losses to all users and dependent parties.
Sustainable Fisheries Goal	To achieve sustainable fisheries by integrating marine reserves into fisheries management.
Natural and Cultural Heritage Goal	To maintain areas for visitor, spiritual and recreational opportunities which include cultural and ecological features and their associated values.
Education Goal	To foster stewardship of the marine environment by providing educational opportunities to increase awareness and encourage responsible use of resources.

B. Need for Monitoring and Future Studies in MPAs

"Today there is growing recognition on the need for coastal managers and marine conservation practitioners to be more systematic in their use of tools, particularly MPAs – so as to improve marine conservation learning and create a set of best management practices. To meet this need, there is now general consensus among conservation practitioners that empirically-based performance monitoring and evaluation will improve MPA use and strengthen managers' abilities to achieve core management goals and objectives" (Pomeroy et al., 2004). Effective management has proven difficult, partially because clear, attainable management goals are never specified. For example, in 1995, less than 1% of the world's oceans were MPAs, and fewer than 10% of those MPAs achieved their management goals and objectives (Kelleher et al., 1995).

These failures reflect that effective management of MPAs should be more adaptive. In other words, MPA managers should systematically test, revise and improve management strategies. A keystone to this strategy is the purposeful integration of monitoring and evaluation processes into MPA management.

Marine reserves are valuable biodiversity conservation areas, and can function to protect a part of the fishery stock against overfishing (Sale et al., 2005). "However, there are significant gaps in scientific knowledge that must be filled if no-take reserves are to be used effectively as fishery management tools" (Sale et al., 2005). These gaps can be filled by comprehensive scientific monitoring of marine reserves. There is a push for using marine reserves as a tool for ecosystem-based management, and by conducting long-term comprehensive monitoring, more information can aide scientists and policy makers in best practices for marine resource management.

"Only reserves will allow the development of natural, extended age structures of target species, maintain their genetic variability and prevent deleterious evolutionary change from the effects of fishing. Species with natural age structures will sustain higher rates of reproduction and will be more resilient to environmental variability" (Roberts et al., 2005). While marine reserves may benefit at risk habitats and vulnerable species, monitoring studies need to be completed to validate these claims. To demographic changes and spillover, researchers should monitor the size and abundance of focal species within reserve boundaries; immigration and emigration of target species from reserves to adjacent fishing grounds; changes in ecological resilience; and behavioral responses of fishermen to spatially explicit closures (Rudd et al., 2003).

1. Long-term MPA monitoring in CINMS

Many of the MPA goals established by MRWG require long-term monitoring in CINMS. Since biological resources naturally vary through time and space, detecting whether marine reserves have a significant influence on these dynamic resources takes time. Long-term monitoring is necessary to avoid erroneously attributing human impacts to fluctuations that may occur naturally (Thrush et al., 1996, p. 49). MPA implementation is a human impact on a marine ecosystem, and the effects from MPA implementation need to be detected and distinguished from natural temporal variation (Jones & Kaly, 1996, p. 29). Therefore, long-term spatial and temporal monitoring, both inside and outside of marine reserves, is the only means of explaining whether any recognizable effects are due to natural variation or reserve establishment. Studies indicate some changes, such fish population structure, caused by reserves can occur within as short a time scale as 5 years; this is the time frame we suggest for preliminary evaluation of the CINMS reserves.

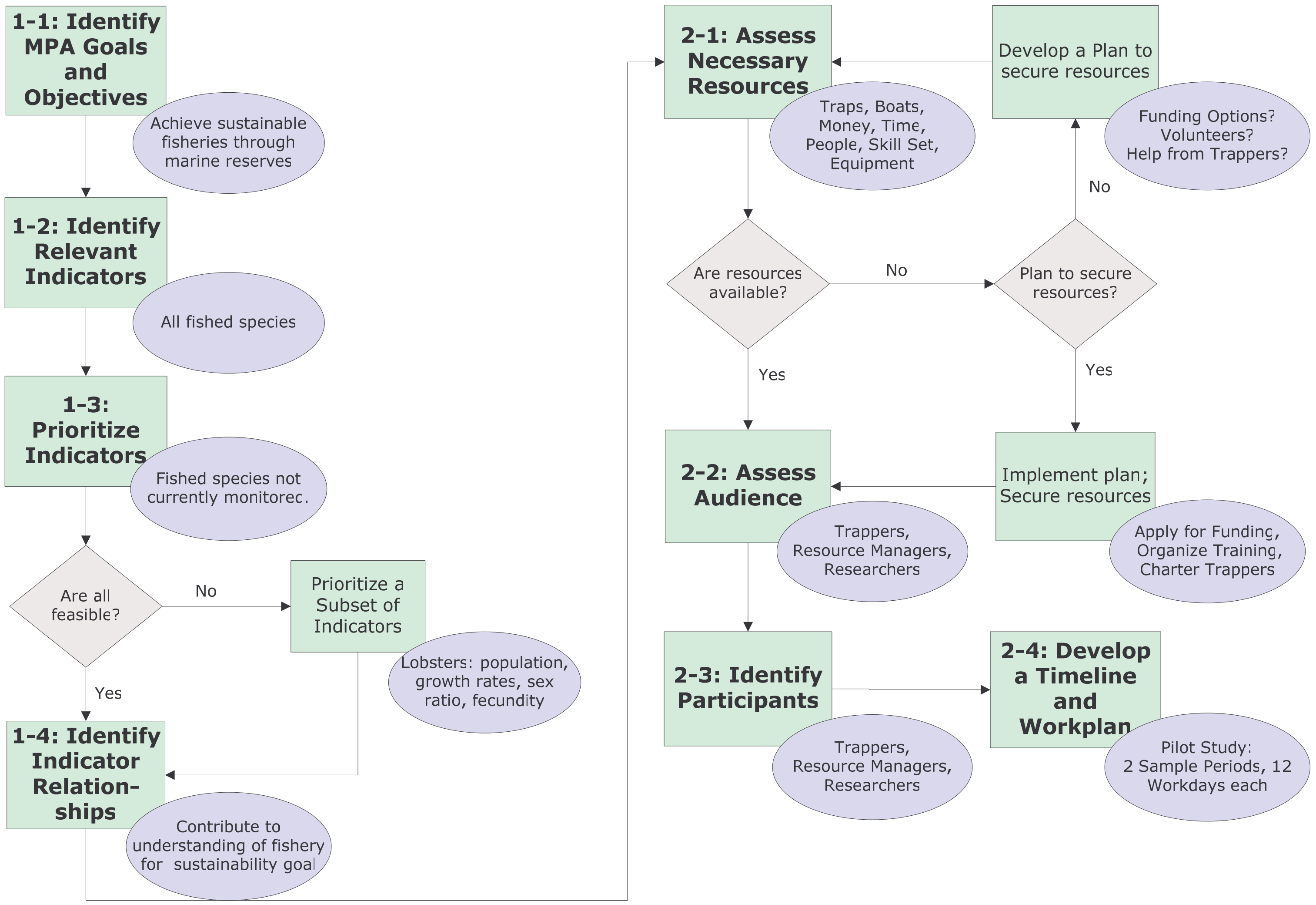
While many groups are monitoring ecosystem-based effects in CINMS, little fishery-related monitoring is currently being conducted in this area (Abeles et al., 2003; 2003). Monitoring MPA effects on fisheries is essential for achieving the sustainable fishery goal. The information from monitoring will help inform fisheries management decisions. For comprehensive monitoring, managers must examine population demographics of a species, as well as movement.

Marine resource managers face many obstacles and must juggle a number of constraints including budget, people, time, resources, and energy. These constraints have led to the concept of focal, or indicator species, used to represent an ecosystem or biodiversity in biological monitoring because they have characteristics that make them suitable for detecting or forecasting impacts (Jones & Kaly, 1996, p. 30). For fisheries monitoring, management ranks focal species according to their economic value. While improved and sustained populations of focal species in MPAs through time argues for MPA effectiveness, monitoring the changes in population abundance of focal species is commonly overlooked (Pomeroy et al., 2004).

2. Monitoring the Spiny lobster fishery in CINMS

The California spiny lobster fishery is one of the most economically valuable marine fisheries in California coastal waters, generating over $4.6 million from over 340 tons of commercial landings during the 2002 trapping season (DFG, 2003e). The northern Channel Islands support some of the most abundant spiny lobster fishing grounds within the state, making lobster the third most valuable fishery for the Santa Barbara/Ventura area behind squid and sea urchins. Monitoring spiny lobster population demographics and movement patterns within CINMS will not only fill a gap in scientific knowledge and understanding about the ecological effects of marine reserves, but also benefit the fishery. Figure 6 illustrates how to use the lobster fishery as an indictor for MPA effectiveness.

The California lobster fishery is interested in pursuing a certification from the Marine Stewardship Council that supports responsible fishing (Miller, 2005). Also, the MLMA aims to foster sustainable fisheries through creating Fishery Management Plans for fished species in California, and currently there is no plan for spiny lobster ("MLMA," 1998). Gathering comprehensive information about spiny lobster populations in the northern Channel Islands is useful because it can be applied to other lobster populations in southern California, and used to draft a Fishery Management Plan. Therefore, the information from monitoring spiny lobster populations within CINMS provides can be used by many managers and stakeholders.


1-1: Identify MPA Goals and Objectives
Achieve sustainable fisheries through marine reserves
1-2: Identify Relevant Indicators
All fished species
1-3: Prioritize Indicators
Fished species not currently monitored.
Are all feasible?
No
Prioritize a Subset of Indicators
Lobsters: population, growth rates, sex ratio, fecundity
Yes
1-4: Identify Indicator Relation-ships
Contribute to understanding of fishery for sustainability goal
2-1: Assess Necessary Resources
Traps, Boats, Money, Time, People, Skill Set, Equipment
Develop a Plan to secure resources
Funding Options? Volunteers? Help from Trappers?
No
Are resources available?
No
Plan to secure resources?
Yes
Yes
2-2: Assess Audience
Trappers, Resource Managers, Researchers
Implement plan; Secure resources
Apply for Funding, Organize Training, Charter Trappers
2-3: Identify Participants
Trappers, Resource Managers, Researchers
2-4: Develop a Timeline and Workplan
Pilot Study: 2 Sample Periods, 12 Workdays each

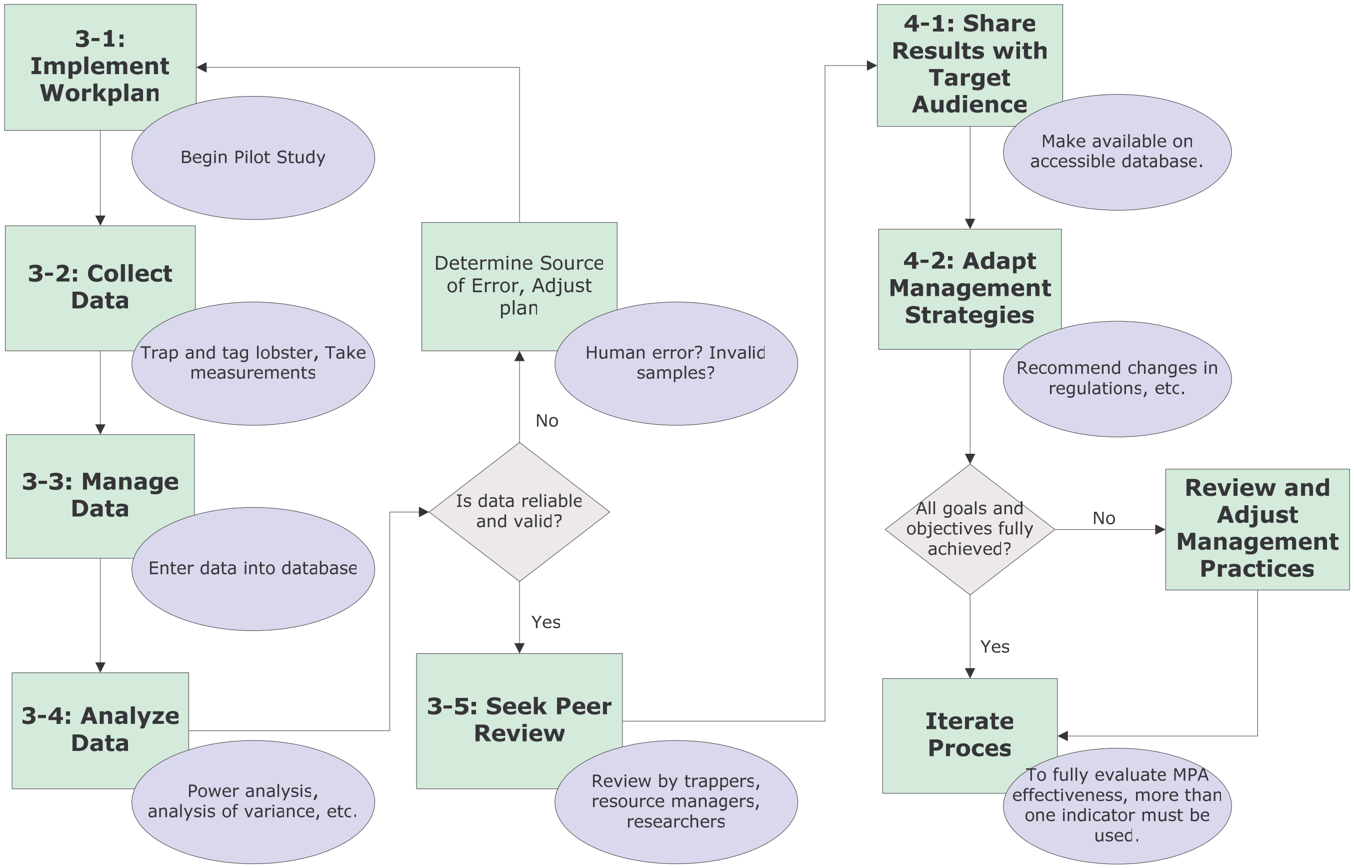


Figure 6: One Aspect of Evaluating MPA Effectiveness, using lobster as an indicator. The flowchart design is adapted from "How is Your MPA Doing?" (Pomeroy et al., 2004), a guidebook of natural and social indictors for evaluating MPA management effectiveness. The flowchart demonstrates four overall stages in evaluating an MPA: 1) selecting indicators, 2) planning the evaluation, 3) conducting the evaluation, and 4) communicating the results and adapting management strategies. The boxes and diamonds are the original steps and questions, while the ovals represent how the lobster fishery can contribute to evaluating the progress of the Channel Islands MPAs towards the sustainable fisheries goal.

III. Project Objectives

The main objectives of our project are to design a collaborative monitoring program for spiny lobster within CINMS MPAs. Monitoring lobster populations will help determine the effects of marine reserves on fished species and the ability of reserves to meet the goal of sustainable fisheries. We report on three aspects of monitoring: the need for a long-term monitoring plan, using a collaborative model for successful monitoring, and understanding the lobster fishery on a finer spatial scale through improving the historical baseline data.

Our three major objectives are to:

1. Design a pilot study for collaborative monitoring of spiny lobster populations inside and outside of marine reserves in CINMS to scientifically test for fishery-specific effects of marine reserves;
2. Facilitate communication and collaboration on marine reserve monitoring between the lobster fishery, governmental agencies (e.g., DFG and CINMS), and the scientific community; and
3. Report a historical baseline of spiny lobster catch data in the northern Channel Islands prior to the implementation of marine reserves in CINMS for future monitoring purposes.

Our deliverables include:

1. An optimal spiny lobster pilot study to collect demographic information and measure possible effects of marine reserve on lobster populations, such as spillover. The pilot study will detail the protocol and procedures for future monitoring in the northern Channel Islands MPAs for CINMS, DFG, and the lobster fishery. Based on prior research (Iacchei et al., 2003, 2004; Stadler, 2004), the monitoring plan will involve a mark-recapture lobster study and includes data collection for demographic and essential fishery information. These data include abundance estimates, population distribution, age and growth characteristics, size frequency, fecundity, spillover, and catch per unit effort (CPUE) (Chapter 3, Appendix H).
2. A report of our recommendations for launching and continuing a collaborative network between local lobster trappers, government agencies, scientists, and researchers (Chapter 2, Appendix A, Appendix B).
3. A dataset providing a historical baseline of fishing effort and catch for spiny lobsters within CINMS prior to the implementation of marine reserves using DFG lobster logbook records (DFG, 2003d) (see Chapter 4, Appendix I, Appendix J, and Appendix K). The historical baseline provides catch information on a finer-grain spatial scale offering estimates of lobster abundance and location inside and outside of marine reserves for future monitoring or research studies within CINMS.

IV. Collaborative Research Planning Among Stakeholders

In 1999, a stakeholder-based community group, called the Marine Reserves Working Group (MRWG), was established and agreed on the following mission statement:

> *"Using the best ecological and socioeconomic and other available information, the Marine Reserve Working Group (MRWG) will collaborate to seek agreement on a recommendation to the Sanctuary Advisory Council regarding the potential establishment of marine reserves within the Channel Islands National Marine Sanctuary area"(2002).*

The working group included resource agencies, scientists, commercial and recreational fishermen, environmental groups, and several other user groups that stepped forward to participate in this community group. As a result, this unique working group embodied diverse perspectives regarding marine reserves in the Channel Islands.

Stakeholders have vested interests in the outcome of the explicit goals established by the MRWG as a guide for the governance of marine reserves (e.g., protection of marine habitats and ecological processes; maintaining long-term socioeconomic viability in the area; achieving sustainable fisheries; maintaining natural and cultural heritage; and providing educational programs) (Ugoretz, 2002). Monitoring marine reserves can play a role in tending to these vested interests; when stakeholders are involved in reserve monitoring, they are better able to evaluate the goals of their interest. For example, the CINMS and DFG are concerned with evaluating the effects of recently instituted marine reserves on fisheries since achieving sustainable fisheries is a goal of the state marine reserves. It is also natural for members of the fishing industry to be involved with monitoring marine reserve effects on fisheries because of their common interest in the sustainable fisheries goal.

In addition, marine resource management through the use of marine reserves may have local social and economic consequences, both positive and negative, which are central to policy and management and need to be monitored. Delaying socioeconomic monitoring may risk intensifying the rift between fishing communities and managers. For example, stakeholder participation in monitoring marine reserve effects on a fishery is a mechanism to mend the rift between agencies and the fishing community, while incorporating socioeconomics into monitoring strategies.

A. Shared Accountability

By partnering resource agencies, scientists, and industry through research, data are generated and shared between parties, as agreed. Collaborative monitoring encourages the parties involved to accept consequent management decisions (Karp et al., 2001). In addition, collaboration demonstrates cooperation in good-faith and encourages the participating parties to be involved throughout the project. These characteristics, in turn, contribute to the defensibility and acceptance of results across stakeholder groups.

B. Expertise

Biological, socioeconomic, policy, and local information are needed to effectively monitor marine reserve effects on fisheries. Collaborative partnerships benefit from the expertise of all involved parties and strengthen the collective knowledge of the group. For example, each party – agencies, scientists, and fishermen – in our project contributes unique skills and expertise.

Resource agencies provide regulatory and policy guidance, as well as historical logbook data. Lobster trappers have a specialized knowledge of the local marine system, and fish behavior and habitat, which are important to site-specific research. This knowledge, often referred to as local ecological knowledge, differs from scientific knowledge, but is useful and perhaps necessary for comprehensive local fisheries research (Scholz et al., 2004). In addition, the trappers provide fishery expertise, gear and vessel operations, and socioeconomic and cultural realities. Scientists are essential to the partnership, as they provide monitoring and biological knowledge, and analytical expertise needed to draw conclusions from research. Scientists are also useful in training fishermen to follow scientific procedures and to collect scientifically defensible data (Haneishi et al., 2003).

C. Trust

Trust is central to all collaborative partnerships. It ensures the success of collaborative research and upholds the relationships between parties through time. Recognizing the importance of trapper research contributions and incorporating their local knowledge in the project helps gain trapper ownership and acceptance of the research; this, in turn, helps build trust (Kaplan & McCay, 2004).

Cross-discipline collaboration also helps to break down barriers between parties. Agency realization that industry involvement in research can be executed in a scientifically defensible manner sets the stage for future collaborative fishery research. Trappers are trusting of management decisions that stem from collaborative work because they understand the scientific process and results that form the basis of ensuing management (2003). Building trust among research participants will not only help achieve cooperation between parties but also bring about support for the results of the monitoring project.

V. Pilot Study

The first step toward creating an effective long-term lobster monitoring plan is to design a robust monitoring program through a *pilot study*. We propose a pilot study that will optimize sampling procedures for future monitoring in the northern Channel Islands marine reserves (Chapter 3). Furthermore, we design the pilot study in a form that can implemented immediately by CINMS, DFG, and/or the lobster industry.

Based on prior research, the pilot study uses mark-recapture methods for obtaining information on lobster population demographics and behavior (Iacchei et al., 2003, 2004; Stadler, 2004). The data collected will offer estimates on lobster abundance, population distribution, size frequency, age and growth characteristics, fecundity, and movement inside and outside of the marine reserves. Administrators of the long-term monitoring plan can use these data as a comprehensive baseline to compare and analyze future monitoring data.

Before implementing a monitoring plan, stakeholders must identify, test and refine an appropriate sampling methodology. This task involves assessing the requisite number of traps and replicate sampling days, as well as approximate depths and geographical locations, using data from the pilot study. "A crucial part of the design of a monitoring program, once the appropriate time scale has been determined, is choosing the sample size. This is usually done by examining the relationship between spatial variation and sampling intensity from data collected in a pilot survey" (Thrush et al., 1996). Furthermore, once the pilot study is underway, participants must assess the methods used to collect the data and make adjustments to the sampling protocol based on their field experience.

Once the pilot study is completed, statistical analyses can detect the variance in trap data as well as the power of the data to detect a significant difference between trap sites and gradient locations, also known as "effect size." The results of the pilot study and these statistical analyses can be used to refine procedures for obtaining accurate and precise data in the long-term monitoring plan. Future researchers can then base their monitoring efforts on sampling where and when it will be most effective given the level of variance of the pilot study data.

In our project, we lay the groundwork for a long-term monitoring plan using results from our robust pilot study sampling procedures (Chapter 3). In turn, we believe this groundwork may ultimately yield quantitative data on lobster demographics and behavior in the northern Channel Islands that will be useful for fishery management in the future.

VI. Historical Baseline Data

Historical baseline data is important because it provides a means of evaluating spatial and temporal variation. Specifically, historical data in CINMS is necessary for long-term monitoring because it provides the *before* data for BACIPS experimental designs, as well as demonstrates the applicability and use of previously collected fishery dependent data. In our project, we built a historical baseline of lobster catch and catch performance (i.e., a measurement similar to catch per unit effort) data for our study area in the northern Channel Islands from DFG commercial lobster logbooks. Our historical baseline spans 5 seasons, 1999 through 2003, all of which were prior to MPA establishment (G. Davis, 2002). Also, our historical baseline dramatically improves the spatial limitations of prior datasets through the use of trapper-identified landmarks (Chapter 4).

Early catch data for the California spiny lobster fishery had broad spatial resolution. These catch data date back to 1872, and were reported by county for 1880 – 1904 from San Diego north to Santa Barbara (Odemar et al., 1975, pp. 16 - 17, Table 1). Modern catch data are increasingly available, and since the 1974 season when the DFG introduced logbooks, catch data have better spatial resolution (Duffy, 1973; Odemar et al., 1975, p. 27; Reid & Ramsay, 2004). Catch data are reported by 10 x 10 minute blocks; each block has a mean area of 194.6 square miles.

Nonetheless, this spatial resolution remains poor for marine reserve monitoring purposes, as it is recommended we set "the spatial scale of the data collection, science, and management appropriate to the spatial scales of the fish and the fishermen" (Hilborn, 2004, p. 276). We utilized the previously unused trapper-identified landmarks reported in the lobster logbooks to improve the spatial resolution of the historical baseline. While this approach yielded spatial areas with uncertain boundaries for historical lobster fishing locations, it provided a powerful basis for analysis (Appendix J, Appendix K).

Chapter 2: Collaboration

I. Approach to Collaboration

A. Purpose – why collaborate?

Collaboration is essential to the success of fishery related research projects. It provides a forum to combine knowledge and experience from parties of diverse backgrounds and a cooperative method to approach common work objectives. In our study, the DFG and CINMS are concerned with evaluating the fishery effects of the recently instituted MPAs, an explicit goal of state MPAs under the MLPA (Ugoretz, 2002). This goal is of principal interest to the lobster fishery due to the loss of important fishing grounds with the establishment of the Channel Islands MPAs in 2003.

Throughout the MPA design phase, trappers adamantly defended their fishing areas; however, some of these areas were designated as no-take zones because of their ecological significance. The industry is concerned that the MPAs will not fulfill the pre-stated goal of fisheries enhancement (Haneishi et al., 2003; Miller, 2005). We propose an alliance between industry, agencies, and scientists that will lead to quantitative evaluation of reserve impacts on the lobster fishery. In turn, this information may provide data for trappers and scientists as they strive towards a larger goal of generating a spiny lobster fishery management plan.

B. Collaboration v. Cooperation

The term “collaborative research” is becoming increasingly popular in fisheries science; however no standard definition for the term exists. The term “cooperative research” has also gained popularity in recent years. Because these terms are not definitive, they are easily confused. Sea Grant defines cooperation as “an association of persons or businesses for common, usually economic, benefit,” and collaboration as “working together in a joint intellectual effort” (OSG, 2000). Collaborative fisheries research commonly refers to a partnership between fishermen and scientists conducting some level of research together, ranging from industry participation in a project designed by scientists to communally designing a research project, typically not for profit (2003).

As industry-science partnerships become more widely used in fisheries research, the difference between cooperation and collaboration becomes more distinct. Table 1 defines various forms of industry-science partnerships (2003). This matrix identifies four industry-science partnerships: networking, cooperation/alliance, coalition, and collaboration; although we only focus on cooperation and collaboration. Although this matrix provides more cataloged criteria for classifying industry-science relationships than the Sea Grant definitions, the existing overlap among categories may make classifying specific research relationships difficult.

In many current models of collaboration, industry-science partnerships begin by collectively designing the research and continue throughout the duration of the project. In these models, fishermen assist with data collection, interpreting results, and reviewing manuscripts (Haneishi et al., 2003). This approach is effective because it involves all of the research participants throughout the entire project. However, there are a few concerns with this framework. Scientists often fear that working with fishermen who lack scientific training will compromise the power of their research. They are also concerned that fishermen misunderstand the extensive time commitment required for research (Haneishi et al., 2003).

If these concerns are addressed in advance, collaborative research can be quite effective. Researchers willing to train fishermen in data collection and scientific processes will improve the collaborative partnership. In addition, both parties should discuss and define their respective time commitments before a research agreement is made.

C. Our Science-Industry Partnership

Our proposed monitoring project has aspects of both cooperative and collaborative partnerships. We approach collaboration by uniting governmental agencies, industry, and scientists. We identified gaps in data and understanding regarding lobster populations in the Channel Islands that require collaboration among all of these stakeholders to fill.

Each party involved in this monitoring project brings unique skills and expertise to the cooperative. Our project is located in a region of joint jurisdiction between state and federal governments, thus, we enlisted the involvement of two management agencies: the DFG and CINMS. The DFG provides access to historical fishing logbook data, while CINMS is the lead agency responsible for managing research in the Sanctuary. Together they provide regulatory and policy guidance.

Participation of lobster trappers is vital because of their rich local knowledge. There is a limited amount of detailed fisheries information for our study area (Abeles et al., 2004; Ugoretz, 2002). Trappers can help fill this information gap by providing local knowledge that is valuable for designing programs such as our monitoring plan. In addition, they provide technical fishing expertise and socio-economic and cultural perspectives (Haneishi et al., 2003).

The role of the scientist in this cooperative is critical in providing the knowledge needed to design and conduct research, and analyze resulting data. By involving agencies, fishermen, and scientists in the visioning process, development of a pilot study, and collection of preliminary data, we have set a basis for continued collaboration and monitoring of spiny lobster in the northern Channel Islands.

Based upon the stakeholders involved in the pilot project our collaborative structure consists of a core group and peripheral parties (Figure 7). The core group, referred to as the Bren-Lobster Collaborative, includes Bren researchers, Santa Barbara lobster trappers, and Sea Grant representatives. Peripheral to the Bren-Lobster Collaborative are parties that act as consultants to the core group, including the DFG and CINMS representatives, UCSB researchers, USC researchers, and other scientists. These peripheral parties are not involved in the daily research tasks of the core group, but are called on by members of the Bren-Lobster Collaborative when their expertise is needed. This model for collaboration may be helpful in setting a framework for involving the fishing industry in future research.

According to the Fisheries Research Partnership Matrix (Table 1), our monitoring plan combines cooperative and collaborative research. Currently, we function more similarly to a cooperative because the original partnership was designed to ease research needs. However, as the Bren-Lobster Collaborative evolves, we are progressing towards a collaborative structure.

Table 1: Fisheries Research Partnership Matrix. Purpose, structure, and process for fisheries research networking, cooperation, coalition, and collaboration partnerships (Houge, 1992).

Levels	Purpose	Structure	Process
Networking	• Find common understanding • Sharing information • Create base of support	• Non-hierarchal • Roles undefined • Loose links between parties • Community action brings parties together	• Minimal leadership • Minimal decision-making • Little conflict • Informal communication
Cooperation, Alliance	• Provide coordination to match needs • Limit duplication of services • Ensure tasks are done	• Central body acts as communication base • Semi-formal links • Partially defined roles • Advisory links between parties • The group leverages/raises money	• Facilitative leaders • Complex decision-making • Some conflict • Formal communications within central group
Coalition	• Share resources to address common issues • Merge resource base to create something new	• All members involved in decision-making • Roles defined • Links recognized with a written agreement • Group develops new resources and joint budget	• Shared leadership • Formal decision-making with all members • Communication is prioritized
Collaboration	• Accomplish shared vision • Build interdependent system to address issues and opportunities	• Consensus used in decision-making • Roles, meetings, and evaluation formalized • Links and positions are formalized with a written agreement	• Representative leadership with high level of trust • Ideas and decisions equally shared • Communication is prominent and priority

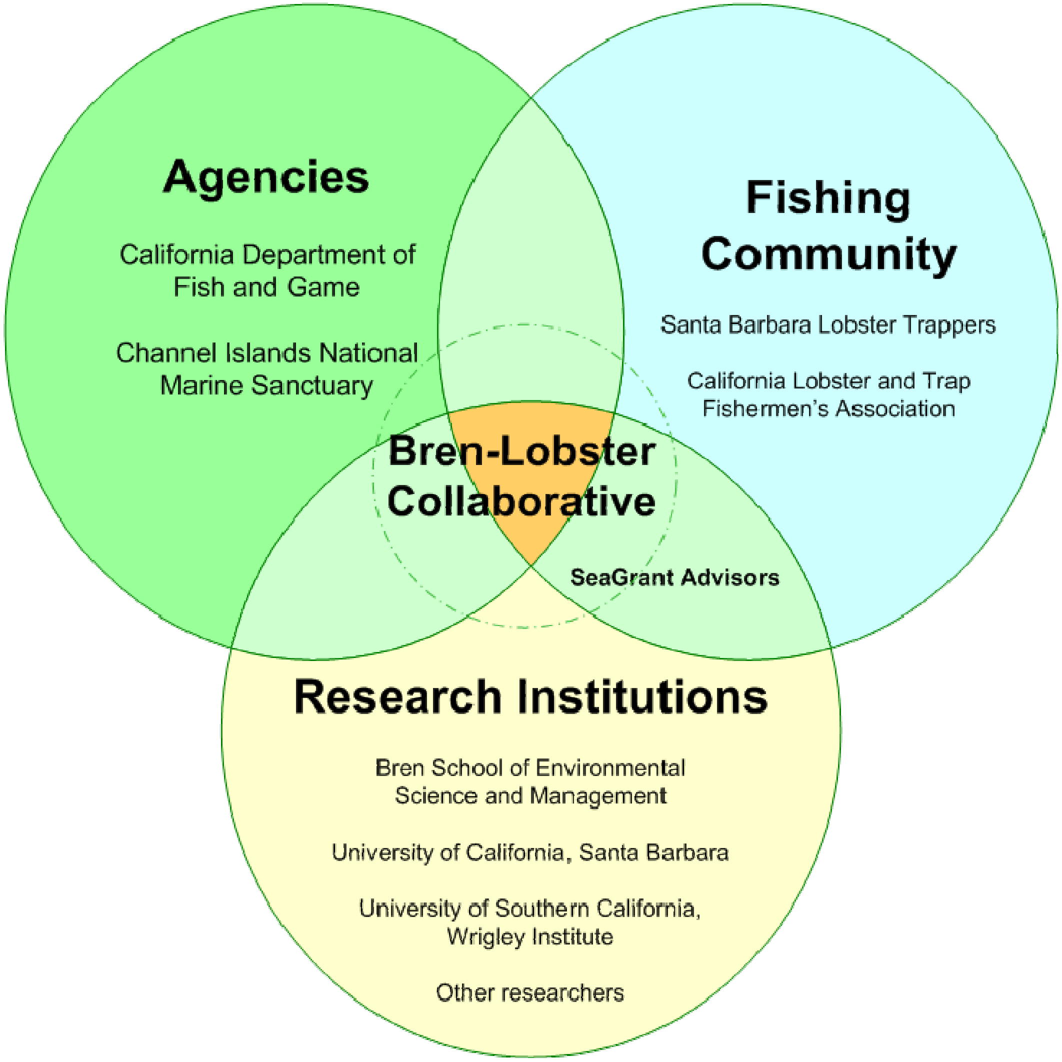


Figure 7: Bren-Lobster Collaborative Structure. Pictorial depiction of the interrelations among collaborative parties involved in this project.

The partnership was originally intended to combine the scientific abilities of researchers with local knowledge and fishing expertise of trappers. Since inception, the Bren scientists have incorporated trapper ideas into the research design with hopes to work towards a shared research vision. For example, the agencies and Bren scientists are interested in monitoring MPA effects on lobster populations. Although this information is useful to trappers, they are more interested in using the data for support as they begin to design a spiny lobster Fishery Management Plan. The lobster trappers are also considering pursuing a Marine Stewardship Council sustainable fisheries certification (Miller, 2005). The scientific and collaborative methods from our pilot project will be useful in modeling future research involving industry and scientists.

Formal roles between parties are characteristic of a collaborative structure. The roles of each party in our partnership reflect a cooperative relationship - they are generally understood, but loosely defined. The links between groups are somewhat informal but if funding for the monitoring program arises, we recommend these links become formalized with a written financial and/or contractual agreement. In addition, our structure is more cooperative because the core acts as a communication center, although communication occurs on an ad-hoc basis. Developing effective communication strategies is essential for successful collaboration and building trust into relationships and has been a focus throughout this project.

The decision-making and data gathering processes within our research relationship incorporate aspects of both cooperatives and collaboratives. Currently, we practice the complex decision-making characteristic of a cooperative, for example whether or not trappers should pursue advanced licensing to accommodate scientific researchers aboard their vessels. The pursuit of advanced licensing is costly and time consuming for trappers, but may be the only option to legally allow researchers aboard their vessels. By integrating consensus-based decision-making processes, the Bren-Lobster Collaborative would proceed towards collaboration and benefit from minimizing rifts among participants.

Our data gathering processes are characteristic of collaboration. Currently, there is no funding to conduct the proposed pilot monitoring study set forth here. Nonetheless, Bren researchers are helping lobster trappers gather demographic information through port-sampling. These data are not helpful for MPA monitoring per se, but are valuable to local trappers as they provide more information about the lobster stock to pursue their goals of designing a spiny lobster Fishery Management Plan and potentially seeking a Marine Stewardship Council sustainable fisheries certification.

II. Benefits and Barriers to Collaboration

A. Benefits

The benefits of collaborative research are many, including improved communications, inclusion of cultural knowledge into a science-based approach, building of trust, and establishment of a forum for resource sharing between diverse groups. Management councils and agencies have recently dedicated more effort and resources to collaboration and co-management projects because they see value in these projects (Kaplan & McCay, 2004).

Collaborative fisheries research improves communications between diverse stakeholders by building positive relationships. It has potential to eliminate some of the stereotypes that exist between management agencies, scientists, and fishermen. Confrontational or reticent interactions can be changed into accepting, affable relationships. Collaborative research is also unique because it increases the transparency of scientific research to a wide range of stakeholders by engaging multiparty participants. Each step of the research involves all participants, including data collection and analysis, which are areas that do not typically involve the fishing industry. Consequently, collaborative research is widely accepted by stakeholders from diverse backgrounds (Kaplan & McCay, 2004).

Collaboration also helps mitigate potential disputes between parties regarding contested fisheries information and management. Collaboration prevents stakeholders from questioning the results, and may increase the acceptance of subsequent management polices by involving resource agencies and industries throughout the entire project (Haneishi et al., 2003; Karp et al., 2001).

Partnerships between stakeholders capitalize on the expertise of all involved and strengthen collective group knowledge. Collaborative research combines scientists' understanding of research methods, analytical power, and biology with fishermen's specialized knowledge of the local marine system, fish behavior and habitat, and vessel and gear operations. Scientifically defensible collaborative programs can influence management by encouraging support for future collaborative research and stimulating the development of more effective marine policies (Kaplan & McCay, 2004).

For monitoring studies, fishermen are helpful for identifying appropriate monitoring sites – their local knowledge provides insight on habitats and locations of certain species (Haneishi et al., 2003). In return, researchers can use their technical skills to train fishermen to follow scientific processes and collect scientifically defensible data. The involvement of agencies is important because of their familiarity with the regulatory framework and processes. Together, the knowledge of each party compounds the overall strength of the collaborative.

Collaborative partnerships also build conviction between typically distrusting stakeholders. Marine policies are based on the best data available; however fishermen are often skeptical of management decisions based on research that is not transparent. Building trust between parties is an essential aspect of collaboration. Collaborative research provides a mechanism to renew trust among parties influenced by management processes (Kaplan & McCay, 2004). Studies show that fishermen involved in data gathering and research have a higher acceptance science-based management decisions, thereby encouraging compliance. (Haneishi et al., 2003).

Giving social science equal representation in research will help gain fishermen trust. Incorporating the social aspect in research provides a mechanism to better understand the people involved, including their motivations, culture, heritage, and economic situations and subsequently improve fishermen compliance to regulations (Kaplan & McCay, 2004). Fishermen have greater support for fisheries research that integrates social science, because the results are informative for their livelihood.

The research needed to address fishery related questions can be conducted independently by agencies or fisheries participants; however, collaborative research is more comprehensive (Karp et al., 2001). Assimilating knowledge from diverse stakeholders in the design phase of a research project sets a cooperative tone and creates solidarity that serves as a basis for future research. Scientist-facilitated workshops help strengthen relationships between scientists and fishermen by providing fishermen the training needed for data collection and using scientific tools, ensuring that scientifically defensible data is generated through collaborative research (Runge & Jones, 2003). Through teamwork and shared resources, collaborative research can generate stronger results than research conducted exclusively by fishermen, scientists, or agencies (Haneishi et al., 2003; Karp et al., 2001).

B. Barriers and steps to overcome them

Collaborative fisheries research is a good method to involve multiple stakeholders in monitoring; however, it is not free from obstacles and challenges. Limited resources, ineffective communication, and a prohibitive regulatory framework often inhibit collaborative research.

Relations soured between fishermen, scientists, and the management community following the MPA design process in the Channel Islands. Fishermen became frustrated because there was no delineated process for them to become involved in monitoring. Additionally, scientists scrutinized any data collected by fishermen (Haneishi et al., 2003).

It is not uncommon for the expectations of agencies, scientists, and fishermen to differ - central to this issue is ineffective communication. This problem extends beyond the northern Channel Islands as these issues have complicated fisheries research around the world. Communication problems often cause adversarial tensions among stakeholders. Real and perceived negative relationships thwart potential partnerships by damaging relationships and self-images (Kaplan & McCay, 2004). This negative atmosphere can impede the management process. Scientists and agencies need to recognize fishermen as natural scientists in their respective areas; they often have the best knowledge about local marine environments. In turn, fishermen need to be more accepting of managing agencies who are working in their direct interest - to sustain resources into the future.

Communications can be improved with a few simple steps. Often protocols do not exist to incorporate ideas from diverse stakeholders regarding issues within a fishery (Haneishi et al., 2003). By opening interpersonal communication networks between agencies and fishermen, both groups may become more accepting of one another. A welcoming attitude by one helps the other feel appreciated and respected.

The Bren-Lobster Collaborative provides a unique opportunity to address these issues locally. Fishermen interviewed after the MPA design process indicated the need to improve relations between the DFG and fishermen before agreeing to participate in monitoring and collaborative fisheries research (Haneishi et al., 2003). Trapper involvement in the Bren-Lobster Collaborative may indicate progress in communications between these parties.

Constraints beyond general collaborative barriers influence this project as well, primarily funding. In order to complete the recommended monitoring program, a budget of up to $50,000 is needed. The DFG or CINMS are likely funding agencies for this project; however problems arise in seeking funds from both of these agencies. First, due to California budget constraints, the DFG is operating with highly restricted funding. It is improbable that the DFG will be able to fund externally proposed projects now or in the near future.

Because there is a need for fisheries monitoring in the MPAs, it is intuitive to seek funds from CINMS. However, federal funding takes almost a year to secure. Thus the process does not couple well with the timeline for a one-year Bren master's project. Therefore, funds must be in place prior to the onset of the project. (See Appendix L for a list of potential funders.)

Time is another constraint for the Bren-Lobster Collaborative. Bren master's projects begin in April and continue through the following April. The proposed MPA monitoring occurs in the summer, from June to September. With funding in place, one sampling season can be completed by a group of Bren master's students; however long term sampling by a single group is not possible.

It may also be difficult to charter lobster trappers during the summer because most trappers fish a second species during the lobster off-season (Miller, 2005). Incentives for trappers to participate in the monitoring program must offset the income they would typically receive from fishing in the summer. Due to these time constraints, we recommend future work be performed by a group that can conduct long-term monitoring and contract trappers in advance.

Regulations pose an additional constraint for conducting this collaborative research. Insurance and permits must be acquired before sampling. Liability can be an issue in cooperative research if researchers charter the fishing vessels. Trappers may need to obtain additional or different insurance to legally take researchers on board their vessels. Scientists affiliated with an organization may have tougher safety requirements than those needed for fishing due to the organization's insurance policies. (2003). Scientists may be able to overcome these insurance issues by obtaining crew permits, thereby gaining coverage by the captain's insurance.

Various permits are also required to conduct fisheries research during a closed fishing season. A research permit is needed from CINMS for any projects in the Sanctuary that may potentially disturb the seafloor. Documentation to acquire this permit includes the type of gear used, research goals, potential disturbances to the seafloor, and planned mitigation measures (if necessary) (2001).

The DFG also requires a Scientific Collecting Permit that involves capture of marine fish or invertebrates, regardless of whether the researchers will be harvesting the samples. To attain the permit a form must be filled out detailing any harmful impacts the research may have on lobster. It must be submitted a few months before the research begins to allow for processing. Issues related to insurance and permits need to be managed before field research can begin.

III. Collaborative Case Studies

The following case studies explore various fisheries research partnerships and provide useful insights to our Bren-Lobster Collaborative. An overview of each case study is presented, as well as a description of the fishery, collaborative model, achievements, and lessons learned from each project. The collaborative structures and lessons learned may be particularly useful in planning future collaborative fisheries research projects.

A. The Red Rock Lobster Fishery of Central Baja California, Mexico[1]

1. Overview

In May 2004, the spiny lobster (locally known as the red rock lobster) fishery in central Baja California became certified as a sustainable fishery by the Marine Stewardship Council (MSC). This valuable fishery is controlled by nine cooperatives in the Federacion Regional de Sociedades Cooperativas (Regional Federation of Cooperative Societies) from Isla Cedros to Punta Abreojos. As the tenth recipient of the MSC certification, this fishery is the first to be recognized from a developing nation.

2. The Fishery

Spiny lobsters are fished commercially in Baja, Mexico from the US-Mexico border to Margarita Island. Most of the stock is fished between Cedros Island and Punta Abreojos along the Pacific coast of Baja by ten cooperatives; these cooperatives account for approximately 80% of the total lobster catch in Baja. Nine of the ten cooperatives, comprised of about 500 trappers, are in the Federation and received MSC certification. Each cooperative employs a biologist or technician to collect data and advise the cooperative, Federation, and government agencies.

The lobster fishery in central Baja began in the early 1900s. In the 1940s, the Mexican government drafted legislation dividing fishing rights in central Baja among cooperatives. The fishery is managed by the Sub-Delegation of Fisheries in cooperation with the National Fisheries Institute and government research bodies. New management efforts began in the 1990s involving a combination of limited entry, spatial management, and community-based self-regulatory measures. Regulations include area closures, seasonal closures, minimum legal size (82.5mm CL), fishing gear restriction, and prohibited catch of egg-bearing females. The Total Allowable Catch for the entire fishery is approximately 1,300 tons.

Fishermen in Baja use small boats and traps to fish lobster. The traps are similar to those used in the California lobster fishery – rectangular traps made of plastic-covered wire mesh and fitted with escape ports. The traps are typically baited with fish or mollusks and most of the catch is sold alive. Red rock lobster is primarily sold on the international market - 90% is exported to Asia, France, and the US, while only 10% is sold domestically, mainly to restaurants (MSC, 2004).

3. Collaborative Model

According to the Fisheries Research Partnership Matrix, the Baja spiny lobster fishery functions as a cooperative or alliance. The cooperatives coordinate with each other to meet their goal – sustained lobster catch. The Federation is a central body that acts as a communication base for the cooperatives. There are facilitative leaders from each cooperative, and semi formal links exist between these cooperatives. The roles of individuals are somewhat defined, for example, scientists travel aboard vessels to collect data regarding the fishery. Each scientist shares data with the Federation and government to assist in management. Communication among cooperatives is important for understanding catch and resource trends in the region, and maintaining management policies.

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[1] Information from this case study is from the red rock lobster MSC report (2004).

4. Achievements and Lessons Learned

An assessment team awarded an MSC certification in May 2004 to the 9 cooperatives that target spiny lobster between Cedros Island and Punta Abreojos. This case illustrates the important role organized fisheries associations or cooperatives play in reaching industry goals.

B. PULSE: A Cooperative Partnership for Coastal Ocean Ecosystem monitoring in the Gulf of Maine[2]

1. Overview

PULSE is a partnership between University of New Hampshire (UNH) and commercial fishermen to design and develop a cooperative, industry-based monitoring strategy for the pelagic ecosystem of the Gulf of Maine. An understanding of fishery and non-fishery specific information is becoming increasingly important in the Gulf of Maine, especially as regional fisheries management progresses towards ecosystem-based management. PULSE seeks to understand the causes of recent dramatic changes in fish stocks by monitoring zooplankton to establish a long-term dataset and be used in system-level analyses (Runge & Jones, 2003).

2. Collaborative Model

PULSE exemplifies a collaborative relationship through its decision-making processes, vision, leadership, communication and roles within the partnership.

The partnership began by selecting a Steering Committee to guide the design, implementation, and analysis of industry participation in a pilot monitoring program. First, the Steering Committee identified monitoring activities and habitats of interest to all stakeholders, examined the cost effectiveness of monitoring efforts led by the fishing industry, and analyzed partnership considerations.

After deciding to proceed with the science-industry partnership, the Steering Committee created a process to encourage broad industry participation and select fishermen participants. In addition, UNH scientists established a laboratory and field equipment for analyzing the oceanographic field samples. The Steering Committee also arranged training workshops to provide hands-on practice for commercial fishermen prior to the research. Scientific researchers are also conducting seminars for commercial fishermen about oceanographic and ecosystem processes, statistical analysis of data, diagnostic and predictive modeling of ocean processes, and other scientific topics selected by the Steering Committee and interested fishermen.

Next, the Steering Committee established procedures for data collection, quality control, database management, and data analysis. To gain experience and gather preliminary data, scientists and fishermen began a pilot sampling program in waters off Portsmouth, Maine. The pilot study produced some valuable recommendations, including modifying the collection gear and sampling design to streamline the research process.

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[2] Information from this case study is from the PULSE Annual Report (Runge & Jones, 2003).

3. Achievements and Lessons Learned

The strong industry and scientist support for the PULSE program is largely due to the careful planning and design of this collaborative. Although the program exemplifies success, recommendations for future collaborative work are identified. The monitoring plan calls for sampling throughout the winter season; however, the winter of 2002-03 was plagued with harsh weather. Consequently, only one sample day was possible in January and February combined. In future projects, weather should be considered when designing a sampling regime and research should be conducted during the calmer seasons.

The original research plan called for alternating between fishing vessels for consecutive sampling days to minimize the economic loss to fishermen by interfering with their fishing time. However, the pilot study revealed that, when possible, using one boat for four successive sampling trips is the most efficient design. The original plan also intended to have the fishery cooperative coordinate boat use, but it quickly became apparent that the cooperative is understaffed. Future boat and trip coordination should be conducted by an organization with personnel available to fulfill the position.

Although these recommendations are specific to the PULSE collaborative, they provide insight on issues that should be considered as future collaborative fisheries research programs are designed and conducted.

C. Fisheries Associations and Management in New Zealand[3]

1. Overview

Collaborative research frequently occurs between fisheries management agencies and commercial fishing associations in New Zealand. This relatively new approach to fisheries research began in the mid 1990s. The rights-based fisheries management framework in New Zealand has indirectly encouraged collaborative research, but only recently has there been an effort to generate a policy framework for collaboration.

In New Zealand seafood landings are taxed by the seafood industry and about four percent of the overall landings value is spent on fisheries research. Research foci include understanding the response of populations to fishing, marine ecosystems, and environmental impacts of fishing; and cost-effectively managing fish stocks. Independent from taxes, the industry also makes considerable voluntary contributions to fisheries research, because they believe research will give New Zealand an advantage in international markets. Institutional arrangements that provide incentives for collaborative research exist across seafood sectors, but currently no government policy in New Zealand promotes or facilitates such research.

2. The Fishery/Organization

Organizations like the New Zealand Seafood Industry Council, Rock Lobster Industry Council, and Hoki Management Company are umbrella agencies for fishery associations in New Zealand. The councils are owned by commercial fishing associations and provide policy, advocacy, information, and scientific training to the seafood industry. The science division of each council employs independent fisheries scientists, and funds many ongoing collaborative research programs in New Zealand.

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[3] Information for this case study is from the New Zealand Seafood Industry Council (Harte, 2001).

3. Collaborative Model

In New Zealand, collaborative research is defined as research that at some phase involves multiple stakeholders. Some government and non-governmental organizations maintain their politically conservative attitudes and denounce the validity of industry-led fisheries research because private third party fisheries consultants hired by the industry conduct this research. Equally, some members of the seafood industry continue to view fisheries research as an extraneous cost or environmentalist plot to close fisheries. In order to fulfill the potential for collaborative fisheries research in New Zealand, these attitudes must be addressed, and government policies supporting collaborative research need to be drafted.

The rights-based fisheries management system in New Zealand has indirectly led to communicative and collaborative relations between industry and scientists that reflect a cooperative structure. In some cases, this system has fostered the potential for co-management, and direct involvement of resource users in fisheries management. This research has inspired some groups of fishermen to organize themselves into fishing associations motivated to raise funds to finance fisheries research and subsequent management activities; to represent the interests of shareholders in government processes such as setting the total allowable catch; and to defend fishermen against loss of harvesting rights.

4. Achievements and Lessons Learned

Although fishing industries in New Zealand are progressive leaders in organizing collaborative fisheries research, fragmentation of organizations may lead to limited resources for research and conflicting objectives. Currently the seafood industry is responsible for funding fisheries research; each sector funds research associated with its respective fishery. If funds are allocated widely across projects, they may be spread thin and exhausted before a project is completed. This decentralized approach may also promote advancement of fisheries knowledge for well-established, wealthy fisheries, but small-scale fisheries that are in need of examination may not have the funds necessary to conduct internal research.

A consistent approach and clear framework for research and management will help realize the full potential of collaborative research throughout New Zealand. This strategy must be motivated by industry, management agencies, and non-governmental organizations; and objectives should be shared by recreational, subsistence, and commercial fishermen. In addition, organizations and managing agencies that are biased against industry-led fisheries research must try to be accepting, and willing to recognize the validity such research. With full backing by government, non-governmental organizations, and the fishing industry, the results from industry-led research will be more powerful than the current piecemeal approach.

Collaborative research necessitates sharing knowledge to gain a collective understanding of fisheries. A framework for integrating scientific and local knowledge through collaboration will improve fisheries management in New Zealand. To effectively reduce the fragmentation of current collaborative efforts and promote collaborative fisheries research in New Zealand, a clear process of integrating results with management practices must be defined in policy.

D. Government-Industry Cooperatives in the North Pacific[4]

1. Overview

In Alaska, government-industry collaboration began in the 1940s with exploratory bottom trawl surveys. These surveys became the foundation for the groundfish surveys currently conducted in the North Pacific by the National Marine Fisheries Service (NMFS). Surveys require fishing gear, expertise, and extensive sea time, thus it is often more economical to conduct these surveys onboard chartered commercial vessels rather than research vessels.

In these industry-science partnerships, NMFS typically designs, directs, and conducts the surveys. However, this research is considered cooperative because it relies heavily on the skills of the crew to carry out fishing operations with scientific objectives in mind. The cost of most collaborative programs in Alaska is shared between industry and agencies. Although much of the research needed to address questions regarding bycatch and species surveys can easily be carried out independently by NMFS or fishermen, there are substantial advantages gained from taking a collaborative approach, including knowledge- and resource-sharing.

2. Collaborative Model

According to the Partnership Matrix, this research follows a cooperative or alliance structure. The coordination is provided to match the needs of industry and agencies without duplicating services. The scientists typically design the research model and analyze the data, while the fishermen provide a chartered vessel and fishing expertise. Research can be initiated by the industry, agencies, or both parties and together they collect field data onboard fishing vessels. In this partnership, the roles of each party are defined, and the group works together to apply for permits and grant monies.

3. Achievements and Lessons Learned

Several benefits of successful cooperative research are revealed through NMFS-industry partnerships. It is not unusual for managing agencies and fishing industries to have broadly overlapping interests. For example, research between the Alaska groundfish fishery and NMFS led to the innovation of a halibut excluder grate on trawlers to mitigate halibut bycatch problems. The grate was designed by fishermen, and reduced halibut bycatch by over 90%. Further work is needed to refine the grate and examine its effect on catching target species; however, this is a clear example of a collaborative success between two diverse stakeholders.

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[4] Information for this case study is from the National Marine Fisheries Service's Alaska Fisheries Science Center (Karp et al., 2001).

In addition, there are fewer concerns over data accuracy with collaborative research than with independent fisheries research. For instance, NMFS set a goal to improve catch-estimation processes for large-scale trawl vessels that process their catch onboard. To do this, NMFS needed to evaluate existing and proposed approaches. Because this research could result in unfavorable regulatory change, they chose to embark on a cooperative study with the large-scale trawlers to increase the transparency of the study. The proposed catch estimation processes proved to be reliable, and management changes were recommended. If implemented, the industry may not welcome the changes, but their involvement throughout the study and its transparency will help the fishermen understand the reasoning behind the management changes.

These cases indicate that collaborative research in Alaska was most successful when industries formed commercial fishing associations. Associations are important for initiating research and ensuring its completion because they formally organize the fishermen. Unassociated fishermen can be useful in collaborative research; however, associations help ensure funding for collaborative fisheries research by showing funders that the industry backs the project. Associations also provide the manpower for research to be completed without compromising the work of individual fishermen.

The Alaska case studies also reveal the importance of contractual agreements between the agencies and industry involved in collaborative research. Occasionally collaborative research generates results that are not welcomed by all of the parties involved. Commitment from members of the collaborative can be seriously tested when the results are not amenable to their interests. In these situations it is beneficial to have contracts in place before the research so members from the industry or agencies cannot fight the results of the study.

IV. Discussion and Conclusions

Case studies indicate that collaborative partnerships are the most effective structure for fisheries research involving questions of interest to both industry and agencies. Maintaining successful collaborative partnerships takes investment of both time and resources. We identify the following criteria as important for effective collaborative research:

- A Steering Committee is elected with equal representation from each participating group before research begins. This committee defines the collaborative structure, project goals, communication strategies, research structure, process for resource allocation, and other large framework decisions.
- Stakeholder expectations are discussed at the beginning of the project.
- Leadership roles are clearly identified and delineated.
- An explicit process for decision making is outlined.
- A contractual Memorandum of Understanding (MOU) is signed at the beginning of the collaborative.
- Members of each participating group are involved throughout the entire project, from design to completion.
- The collaborative relationship is a focal point throughout the project.

The Bren-Lobster Collaborative is progressing from a cooperative to a collaborative partnership as the project continues. Currently, the Santa Barbara lobster trappers are loosely affiliated with the statewide California Lobster and Trap Fishing Association; however participation in this association is minimal. To create a successful collaborative research relationship, we recommend that the trappers organize into an active cooperative or association and select a representative from the association to serve as a leader within the Bren-Lobster Collaborative.

It may also benefit the partnership to identify a leader for conflict-resolution before the research begins. This person should be a peripheral member to the group who is familiar with the research and trusted by all members of the collaborative. We also recommend that all research participants sign a MOU before the onset of the project be witnessed by the conflict-resolution leader, or another objective third-party.

Acting on these recommendations will help the Bren-Lobster Collaborative progress towards a more effective collaborative partnership. A solid collaborative alliance will lead to quantitative evaluation of the reserve impacts on the lobster fishery. In turn, these data may provide for future use by trappers and scientists as they strive towards larger goals involving fisheries management and resource evaluation.

Chapter 3: Pilot Study

I. Introduction

We designed a pilot study for a long-term spiny lobster monitoring plan in the northern Channel Islands MPAs based on prior research by Stadler (2004). Long-term monitoring provides a means of evaluating the impacts of MPAs on the local lobster fishery, such as adult and juvenile spillover from inside reserves to fished areas. This pilot study is the first step toward a lobster monitoring plan; once implemented, researchers can use pilot study results to modify long-term monitoring methods. Over time, resource managers can use essential fishery information from long-term monitoring to assess the effectiveness of the MPAs as integrated fisheries management tools (Ugoretz, 2002).

We recommend implementing a pilot study to (a) identify optimal sampling methods for an effective long-term fishery monitoring program, and (b) establish baseline population information for spiny lobster in the northern Channel Islands. Andrews and Mapstone (1987) note that pilot studies are preferable to drawing inferences from previous studies or published data. Pilot study results will help scientists determine the variation between and within data sets collected in and outside of MPAs, how datasets compare over time, and how reliably perceived changes or trends can be explained from the data. Even for populations such as lobster that may exhibit large annual density fluctuations, baseline population information obtained from a pilot study will be relevant for long-term monitoring of the species (Thrush et al., 1996). Our pilot study recommends collecting this baseline information through a mark-recapture program at 18 sampling sites at each of three depths both in and outside of three MPAs each day for four consecutive days (Section Chapter 3:III).

A. Goals

We have these primary goals for this pilot study:

- Establish a framework for future implementation of a long-term lobster monitoring program using mark-capture methods;
- Test the monitoring program sampling design variables (e.g., optimal size of sample units and number of replicates);
- Analyze the relative accuracy and precision of sampling units;
- Collect data on sex, fecundity and size at locations within, near and far from at least 3 MPAs to provide a baseline of biological information to researchers for future monitoring comparison (e.g., estimates of size frequency, adult population distribution, net movement, and age and growth characteristics between reserve and non-reserve areas).

II. Pilot Study Approach

A. Synopsis

Evaluating the effectiveness of MPAs as a lobster fishery management strategy requires a thorough understanding of spiny lobster population demographics and behavior. With this objective in mind, we refined a lobster monitoring framework developed by Stadler (2004) for use within (impact sites) and outside (control sites) of no-take marine reserves. Reserves are the only truly unfished areas useable for fishery stock assessment models in the Santa Barbara Channel. Resource managers and local lobster trappers can use data gathered in this study to better understand the impacts of the Channel Island's MPAs on local juvenile and adult lobster populations.

The sampling regime we designed is based upon a mark-recapture method that will allow for direct comparison of individual adult lobster growth and movement over time. Standardized study sites located within, near and far from marine reserves at Santa Rosa, Santa Cruz and Anacapa Islands were chosen based upon local trapper knowledge of areas containing the most suitable habitat. Traps are placed within these locations according to a stratified random sampling design. We recommend sampling for two periods during the lobster fishing off-season, and using standard trapping equipment and bait techniques through paid charter of local lobster trappers.

Table 2 shows the short-term and long-term variables, questions, data, and statistical analysis for the pilot study and monitoring plan. Pilot study estimates of adult size distribution and abundance, sex ratios, and reproductive characteristics will serve as baseline demographic data. We recommend statistically analyzing this data through a nested 3-way analysis of variance (ANOVA). The pilot study will further test the data collection methods and can be used to assess the need for changes in sampling methodology for the long-term monitoring plan.

B. Requirements

Pilot study requirements include 3 boats, 2 sampling periods of 9 days each, a variety of researchers with different skill sets, and funding. We describe each of these requirements in detail in the following four sections.

1. Boats

Our pilot study recommends that researchers should use three boats that can carry 54 traps. With three boats, researchers can sample all three reserves simultaneously, thus reducing the opportunity for unnecessarily biased data due to natural variability.

2. Time

Preparation for the pilot study fieldwork should begin in February, including filing applications for trapping permits, contracting trappers for paid charter of fishing boats, and purchasing field equipment. Funding should also be secured by this time (see Appendix C for project timeline). Our pilot study requires two field sampling periods, one in June and one in September (Section Chapter 3:III.B). With three boats (Section Chapter 3:II.B.1), each sampling period will last approximately nine days, weather permitting.

Table 2: Framework for Developing Pilot Study and Monitoring Plan. Variables are broken down into short-term, to be determined through the pilot study, and long-term for the monitoring plan. Short-term and long-term questions correspond with these variables; corresponding data to be collected and analyses to interpret these data are listed in the two right columns. Catch Performance is the total number of lobster caught per trap. Catch Performance = (Shorts + Legals)/Traps. Population Size = (#Marked* #Sampled)/ #Recaptured.

Short Term		Long Term		Data Needed	Stat Analysis
Variable	Question	Variable	Question		
Catch Performance	How many lobsters are trapped?	Population Size	What is the estimated lobster population size at each location gradient?	Number of Marked, Sampled, Recaptured Individual Lobsters	3-way nested analysis of variance; Long-term results depend on recapture rate.
	What is the Catch Performance of each MPA, location gradient, depth and how do they compare?		How does estimated population size change at location gradients through time?		
Size Distribution	How are mean lobster sizes distributed over space?	Growth rates and patterns	What's the difference in mean CL of recaptured lobsters?	Carapace Length of Individual Lobsters from each Sampling Site	3-way nested analysis of variance; Long-term results depend on recapture rate.
			How do growth rates change over space and time?		
	How does abundance in size differ spatially?		How does abundance in size differ spatially and temporally?		
Sex Ratio	How are sex ratios distributed at location gradient of each MPA?	Sex Ratio	How does the sex ratio change over space and time?	Number of Female Lobsters to Male Lobsters at each Site	3-way nested analysis of variance; Long-term results depend on recapture rate.
	How does abundance in sex differ spatially?		How does abundance in sex differ spatially and temporally?		
	Are some areas male-dominated or female-dominated?		How do male-dominated or female-dominated areas change?		
Fecundity	What percent of female lobsters sampled are berried?	Fecundity	How do reproductive characteristics change over time?	Percent of Berried Females	3-way nested analysis of variance; Long-term results depend on recapture rate.
			Is there a correlation between reproductive characteristics and changes in lobster densities?		
	What percent of female lobsters sampled have a spermatophore?		How do reproductive characteristics change over time?	Percent of Females with Spermatophore	3-way nested analysis of variance; Long-term results depend on recapture rate.
			Is there a correlation between reproductive characteristics and changes in lobster densities?		
None	Where are lobsters trapped and tagged (GPS coordinates)?	Adult Net Movement Patterns	How do individual adult lobsters move over space and time?	Location of Tagged and Recaptured Lobsters	Calculate proportions with confidence level; Long-term results depend on recapture rate.

3. Researchers and Necessary Skill Sets

Personnel requirements for this pilot study depend on the resources available. With three boats (Section Chapter 3:II.B.1), our pilot study requires a minimum of 11 people:

3 Trappers	At least three experienced local lobster trappers are needed to operate the boats, provide trapping expertise and knowledge of the northern Channel Islands, and provide necessary trapping equipment.
6 Data Collectors	Each boat needs two data collectors for a total of six people. One person will take measurements, while one person records measurements (explained in detail in Appendix H).
1 Scientific Researcher	A marine ecologist with experience in experimental design and collaborative research should be available to assist researchers, when necessary.
1 Statistician	A statistician should be available to help with data analysis.

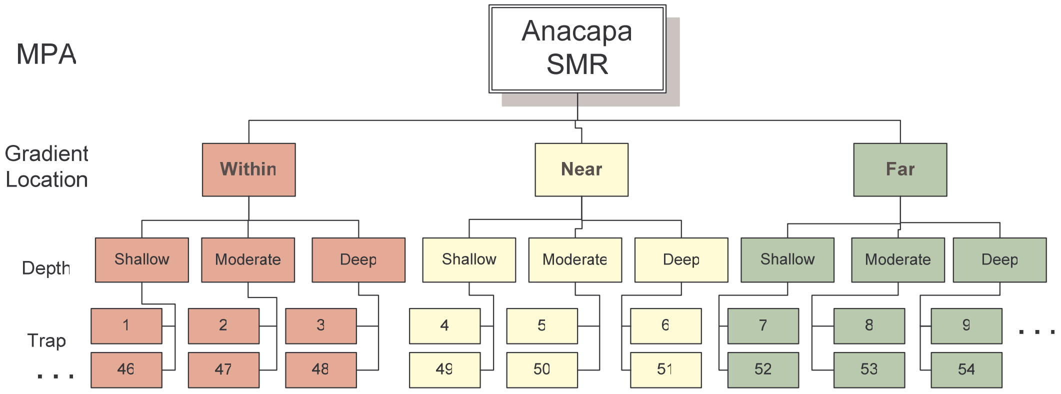
4. Budget

We have developed four pilot study implementation scenarios and corresponding budget estimations. Each scenario is based on two key implementation variables: (a) the number of boats available, and (b) whether researchers will purchase gear or use trappers' gear (e.g., traps, rope). Table 3 shows the summarized budget information; Appendix F contains the detailed scenarios and budgets. In Section Chapter 3:II.B.1 we recommend using three boats for the pilot study. The comparison in Table 3 demonstrates that, assuming researchers are able to use trappers' equipment, chartering three boats for two 4-day sampling periods costs approximately $1,216.20 (4.1%) more than chartering one boat for two 12-day sampling periods.

Table 3: Estimated Budgets. Each budget is based on the number of boats and gear available for pilot study implementation. The "Buy" column shows the subtotaled costs associated with purchasing traps, rope, and buoys and using University boats for hauling gear to and from the islands. The "Borrow" column shows subtotaled costs associated with using trappers' gear and hauling gear to and from islands on trappers' boats. We assume researchers will charter trappers' boats for sampling periods in both scenarios.

Type of Cost	One Boat		Three Boats	
	Buy	Borrow	Buy	Borrow
Equipment	$ 20,177.17	$ 1,459.63	$ 20,277.17	$ 1,559.63
Boat	$ 28,137.60	$ 27,812.00	$ 29,440.00	$ 28,463.20
Additional	$ 232.50	$ 232.50	$ 397.50	$ 697.50
Totals	$ 48,547.27	$ 29,504.13	$ 50,114.67	$ 30,720.33

III. Pilot Study Sampling Procedure



Prepared by K. DeLeuw 3/20/05

Figure 8: Pilot Study Trap Site Hierarchy. This figure shows four levels that describe exactly where a sample will be taken. Levels are listed on the left. The numbers at the trap level represent the traps at placed for each depth and location gradient for a total of 54 traps at one MPA. The colors represent fishing restrictions at each location gradient: within is red because no fishing is permitting within the reserve; near is yellow to represent fishing with caution because the reserve boundary is near; far is green because fishing is permitted and no reserve boundary is near enough to cause concern.

Table 4: Experimental Design. This design template demonstrates the numbers of required samples and the number of lobster to be tagged. These total estimates include three MPAs, three location gradients, and six traps at three depths for a four-day sampling period, as recommended for our pilot study. Again, the colors represent fishing restrictions at each gradient location. Gull Island SMR may be substituted for Carrington State Marine Reserve.

Site	Location Gradient	Depth	Total No. Traps per Day	No. Pulls Required**	Total No. Pulls	Total No. traps Per Gradient	Avg No. Lobsters per Trap	% Tagged Lobsters per Trap	No. Tagged Lobsters
Anacapa State Marine Reserve	Within	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Near	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Far	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
Subtotal			*54*		*216*	*216*			*216*
Scorpion State Marine Reserve	Within	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Near	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Far	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
Subtotal			*54*		*216*	*216*			*216*
Carrington State Marine Reserve*	Within	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Near	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
	Far	shallow	6	4	24	72	1	100%	24
		moderate	6		24				24
		deep	6		24				24
Subtotal			*54*		*216*	*216*			*216*
Grand Total			*162*		*648*	*648*			*648*

A. Stratified Random Sampling Design

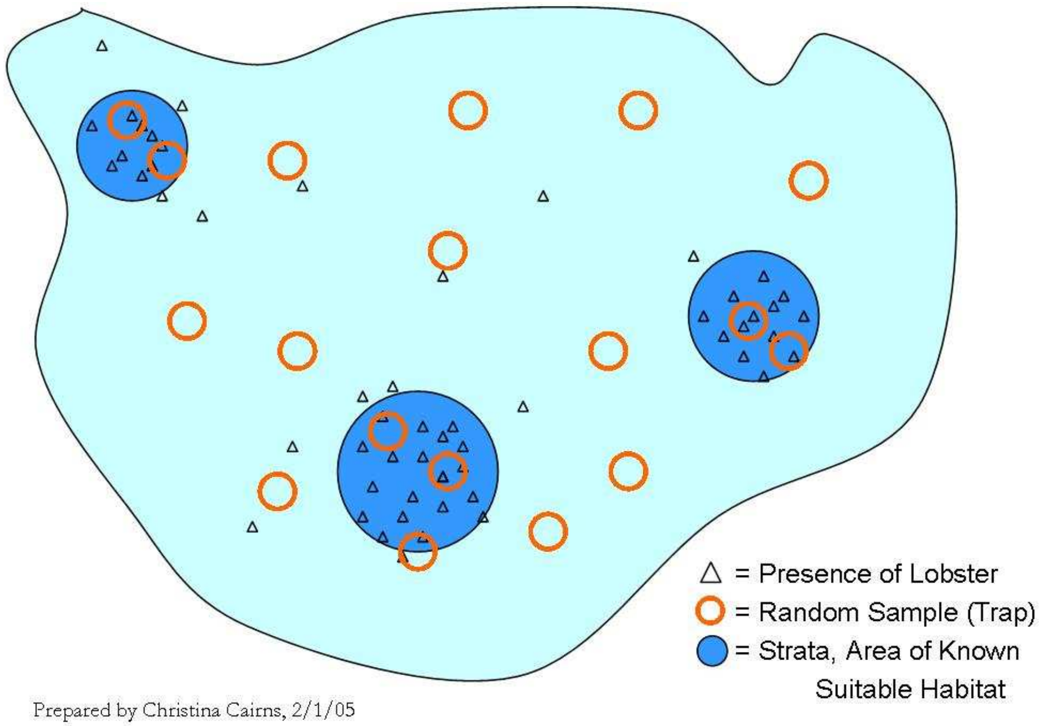


Figure 9: Stratified Random Sampling Design. This schematic shows how traps, represented by the red circles, will be placed randomly within known lobster habitat to obtain optimal sampling results.

Samples must be both representative and random in order to accurately estimate lobster population demographics and behavior. Random sampling gives every member of the population an equal and independent chance of being sampled (Underwood, 1997). This design removes potential sampler bias, conscious or not, from sampling.

Simple random samples are not always appropriate because samples must account for patchiness. Accurate density estimates must include knowledge of the spatial arrangement of organisms (Thrush et al., 1996). Adult spiny lobsters are primarily found in crevices of rocky areas, but simple random sampling designs may include other habitat-types and may overlook these significant habitat areas. To reduce wasted sampling effort, we recommend a stratified random sampling design as shown in Figure 9, allowing random sampling within areas of known suitable habitat (strata) that share the same characteristics. Stratifying the design will minimize trap catches of zero or very few lobsters (Stadler, 2004).

B. Sample Period

Biological monitoring data should be collected regularly depending on the life history and behavior of the organism involved. Our pilot study recommends sampling twice a year – during June and September – to gather demographic data for lobster and calculate growth rates at a regular interval.

June and September are optimal sample periods. They are off-season for lobster trapping, which minimizes the possibility of nearby commercial traps interfering with pilot study traps. June and September also allow for sampling around the June-August molting season (Abramson et al., 2004), which is essential for estimating growth rates over long-term monitoring. While pilot study data alone are insufficient to estimate growth rates, these initial sample periods will provide recapture rate estimates from June to September to help refine the experimental design before implementing long-term monitoring. Sampling will be most effective around the new moon in these months because catch is usually highest during the new moon and lowest during the full moon (Brown & Caputi, 1985).

C. Sampling Marine Protected Areas

Our pilot study recommends sampling at three MPAs in the Channel Islands, allowing for comparison between sites while still leaving room to eliminate possible outliers. In general, ecologists concur that studies require a minimum of three replicates due to the amount of spatial and temporal variability of ecological responses (Abeles et al., 2004). Data from multiple MPAs reduce variability and thus provide a better estimate of the average effect of MPAs on lobster populations than a single large experiment (Abeles et al., 2004; Underwood, 1997).

We evaluated four MPAs for our pilot study (Table 5), but our pilot study recommends focusing on only three of these four MPAs. Section Chapter 3:III.D describes each MPA and its recommended sampling sites in detail.

Our pilot study uses sample sites at Anacapa and Santa Cruz Islands based on three factors. First, oceanographic conditions (e.g., water temperature) are more similar between Anacapa and Santa Cruz Islands than other northern Channel Islands. Second, while lobsters inhabit all the Channel Islands, lobsters are more abundant in the Californian and Transition Zones (Anacapa Island and south Santa Cruz Island) than in the Oregonian Province (Ugoretz, 2002, p. 44). Thus, abundance may be greater at these islands. Third, Anacapa and Santa Cruz Islands are more easily accessible than San Miguel or Santa Barbara Islands due to their proximity to the mainland and each other.

Our pilot study also recommends sampling at Santa Rosa Island, although it is located farther from the coast. Specifically, we recommend sampling in Carrington Point State Marine Reserve on the northeast tip of the island, because it has extensive reef habitat, and because multiple trappers recommended its inclusion (Abramson et al., 2004).

Table 5: Evaluated Marine Reserves.

Marine Reserve	Island
Anacapa State Marine Reserve	Anacapa Island
Carrington Point State Marine Reserve	Santa Rosa Island
Gull Island State Marine Reserve	Santa Cruz Island
Scorpion State Marine Reserve	

D. Gradient Location and Sample Sites

To detect juvenile and adult spillover, researchers should sample at sites both inside (treatment sites) and outside (control sites) the MPA, including sites immediately adjacent to the MPA boundary (Pomeroy et al., 2004, p. 58). Our pilot study recommends sampling along a gradient at three locations with suitable lobster habitat: (a) at a treatment area within the MPA (i.e., *within*), (b) a control area at the edge of the MPA (i.e., *near*), and (c) a control area at least two kilometers from the MPA (i.e., *far*). Each *gradient location* includes a total of 18 replicate treatment and control sites per sample period. Figure 8 and Table 4 show how gradient locations fit into the pilot study experimental design.

Designated sample sites should maintain similar habitat types and be stratified along consistent depth/contour profiles (Pomeroy et al., 2004, p. 29). In this pilot study, areas within MPAs are considered treatment areas because they have human-induced impacts through implementation of a no-fishing zone. Control areas should have similar physical features as the treatment area (e.g., lobster habitat, depth, species composition and bathymetry). Control and treatment areas should be in close proximity to experience similar environmental fluctuations, but not so much as to be affected by the treatment (Stewart-Oaten, 1996, pp. 115-116).

In collaboration with local trappers and researchers, our pilot study recommends sample sites representative of lobster habitat at each gradient location based on topographic relief, habitat type and oceanographic conditions. Many of these sites also correspond with landmarks identified from DFG commercial lobster logbooks (Chapter 4). We recommend sampling within a 300 x 30 meter site at each gradient location because this size allows for sufficient distance (10 m) between traps at each location.

The following sections describe each of the recommended MPAs (Section Chapter 3:III.C) and their recommended sampling sites.

1. Anacapa State Marine Reserve, Anacapa Island

Description No take of living, geological, or cultural resources (from here on referred to as *no take*) is allowed in the area bounded by the mean high tide line and the following points (DFG, 2003b):

34.067° N. lat. 119.41° W. long.;
34.067° N. lat. 119.357° W. long.;
34.017° N. lat. 119.357° W. long.;
34.007° N. lat. 119.41° W. long.
Shoreline Length: 3.3 nm
Area: 8.90 nm²
Depth Range (feet): 0 – 600

Within The within sample site is not recognizable by name. This is located on the north side of Anacapa Island, on the eastern edge of the west part of the island before the break between two sections of the island, at approximately 119.386° W. long.

Near West of the reserve boundary in Anacapa Island State Marine Conservation Area, bound on east by 119.402° W. long. This site is located within the Anacapa Marine Conservation Area, which allows recreational and commercial lobster fishing but restricts most other fishing. Analyses may need to account for variability due to the unusual restrictions in use at this location.

Far Western edge of Anacapa Island on northern side of island, bound on the west by 119.436° W. long. This is approximately 3.5 km from reserve boundary. This site is located within the Anacapa Marine Conservation Area, which allows recreational and commercial lobster fishing but restricts most other fishing. Analyses may need to account for variability due to the unusual restrictions in use at this location.

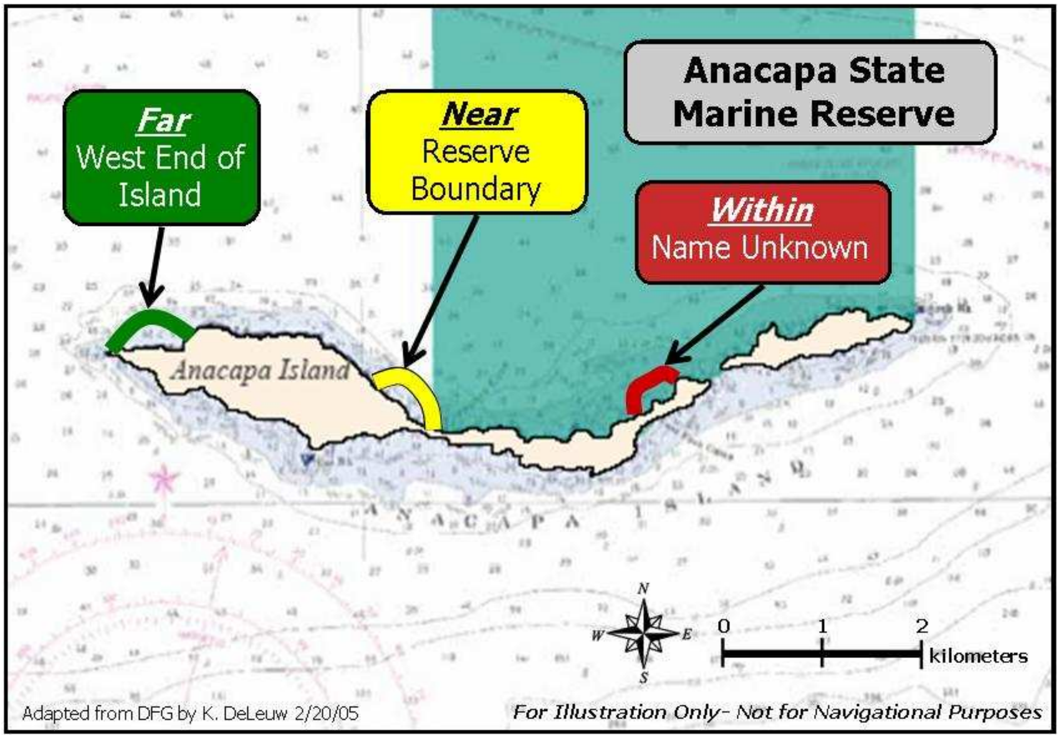


Figure 10: Recommended Sample Areas for Anacapa State Marine Reserve. This shows recommended within, near and far sample sites for the pilot study. The colors represent fishing restrictions at each location gradient: red represents within because no fishing is permitted within the reserve; near is yellow to represent caution when fishing because of the proximity to the reserve boundary; far is green because fishing is permitted and no reserve boundary is near enough to cause concern.

2. Carrington Point State Marine Reserve, Santa Rosa Island

Description No take is allowed in the area bounded by the mean high tide line and the following points (DFG, 2003b):

34.067° N. lat. 120.087° W. long.;
34.067° N. lat. 120.017° W. long.;
34.008° N. lat. 120.017° W. long.;
34.008° N. lat. 120.047° W. long.;
34.022° N. lat. 120.087° W. long.
Shoreline Length: 5.3 nm
Area: 9.63 nm^2
Depth Range (feet): 0 – 180

Within Carrington Point and west; eastern boundary of site is 120.042° W. long.

Near Eastern boundary is the west edge of reserve, at 120.87° W. long.

Far Sample site includes Rodes Reef, located at 34.072° N. lat. 120.123° W. long. This is approximately 3.8 km from reserve boundary.

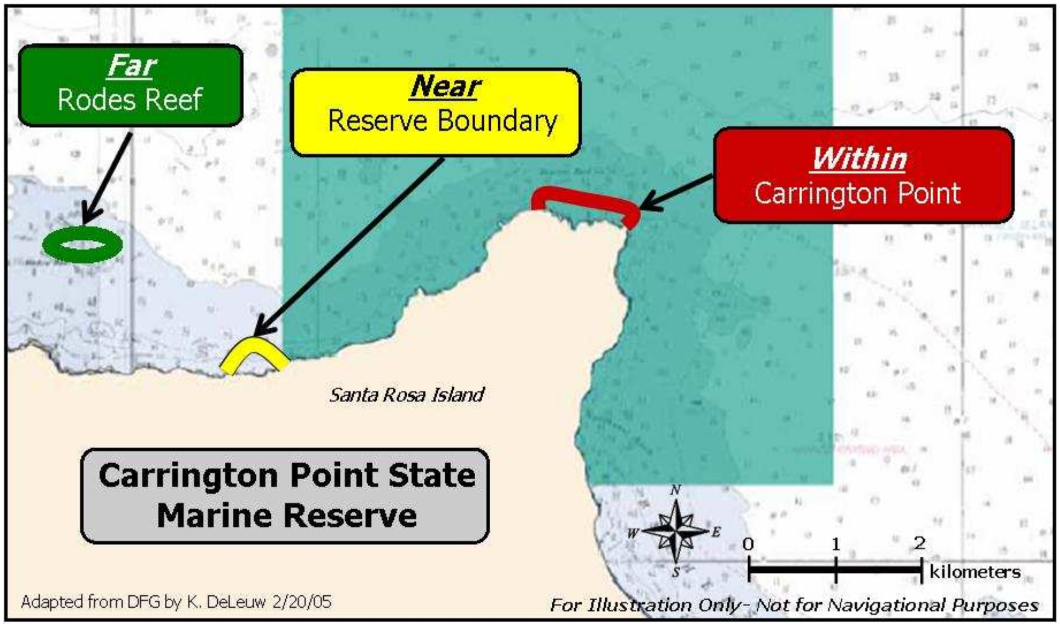


Figure 11: Recommended Sample Areas for Carrington State Marine Reserve. This shows recommended within, near and far sample sites for the pilot study. The colors represent fishing restrictions at each location gradient: red represents within because no fishing is permitted within the reserve; near is yellow to represent caution when fishing because of the proximity to the reserve boundary; far is green because fishing is permitted and no reserve boundary is near enough to cause concern.

3. Gull Island State Marine Reserve, Santa Cruz Island

Description	No take is allowed in the area bounded by the mean high tide line and the following points (DFG, 2003b): 33.967° N. lat. 119.883° W. long.; 33.967° N. lat. 119.85° W. long.; 33.962° N. lat. 119.8° W. long.; 33.92° N. lat. 119.8° W. long.; 33.92° N. lat. 119.883° W. long. Shoreline Length: 2.9 nm Area: 11.58 nm2 Depth Range (feet): 0 - 1,800
Within	Sample site includes Punta Arena, unknown coordinates.
Near	Sample site is bound on east by Morse Point, located at 33.967° N. lat. 119.848° W. long.
Far	Sample site includes Willows Anchorage, located at 33.962° N. lat. 119.748° W. long. This is approximately 5.2 km from reserve boundary.

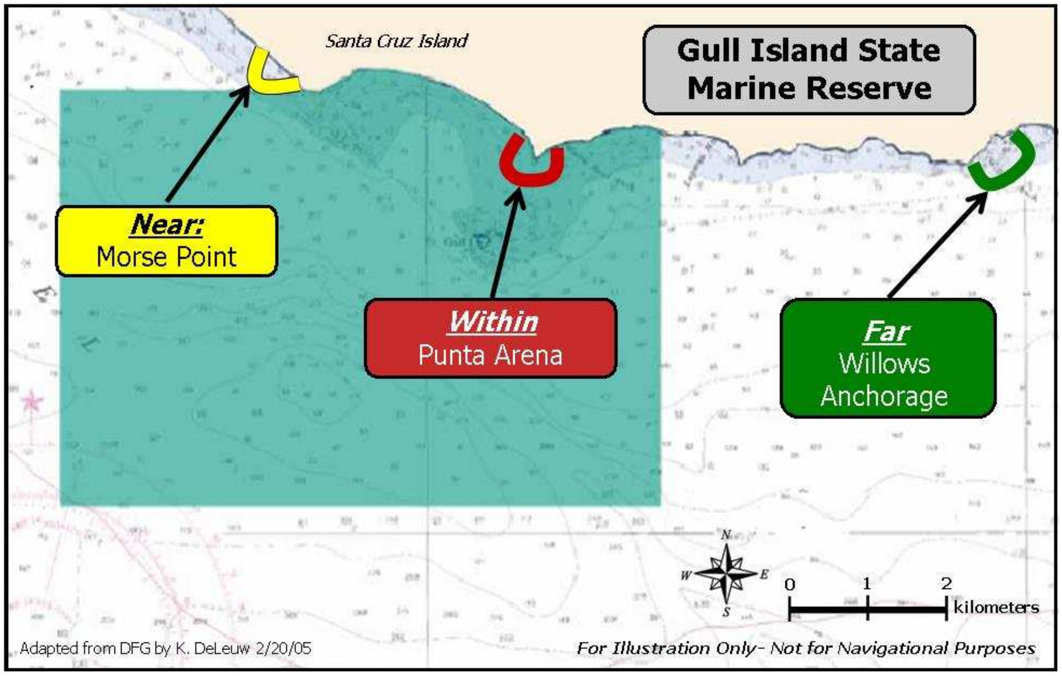


Figure 12: Recommended Sample Areas for Gull Island State Marine Reserve. This shows recommended within, near and far sample sites for the pilot study. The colors represent fishing restrictions at each location gradient: red represents within because no fishing is permitted within the reserve; near is yellow to represent caution when fishing because of the proximity to the reserve boundary; far is green because fishing is permitted and no reserve boundary is near enough to cause concern.

4. Scorpion State Marine Reserve, Santa Cruz Island

Description No take is allowed in the area bounded by the mean high tide line and the following points (DFG, 2003b):

34.103° N. lat. 119.592° W. long.;
34.103° N. lat. 119.547° W. long.;
34.047° N. lat. 119.547° W. long.;
34.049° N. lat. 119.592° W. long.
Shoreline Length: 3.3 nm
Area: 7.02 nm2
Depth Range (feet): 0 – 750

Within	East of Cavern Point; site is bound on west by 34.056° N. lat. 119.563° W. long.
Near	“Potato Rock,” west of Potato Harbor. Site is bound on east by 34.048° N. lat. 119.593° W. long.
Far	Sample site includes Coche Point, located at 34.037° N. lat. 119.608° W. long. This is approximately 2.2 km from reserve boundary.

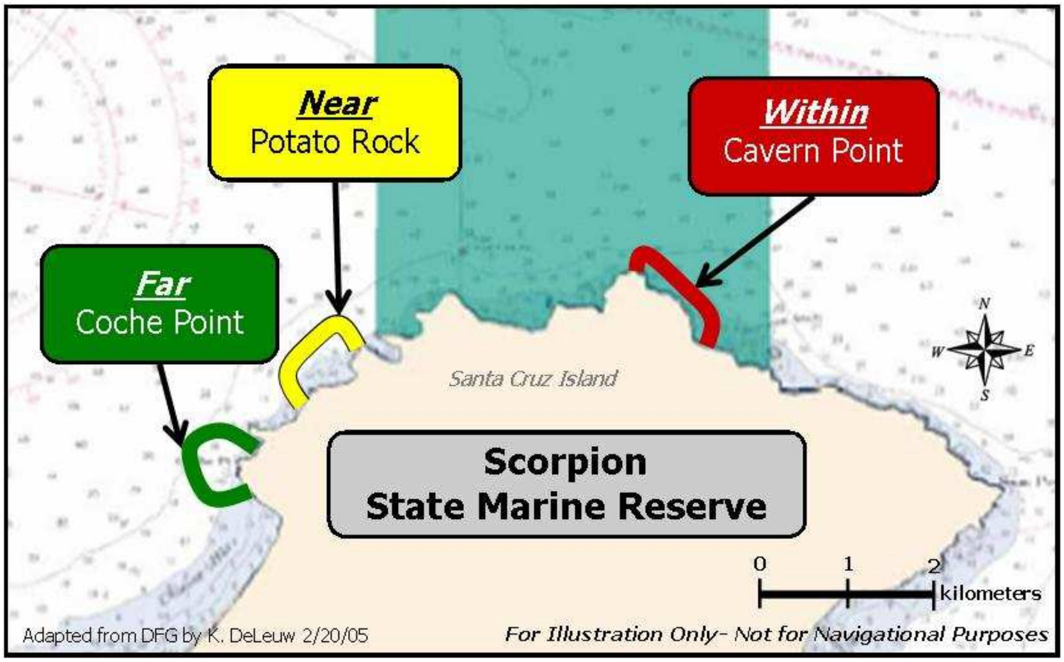


Figure 13: Recommended Sample Areas for Scorpion State Marine Reserve. This shows recommended within, near and far sample sites for the pilot study. The colors represent fishing restrictions at each location gradient: red represents within because no fishing is permitted within the reserve; near is yellow to represent caution when fishing because of the proximity to the reserve boundary; far is green because fishing is permitted and no reserve boundary is near enough to cause concern. Sample Depths

Figure 8 and Table 4 show how sample depths fit into the pilot study experimental design. Our pilot study recommends that samples be taken from three depths at each gradient location:

shallow	3 – 6.9 m
moderate	7 – 9.9 m
deep	10 – 19.9 m

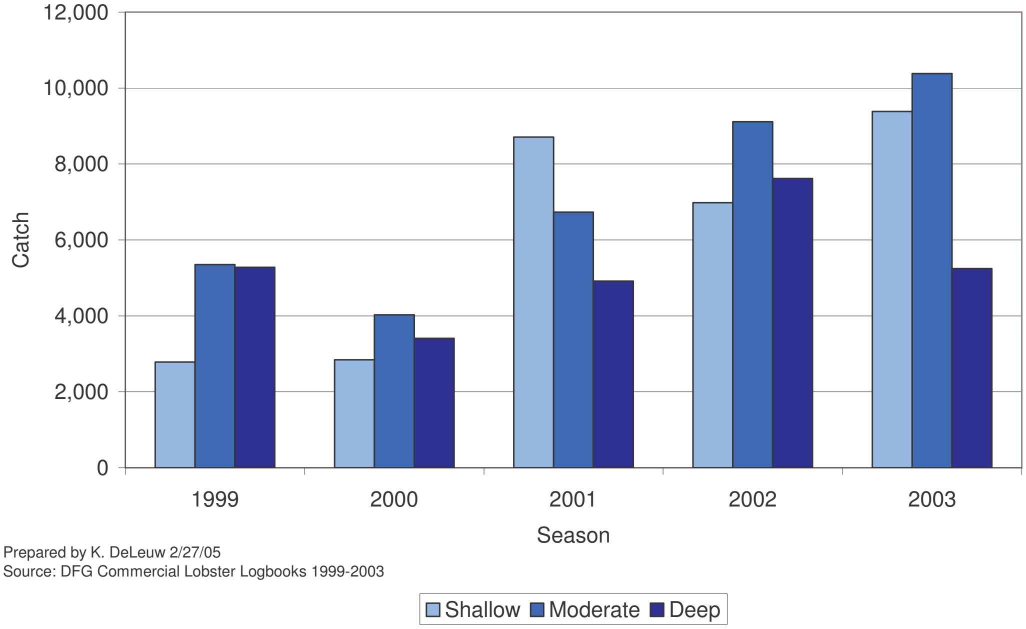
Each depth range accounts for the variability in bottom relief and increases the area available for sampling (Stadler, 2004). California spiny lobsters inhabit low intertidal to subtidal depths of 80 m, yet most fishing occurs in water less than 30 m deep (Ugoretz, 2002). While lobsters have been trapped at depths up to 92 m in the northern Channel Islands, these depths ranges were chosen because our proposed off-season sampling periods coincide with the months when lobsters typically move into warmer, shallower waters (John Marlin Engle, 1979). Local trappers concur that lobsters are less abundant in relatively deep waters in June and September (Abramson et al., 2004).

Specific sample depth ranges were identified from DFG commercial lobster logbook data, which are discussed in detail in Chapter 4. Northern Channel Islands catch records from October of each commercial season between 1999 and 2003 revealed fishing depths ranging from 1.5 – 49 m (DFG, 2003d). Catch is the number of legal lobsters landed by commercial trappers. 98% of total traps pulled and total catch in these seasons ranged from 3 – 19.9 m deep.

We determined each sampling depth range by the percent of total traps pulled and catch recorded at specific depths. We kept these percentages as equal as possible while accounting for spikes in recorded depths at 6.1 m, 7.6 m, and 9.1 m, which may by due to trapper approximations at these depths. Percentages of traps pulled and catch recorded from each October of the 1999 – 2003 seasons within each sampling depth range are shown in Table 6. Figure 14 and Figure 15 show the catch distributed by depth and the number of traps at each depth in October of the 1999 – 2003 seasons.

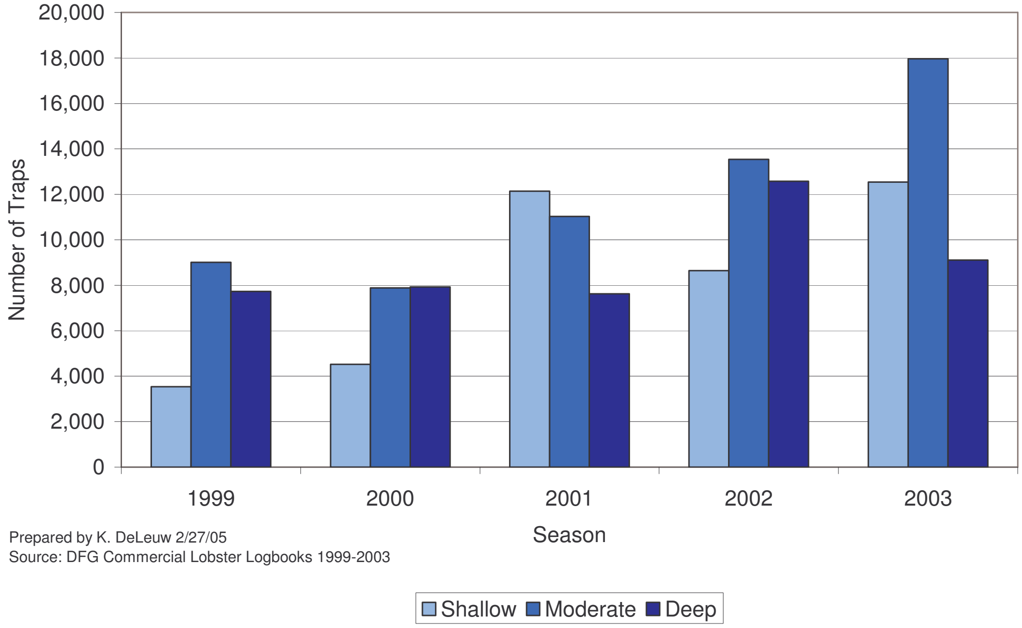
Table 6: Depth Ranges. For each depth range, the associated catch and number of traps is shown. The total catch and number of traps for each October of the 1999 to 2003 seasons are listed at the bottom.

Depth	No. Traps	% Traps	Catch	% Catch
Shallow (3-6.9m)	41,392	28%	30,707	33%
Moderate (7-9.9m)	59,428	41%	35,608	38%
Deep (10-19.9m)	42,050	29%	24,406	26%
Subtotal	142,870	98%	90,721	98%
Total	145,821	100%	92,797	100%



Prepared by K. DeLeuw 2/27/05
Source: DFG Commercial Lobster Logbooks 1999-2003

Figure 14: Catch Distribution by Depth over Season. This figure shows the distribution of catch among each depth range during each October from the 1999 – 2003 seasons.



Prepared by K. DeLeuw 2/27/05
Source: DFG Commercial Lobster Logbooks 1999-2003

Figure 15: Numbers of Traps by Depth over Season. This figure shows the distribution of numbers of traps at each depth range during each October from the 1999 – 2003 seasons.

E. Number of Traps and Trap Location

Replicated traps are necessary in each control and treatment site to avoid the problem of confounding data by comparing abundances in two locations (Underwood, 1996, p. 154). Biological systems are inherently variable; replication minimizes variability and provides stronger confidence in attributing differences between treatment and control sites to lobster behavior, rather than natural site differences (Pomeroy et al., 2004, p. 29; Quinn & Keough, 2002, p. 158). To sample with a randomly stratified design, traps should be dropped at random locations with appropriate physical characteristics, representative of lobster habitat (see Figure 16).

Based on power analyses, our pilot study recommends setting six traps in each depth range at each gradient location, for each site per sampling day. This design brings the total to 18 traps per gradient location per day during each of the two sampling periods. Figure 8 andTable 4 show how numbers of traps fit into the pilot study experimental design.

Our pilot study requires that traps be set in a stratified random design set at least 10 m apart within each 9,000 m² (300 x 30 m) monitoring site. The samples should be randomized to eliminate human bias in trap site selection.

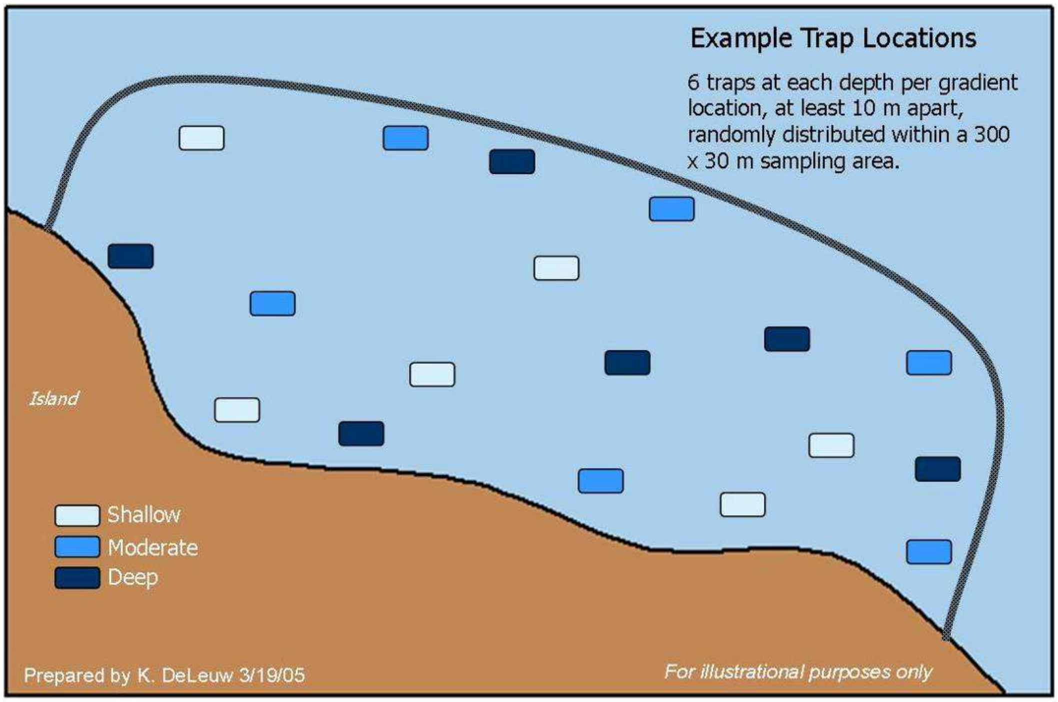


Figure 16: Example Trap Location. This schematic is an example of the 9,000 square meter site within which 18 traps will be randomly distributed, but remain at least 10 m apart to prevent competitive behavior. Six traps will be placed at each of three depths within this sampling area.

F. Temporal Replication: Trap Days

Repeated sampling is necessary to avoid coincidence with natural disturbances and to identify patterns of change. Our pilot study recommends researchers pull traps every 24 hours for a four-day sampling period at each MPA, allowing for a soak (trap immersion) period of approximately 24 hours.

To imitate standard commercial lobster trapping practices as closely as possible, traps should be pre-soaked for a period of approximately four days before sampling. Pre-soaking the traps allows them to acclimate to ocean conditions and improves catch success by reducing bubbling and unusual smells that could deter lobsters (Stadler, 2004).

Table 7: Trapping Timeline. In the recommended scenario, a total of nine days are required for three boats to sample with a four day soaking period prior to sampling. Gull Island may be substituted for Carrington MPA.

BOAT 1	**Pre-Soak**		**Anacapa MPA**		
Day	1	…	5	…	9
Action	Drop	Soak	Pull/Drop	Pull/Drop	Pull
BOAT 2	**Pre-Soak**		**Scorpion MPA**		
Day	1	…	5	…	9
Action	Drop	Soak	Pull/Drop	Pull/Drop	Pull
BOAT 3	**Pre-Soak**		**Carrington MPA**		
Day	1	…	5	…	9
Action	Drop	Soak	Pull/Drop	Pull/Drop	Pull

G. Sample Equipment

1. Trap size and escape port

Northern Channel Islands lobster trappers use two different sized traps during a season. The larger traps are 92 x 122 x 42 cm with a 19 cm hoop diameter, while smaller traps are 72 x 92 x 42 cm with a 19 cm hoop diameter.

Our pilot study recommends using the smaller traps for fieldwork because lobster trappers use smaller traps when fishing in shallow waters, and recommend using them in the summer months. This standardized trap size will provide consistency for the experiment. The escape port required by law for commercial trapping should be closed for sampling to allow for sampling both legal and sublegal (less than 82.5 mm carapace length) sized lobsters.

2. Bait

Our pilot study requires standardizing bait at 500 g of fresh mackerel (*Scomber japonicus*) placed in a perforated bait container. This bait was recommended by local trappers and used in previous research by Iacchai et al. (2004) at Santa Catalina Island.

H. Data to be collected

Table 8: Data Categories and Measurements. This table shows each measurement and piece of information researchers should record while sampling. These measurements will be used to compare growth rates, size and sex distribution, and changes in abundance over time between each gradient location. This data may also indicate the effects of juvenile and adult spillover from within reserves to outside reserves over time. Collection procedures are discussed in greater detail in Appendix H.

Category	Measurement
Movement	GPS location of trap pull Depth and date of trap pull Number of recaptured lobsters Tag numbers of tagged lobsters Tag number of recaptured lobsters
Abundance	Total number of lobsters per trap
Size Characteristics	Carapace length
Sex Characteristics	Sex Setose Egg-bearing Plastered (Spermatophore)
Other Variables	Injuries Bycatch Temperature at 10 m Salinity Swell Direction Swell Height Barometric Pressure Moon Phase

IV. Statistical Analysis

A. Pilot Study

In addition to refining the design of a monitoring plan and assessing the sampling methodology, the results of a pilot study will help determine the natural variability of lobster demographics as determined through data collection and statistical analyses. A power analysis will determine whether the pilot study methodology is adequate for obtaining our desired level of confidence and effect size for a long-term monitoring plan. According to Simon Thrush et al, "a crucial part of the design of a monitoring program, once the appropriate time scale has been determined, is choosing the sample size. This is usually done by examining the relationship between spatial variation and sampling intensity from data collected in a pilot survey" (Thrush et al., 1996).

B. Analysis of Procedures

1. Power Analysis

Given the resource constraints on sampling effort as well as the need to gather sufficient data, a minimum number of samples should be collected at each site to establish the optimal sampling intensity for future visits. This number must be decided by "balancing effort against precision" (Thrush et al., 1996). Power analyses help determine the recommended number of samples necessary, including number of traps and replicates over time, to detect a given effect size. Effect size is the amount of difference between the null hypothesis – in this case, no difference in estimates of lobster demographics between the reserve and non-reserve areas – and the specified alternative hypothesis (Underwood, 1997, p. 92).

2. Repetition of Power Analysis

We performed a power analysis before implementing the pilot study and recommend executing a similar analysis after the pilot study is completed and the results are compiled. (See Appendix E for Power Analysis Code in 'R'.) In order to assure a robust sampling method and account for temporal variability in the data, repeated power analyses should be done periodically throughout the duration of the long-term monitoring plan.

3. Pre-Pilot Study Power Analysis

We conducted an initial Power Analysis to identify the sample size necessary for the pilot study to detect a statistically significant difference in numbers of lobster between fished and non-fished reserve areas, known as the observed effect size. Using the statistical software package "R", we input the average number and variability in lobsters caught per commercial lobster trap throughout the Channel Islands, as reported by local lobster trappers (Miller & Bortolazzo, 2005).

We used a mean of 1 lobster per trap and a standard deviation of 1 lobster to conduct a power analysis, which calculated the requisite number of traps per site and replicate samples to detect a difference of one lobster trapped (delta=1). The power analysis revealed a minimum requirement of 18 traps per gradient location. Over three sampling depths, this requirement translates into 6 traps per depth per sampling day, which detects a sufficiently large effect size (Power=0.90) (Figure 17). We chose a minimum effect size of 0.90 to ensure a high statistical power for detecting a difference between reserve and non-reserve areas. Furthermore, we chose a confidence interval of 0.95 as researchers and statisticians have conventionally chosen the probability of 0.05 (Type I error) as an appropriate level of acceptable error (Underwood, 1997, p. 57).

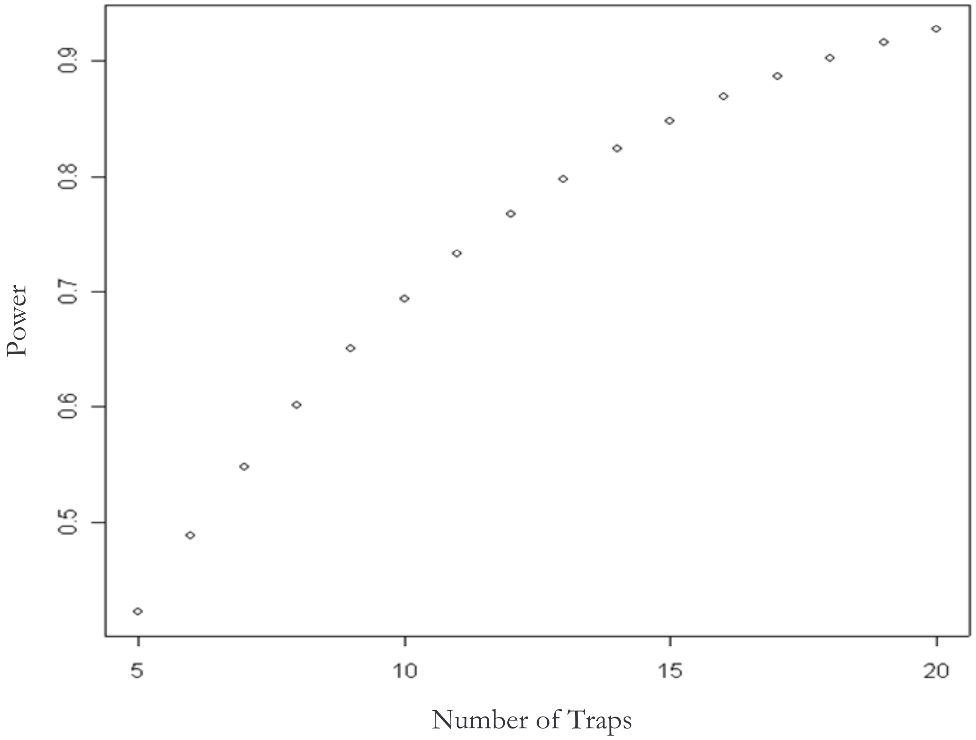


Figure 17: Required Number of Traps. The results of the power analysis show that 18 traps are necessary to detect a change in the number of lobster between trap sites – for an effect size of 0.90 with 0.95 confidence (delta=1, sd=1, n=5:20, type of test="one.sided").

4. Post-Pilot Study Power Analysis

We recommend performing a similar power analysis using actual results of the pilot study to determine the sample size needed for a long-term monitoring plan. The variance and frequency distribution of sample means as well as the rate of tag recovery between sites observed during the pilot study will allow a more precise estimate of the number of traps and replicates needed for long-term monitoring. Future researchers can more accurately predict effect size between fished and non-fished areas by using these estimates of mean and standard deviation from the pilot study. Modifications to the sampling procedure, such as increasing or decreasing the number of traps or replicates involved, can be made as monitoring continues (Thrush et al., 1996, p. 63).

5. Post-Pilot Study Statistical Analysis

In addition to helping determine the necessary sample size for long-term monitoring, pilot study results will offer initial estimates of the mean adult lobster size, population abundance, sex ratio, and reproductive characteristics, as well as their variation between gradient locations. Such information on population demographics will provide a baseline dataset for future monitoring efforts.

The combined intrinsic and extrinsic causes of variation in biological observations can result in inaccurate estimates of the true values of the population mean and variance as determined through field measurements. Variability may arise in the results of the pilot study or monitoring plan due to the fundamental variability of biological and ocean systems, the diverse resources available to different lobster populations, and unforeseen biases in sample methods between researchers (Underwood, 1997, p. 57).

One can determine the approximate scale of variability by examining the variance in lobster data over space and time. For example, by associating data with a particular event or place, one can decide whether the variability is due to different local processes acting upon the population at each site or a larger scale influence affecting all sites simultaneously. "Direct analysis of variability is useful in… assessing the relative importance of processes operating on difference scales. If abundance varies among sites but is consistent at each site over time, then a major influence on processes is associated with the sites. Conversely, if abundance shows strong variability among years at sites but a high degree of consistency in each year across sites, then a major influence of a large-scale factor (e.g., weather) is implicated" (Thrush et al., 1996, p. 63).Variability due to human sampling error must also be considered within and across sites.

C. Data Analysis

1. Analysis of Variance

To gain an accurate estimate of the sample means and variance from the pilot study as well as necessary annual monitoring efforts, we recommend performing statistical analyses using a nested 3-way ANOVA design for each of the following variables:

- Population size estimates, using number of individual lobster per site;
- Individual size frequency and growth increments, using measurements of lobster carapace lengths before and after lobster molt;
- Sex ratios, using numbers of males and females within each trap;
- Reproductive patterns, using numbers of berried females and those with presence of a spermatophore.

This ANOVA design suits our study well for the purpose of comparing data within, near, and far from reserves. The 3-way nested design accounts for sampling collection procedures at a trap site of a certain depth nested within a 300m x 30 m gradient location located within a specific marine reserve. Many statistical software packages can analyze this information in an efficient manner.

2. Analysis of Covariance

Further analysis using ANCOVA is recommended to determine the covariance of lobster data (abundance, size, reproductive characteristics, and net movement) at each site with oceanographic and weather conditions. We recommend including these exogenous (i.e., not affected by fishing) variables in the analysis to estimate the contribution of natural environmental fluctuations to the data. By accounting for natural environmental fluctuations in the statistical analysis, one can reduce the variances of estimated effects between fished and non-fished areas. Calculating these variances obtains "adjusted" estimates with smaller serial correlation than the raw data (Stewart-Oaten, 1996, p. 115). Such analysis of covariance can be performed on temperature, salinity, wind speed and direction, swell direction and height, and barometric pressure discussed under in Appendix H: Data Collection.

3. Long-term Patterns of Movement

The mark-recapture techniques specific to this sampling methodology will provide location data with GPS coordinates. By calculating the proportional movement of lobster through time and space, one can quantify patterns of lobster movement among trap sites and, depending on the extent of movement, between fished and reserve areas. Patterns of lobster movement can be identified utilizing GIS software to map the specific locations of recaptured tagged lobster. Stadler (2004) identifies several potential movement patterns including:

- Unidirectional movement from reserves to surrounding waters, potentially through "spillover" from increased lobster density within the reserves;
- Unidirectional movement into reserves from surrounding waters;
- Seasonal inshore-offshore or alongshore movements related to molting, breeding or feeding cycles;
- Longer distance migratory patterns, either inshore-offshore or along the shore.

Information on the net movement patterns of lobster can be used to determine home ranges and site fidelity, spillover responses, environmental cues, and depth distributions (Stadler, 2004). This information is essential to the primary objective of long term monitoring - evaluating the potential spillover of lobsters from MPAs. Movement data are necessary to predict species responses to protection (relative to other environmental factors), and to examine the role MPAs have in fisheries management (Kelly & MacDiarmid, 2003).

D. Interpretation of Pilot Study Results

1. What do these analyses mean for a monitoring plan?

Data from the pilot study cannot immediately be used to determine lobster population size or measure population viability at the Channel Islands. However, it will allow comparison of important population demographics and variables among different sites, and provide a baseline for future monitoring data.

2. Refinements for Monitoring Plan from Pilot Study

Results of statistical tests performed on the pilot study data, and on the accuracy and precision of the sampling procedure, could alter the long-term monitoring plan. Accuracy and precision are affected by many parameters, including the number of traps, number of replicate sampling days, depths chosen, location of sampling sites and sampling season. Alterations to the monitoring plan, such as changes in number of traps or replicates, should be based on the power analysis of the pilot study data. Future refinements of other parameters, such as sampling depths, locations, or seasons, should also be based on the pilot study, with stakeholders providing as much additional information as possible on optimal fishing grounds and lobster behavior.

V. Future Work

A. Ground truthing

Our collaboration with local trappers and scientific researchers allowed us to identify pilot study sampling sites in lobster habitat based on topographic relief, habitat type, and oceanographic conditions. However, it is important that these recommended sites be verified by observation. We recommend ground-truthing sampling sites using SCUBA to ensure that similar lobster habitat is present among sampling locations and to identify significant variables between sites (i.e., substrate type, presence of rocky reefs/boulders, density of kelp and/or urchins, and proximity to sandy bottom foraging areas). If adequate resources exist for more extensive ground-truthing, we further recommend conducting transect surveys for number of lobster observed at each site to obtain an estimate of the proportion of individuals trapped that are surveyed and roughly estimate population abundance (Hilborn, 2001); however, this method of sampling may be very difficult due to the reclusive nature of lobsters during the daytime.

B. Habitat mapping

1. GIS bathymetry and habitat data

Bathymetry data for specific landmarks and surrounding areas, available from NOAA, can help in selecting specific locations for sampling and further refining the depth ranges and/or distribution of traps according to historical catch at each depth range. Cross-correlating bathymetry data at landmark locations with historical catch data will help refine the long-term monitoring plan at landmarks.

No habitat data for these marine protected areas currently exist. The best data available for determining suitable lobster habitat is the result of lobster trapper Chris Miller and UCSB scientist Dr. Barbara Walker's collaborative endeavor to map lobster catch effort in the northern Channel Islands. Miller and Walker have created a map of lobster data comparison by ex-vessel value and number of fishermen within 100 nautical square mile (10 minute x 10 minute) blocks around the northern Channel Islands (Miller & Walker, 2005). Future work could interpret this data on ex-vessel value and catch value as measures of habitat value.

Further habitat mapping will require GIS data on key ecological criteria for lobster viability, including bathymetry, sediment type, presence of kelp and/or urchins and water column temperature (John Marlin Engle, 1979; John M. Engle, 2004). This data can be compiled from NOAA, PISCO and NPS monitoring datasets gathered from the Channel Islands. GIS multicriteria evaluation can then generate habitat maps where optimal habitat sites are identified based on the presence of key ecological criteria.

2. Ethnographic studies

A multicriteria evaluation could also consider socioeconomic inputs such as number of boats, catch data from logbooks, and financial value of the lobster fishery through economic surveys. Existing ethnographic surveys (Kronman et al., 2000; NOAA, 2003) describe general human use values of the Channel Islands, including commercial and recreational fisheries catch and value, as well as the cultural value of fishing, and non-consumptive values from activities like SCUBA diving, research, and education.

3. Local lobster trapper knowledge

Collaboration should continue with local trappers familiar with the Channel Islands spiny lobster fishery and its territories to identify areas of suitable habitat for sampling sites at gradient locations. Consulting with lobster trappers may also help verify that optimal trapping techniques are being pursued.

C. Other Measurements

Other variables that may be important to future lobster demographic surveys, which we did not identify as priorities in the pilot study, include:

- Ratio of weight-to-size for males and females
- Ratio of carapace length-to-tail length for males and females
- Molting stage

Weighing and measuring lobster to determine a reliable weight-to-size ratio will allow future lobster studies in the Channel Islands to determine either variable given the other. Measuring carapace length against tail length for male and female lobster will help to ascribe differences in size to the length of the tail depending on the sex of the individual observed. It is important to quantify the length-to-tail ratio separately for male and female lobster because it is generally understood that tail lengths tend to vary between male and female lobster, however a correlation has not yet been identified for this population (Parrish, 2005). Determining the molting stage in conjunction with size measurements is important to assess the shedding rates and therefore individual growth stages of lobster (Parrish, 2005).

Due to the limited resources available, we did not include these measurements in our pilot study because we did not deem them essential to our overall monitoring objective of assessing lobster population abundance, size distribution, reproductive characteristics and net movement. However, if funding permits, we recommend taking these extra measurements in the data collection process and predict that they will add on 5 to 10 more minutes per sample taken.

D. Port Sampling

We recognize that our recommended method of field sampling may not be effectively implemented if future resources such as money and time are of a limited extent. In such cases, a port sampling method is an alternative that may be helpful in obtaining fishery information. Port sampling offers the opportunity to collect data, such as abundance, sex ratios and molting stages, on trapped lobster between sampling sites at the Channel Islands and the mainland.

This information may be pertinent to addressing larger-scale questions regarding lobster demographics in the northern Channel Islands. However, such data is of limited value when quantifying the demographic effects of MPAs on lobster, and we believe a port sampling scheme is inadequate to address the goals and objectives set out in this research project. First, port sampling does not provide a means of measuring the impacts of MPAs on lobster populations through control/impact assessment due to the lack of data from within reserves where fishermen are not allowed to trap. Second, this technique is dependent on a third party to collect necessary data; this may introduce increased bias and imprecision in the data due to the varying methods and equipment different collectors use for sampling. Third, such data does not provide a complete picture of lobster demographics if lobster trappers can only retain adult lobster from their traps. Unlike port sampling, field sampling allows monitoring of lobsters that are discarded from the traps, such as shorts (below legal size), egg-bearing, or tagged/notched lobster (Alden & Perkins, 2001). Therefore, we do not recommend port sampling as a back-up method for this project due to the limitations on available data and the lack of standardized trapping techniques.

E. Other survey methods

We recognize that resources will likely be limited in the future, and therefore have chosen the most important sampling methods for our recommended pilot study procedures. A variety of sampling methods may be optimal to accurately estimate lobster population and behavior, and any combination of these recommended methods would be welcome in conjunction with our recommended pilot study. Future population studies may incorporate technologically-advanced methods we have not identified here, such as radio tagging, that may yield important clues to lobster behavior but that are preventatively expensive for the purposes of our study.

Chapter 4: Analysis of Commercial Logbooks

I. Introduction

A. Long-term Monitoring Requires a Historical Baseline

An effective long-term monitoring study of spiny lobster populations in the northern Channel Islands requires a historical baseline population dataset against which future population data can be compared. The historical dataset provides information on current and past catch statistics of spiny lobsters in our study area. Spiny lobster catch information includes the location and number of spiny lobsters trapped throughout five commercial fishing seasons, 1999-2003. The historical baseline data provides catch details about the pre-MPA status of our study area and the variation in populations over time. Baseline monitoring data is useful for three main purposes: 1) it aids in scoping priorities for further research and defining project goals; 2) it provides vital background information for a monitoring program; and 3) it provides a basis for measuring changes in lobster population.

Ideally, to monitor abundance and size distribution effects of marine reserves on spiny lobster populations in CINMS, we would have sufficient knowledge of population dynamics prior to the marine reserve implementation. "A common goal [in monitoring programs] is to compare the value of some biological parameter at the affected site before the alteration to the value after" (Osenberg & Schmitt, 1996). The sampling protocol we have created is intended to assess changes in spiny lobster population abundance, size distribution, sex ratios, and movement over time. These biological parameters can fluctuate greatly over time, thereby making comprehensive background data of spiny lobster populations in our study area imperative.

B. Commercial Logbooks Offer Promising Data

The California DFG possesses commercial spiny lobster catch records known as logbooks, which the DFG stores in an electronic database. This logbook database has never been analyzed specifically for the northern Channel Islands, yet offers catch data on spiny lobster populations prior to implementation of marine reserves back to 1996. This *before* data will contribute a historical baseline for our evaluation of the effects of marine reserves on lobster populations. Commercial logbooks provide statistics on catch of spiny lobster over time that can be aggregated in DFG blocks. While the northern Channel Islands consist of 18 DFG blocks, only 12 blocks fall within our study area. We recommend using logbooks as the historical baseline dataset for long-term spiny lobster monitoring because they provide a rough estimate of lobster population size represented by catch.

To our knowledge, DFG logbooks are the only verifiable records available to provide historical baseline information on the numbers of spiny lobster in the northern Channel Islands. The principle purposes for collecting, recording, and integrating commercial logbooks are fisheries research and management (DFG, 1996a). Commercial fishery logbook data compare favorably with research catch data for catch locations, catch rates, and biomass estimates (Fox & Starr, 1996). The data in lobster logbooks provides limited biological information, but offers catch related data such as numbers of retained spiny lobster (legals) and numbers of released spiny lobsters (shorts) within DFG blocks, the depth at which lobsters are trapped, the date on which lobsters are trapped, and catch statistics per boat. The catch data in logbooks offers a rough estimate of lobster population size and location, as well as effort patterns of trappers to shallow and deep waters throughout a season indicating the movement patterns of spiny lobsters.

The logbooks also contain qualitative information on catch locations by specifying landmark names for fishing sites. While the DFG collects this landmark information, the agency only uses block-level information, although even block-level data has been left unpublished. Landmark names have not previously been included in the logbook database, thus they have not been evaluated in any way. Landmark data defines spiny lobster population abundance, distribution, and behavior in the northern Channel Islands region on a much finer spatial scale. To perform this detailed analysis of logbook data at the landmark level we integrated landmark names into a Bren database framed by the original DFG database.

II. Purpose

For monitoring purposes, *catch* and *catch performance* are key data for the historical baseline: catch defines the number of legal lobsters landed, and catch performance defines the mean number of legal lobsters landed per trap. For the spiny lobster fishery, few information sources offer datasets sufficient to build a historical baseline, and even fewer offer high-resolution catch data. The logbooks directly provide catch and catch performance. Furthermore, this historical baseline indirectly provides economic value through correlation with landing receipts (Appendix J).

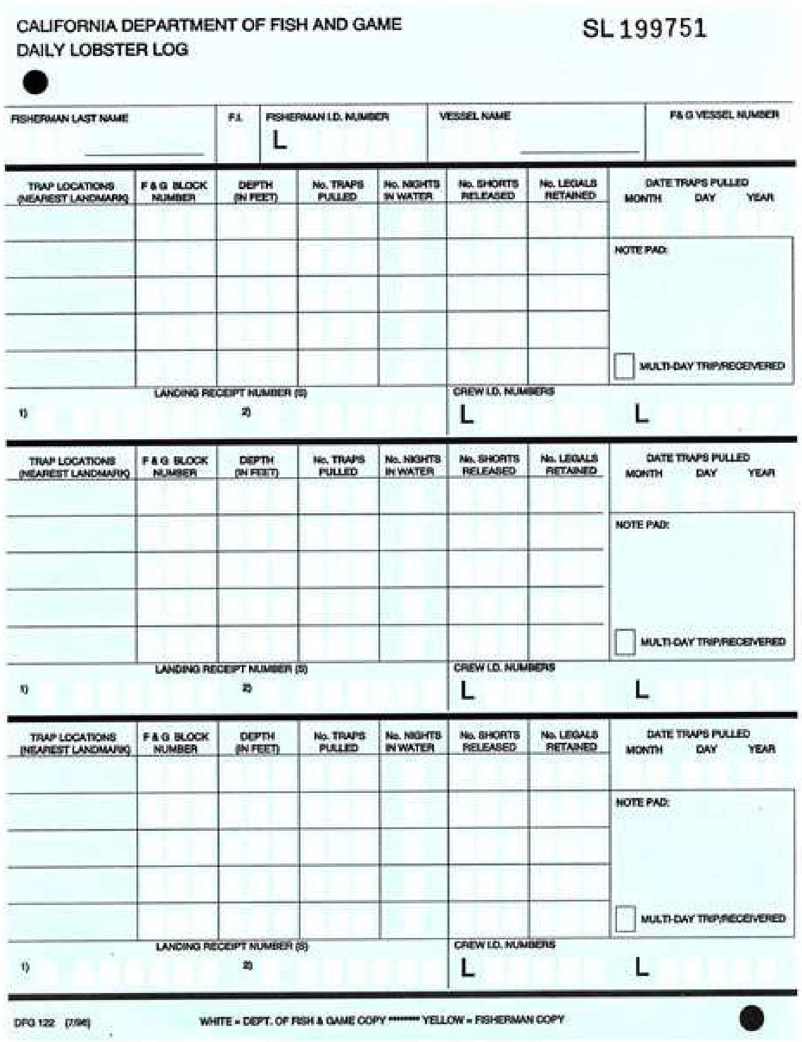
For catch data prior to April 2003 (when the MPAs went into effect), the typical resolution is a single DFG block or a “fishing area” defined by a collection of blocks. The DFG typically defines a block as a 10 x 10 minute area with a mean area of 194.6 square miles. These expansive fishing blocks are inadequate for monitoring the 12 Channel Islands MPAs that range from 2 to 46 square miles individually, and together total 196 square miles in area. We seek to improve the historical baseline dataset to represent catch data at finer resolutions than DFG blocks or marine reserves; in other words, trapping regions measured in meters not miles.

Lastly, the historical baseline should adequately capture local trapper knowledge of landmarks for spatial distribution of catch and catch performance. Without this capacity, the historical baseline may not accurately define spatial resolutions that are fine enough for our pilot study that recommends 1 to 2 km per marine reserves study site.

III. Description of Commercial Lobster Logbooks

A commercial lobster logbook is a paper record of fishing information that commercial lobster trappers must complete every time they fish. The DFG states: “Any person who owns and/or operates any vessel used to take lobsters shall complete and submit an accurate record of his lobster fishing activities on forms provided by the Department” (DFG, 1996a). The state of California titles this the Daily Lobster Fishing Log (DFG, 1996a); one paper form is a commercial logbook.

One Daily Lobster Fishing Log has three fishing activity sections, and each section has a maximum of five entries, and trappers must document trapping information for every location. The lobster trappers must also complete a new fishing activity section when the date they pull traps changes. Therefore, at maximum, one logbook can contain 3 separate days of trap and catch information, including multiple-day fishing trips (DFG, 1996a).



CALIFORNIA DEPARTMENT OF FISH AND GAME
DAILY LOBSTER LOG

SL 199751

FISHERMAN LAST NAME	F.I.	FISHERMAN I.D. NUMBER	VESSEL NAME	F& G VESSEL NUMBER
		L		

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR

NOTE PAD:

☐ MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S)
1) 2)

CREW I.D. NUMBERS
L L

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR

NOTE PAD:

☐ MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S)
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L L

TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR

NOTE PAD:

☐ MULTI-DAY TRIP/RECEIVERED

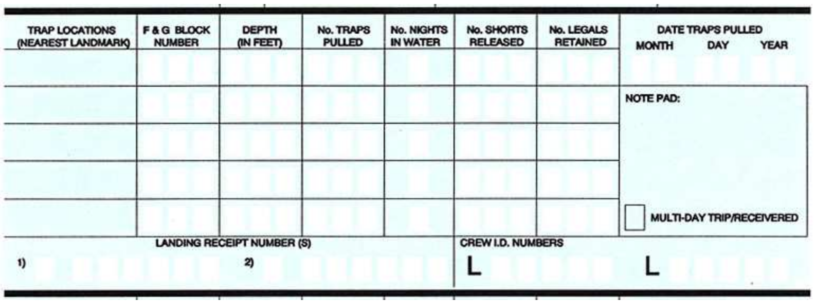
LANDING RECEIPT NUMBER (S)
1) 2)

CREW I.D. NUMBERS
L L

DFG 122 (7/96)

WHITE = DEPT. OF FISH & GAME COPY ******* YELLOW = FISHERMAN COPY

Figure 18: DFG Daily Lobster Fishing Log. Blank example of DFG Daily Lobster Fishing Log, or the lobster log paperwork (Form 122, revised July 1996).



TRAP LOCATIONS (NEAREST LANDMARK)	F & G BLOCK NUMBER	DEPTH (IN FEET)	No. TRAPS PULLED	No. NIGHTS IN WATER	No. SHORTS RELEASED	No. LEGALS RETAINED	DATE TRAPS PULLED MONTH DAY YEAR

NOTE PAD:

☐ MULTI-DAY TRIP/RECEIVERED

LANDING RECEIPT NUMBER (S)
1) 2)

CREW I.D. NUMBERS
L L

Figure 19: Fishing Activity Section. Blank example of the fishing activity section from a Daily Lobster Fishing Log.

A. Information Contained in Daily Lobster Fishing Logs

The information is hand-written by trappers into respective fields on Daily Lobster Fishing Logs (Table 9). According to DFG rules, all information must be printed with ink only using all capital letters and full names.

Table 9: DFG Commercial Spiny Lobster Logbooks Fields. Source: (DFG, 1996a).

Logbook Fields
Fisherman's Last Name
Fisherman's Identification Number
Vessel Name
DFG Vessel Number
Crew Member Identification Number (if applicable)
Multi-day Trip Box (checked if applicable)
Landing Receipt Number(s) [corresponds to lobsters sold for a logbook section]
Trap Location [nearest landmark location to where fishing occurs]
DFG Block Number [where most of the fishing occurred]
Depth [average depth at which most of the traps were placed]
Number of Traps Pulled [per location]
Number of Nights in Water [average number of nights traps are in the water per each trap location]
Number of Shorts Released [sub-legal lobsters trapped and released]
Number of Legals Retained [adult legal lobsters trapped and retained]
Date Traps Pulled
Note Pad [note area for weather, vessel, and all other comments]

B. Current Management of Commercial Lobster Logbooks

The DFG scans paper forms of Daily Lobster Fishing Logs into an electronic Microsoft Access database using Optical Character Recognition (OCR) technology. This process does not tolerate any numerical ranges for data entries. For example, ranges in the depth of traps, multiple DFG blocks entered or crossed while fishing, and ranges for the nights in the water are not accepted. Trappers must choose exact values for each one of these fields that best describes where and when most of the fishing activity occurred.

The DFG uses lobster logbook data in limited ways. One use is summarizing information for a commercial fishing season for agency reports. For example, a California Spiny Lobster Logbook Data Summary for 1997-98 Commercial Season contains three summary reports from the 1997-1998 commercial season (Reid & Ramsay, 2004). The summary reports consist of regulatory information as well as lobster catch and trapping effort by fishing area and by month (Reid & Ramsay, 2004). The regulatory information primarily includes the total number of annual lobster permits issued and the number of permittees submitting logbook information. The summary sheets started in 1978-1979; we have located data for the 1980-1981 to 1995-1996 and the 1998-1999 to 2003-2004 commercial seasons. Here is a comparison of total catch for all fishing areas to total catch for the northern Channel Islands from the California Spiny Lobster Logbook Data Summary For 1998-99 Commercial Season (Reid & Ramsay, 2004):

All Commercial Lobster Fishing Areas	Northern Channel Islands Fishing Area
• 861,143 Traps Pulled	• 113,568 Traps Pulled
• 822,294 Shorts Released	• 34,200 Shorts Released
• 395,366 Legals Retained	• 62,684 Legal Retained
• 0.95 Shorts per Trap	• 0.30 Shorts per Trap
• 0.46 Legals per Trap	• 0.55 Legals per Trap

The final summary report contained in the California Spiny Lobster Logbook Data Summary breaks down lobster catch and trapper effort by month. It also includes totals for the number of permittees fishing and the average depth fished. For example, in the commercial lobster fishing season of 1998-1999, there were 173 permittees fishing in October at an average depth of 43 feet and 99 permittees fishing in March at an average depth of 67 feet.

IV. Approach

Prior to our project, DFG commercial lobster logbook data was relatively unexplored for catch locations because the DFG had not digitized the trap locations due to the lack of standardized nomenclature. We revisited 5 seasons, 1999-2003, of logbooks and recorded trap locations for the catch.

Our approach is straightforward and applicable to other management situations that require improved spatial resolution. First, we identified our study area and obtained catch and catch performance data for it. Second, we imported that data into a database we designed to support our research questions and performed rigorous validation on the data. Third, we entered and associated trap locations with catch and catch performance data, and then consolidated trap locations into an *Official Landmark* list. Finally, we located and further identified official landmarks, and then performed analyses on the historical baseline dataset.

A. Logbooks

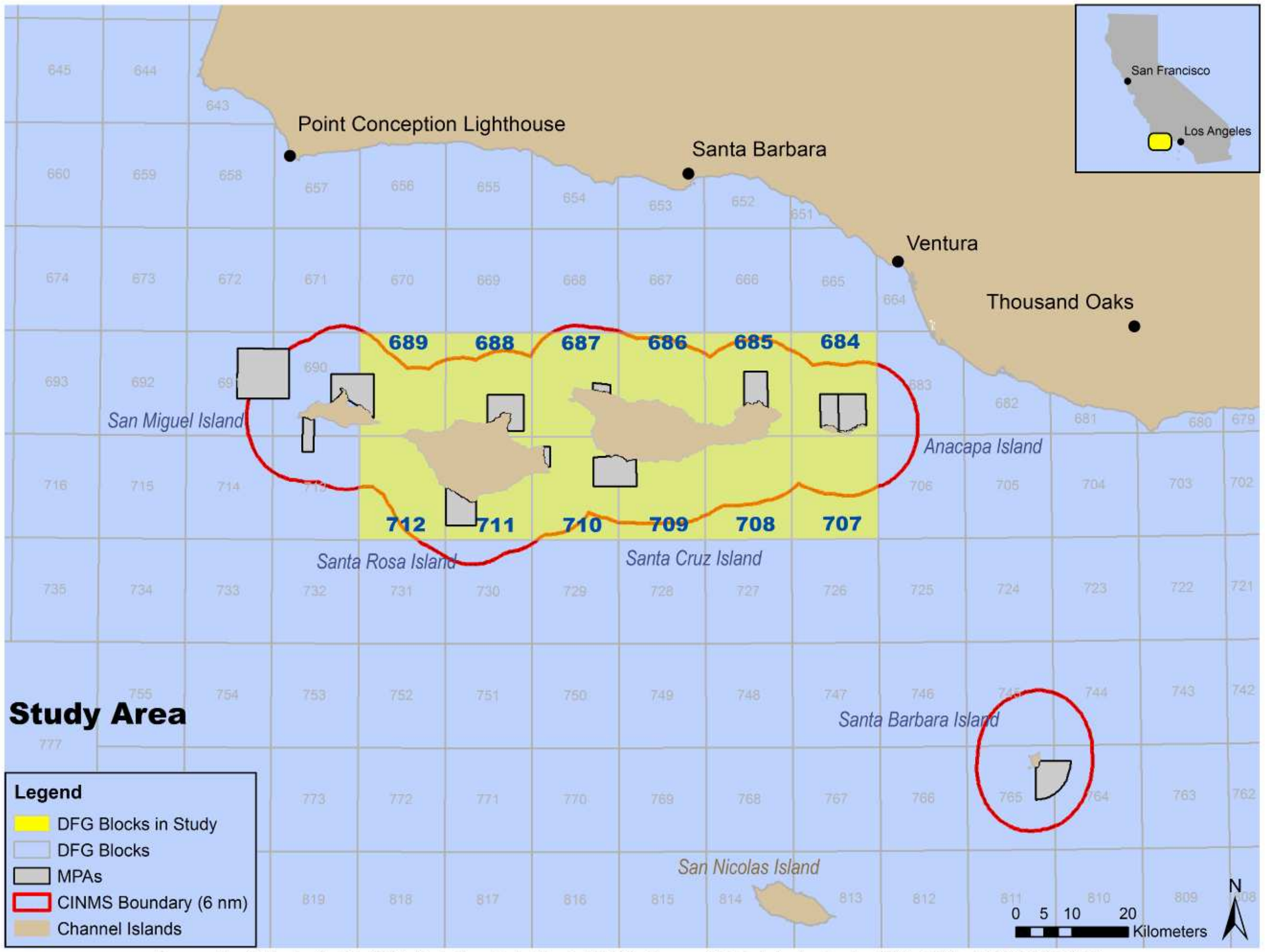
1. Identify study area

DFG logbooks represent lobster fishing for the entire California coast. However, our monitoring questions are specific to the northern Channel Islands, so our first step was to identify a clear study area for the logbook data. The DFG uses blocks to segment the logbook data (DFG, 1996b), and the following blocks define our study area: 684, 685, 686, 687, 688, 689, 707, 708, 709, 710, 711, and 712.

Map 1 shows our study area in detail. First, we selected MPAs that were of primary interest in our pilot study: Anacapa SMR, Carrington Point SMR, Gull Island SMR, and Scorpion SMR. Then we chose blocks that are contained within these MPAs, or probable fishing areas near these MPAs (e.g., 684, 685, 687, 688, 707, 709, and 710). Next, we decided to include all blocks around Santa Rosa Island, Santa Cruz Island, and Anacapa Island since we were uncertain if other MPAs will be included in future monitoring plans; locations within these blocks may be used as sites for the "far" gradient in the monitoring plan.

2. Design database

The DFG manages their logbook database via a semi-automated process of optical scanning, and their database design reflects this automation. The data model is not conducive to asking research questions, but rather to cost-effective automation. Therefore, our approach is to design a proxy database between the DFG database and our research to provide the ability to query and analyze the logbook data easily. In database terms, we designed our database to have a fully normalized relational data model (e.g., third normal form), which eliminates data redundancy (Ullman, 1980).



Prepared by D. Hardy, 21-Feb-2005. Projection: TealeAlberts, NAD83. Source: DFG Lobster Logbooks, 1999 - 2003. USGS GNIS, 2004.

Map 1: Logbook Study Area. Northern Channel Islands bound by DFG Blocks 684 – 689 and 707 – 712.

3. Validate data

Furthermore, the automation and trapper reporting lead to mechanical and human errors in the data. Our proxy database enforces additional data validation rules to further refine the data integrity (Appendix I). For example, our rules check for data errors such as invalid block numbers, depths outside 0 – 300 ft, nights greater than 9 (only 1 digit is allowed), and so on. Figure 20 shows the framework for integrating the DFG database and the processes involved with the creation of the proxy database.

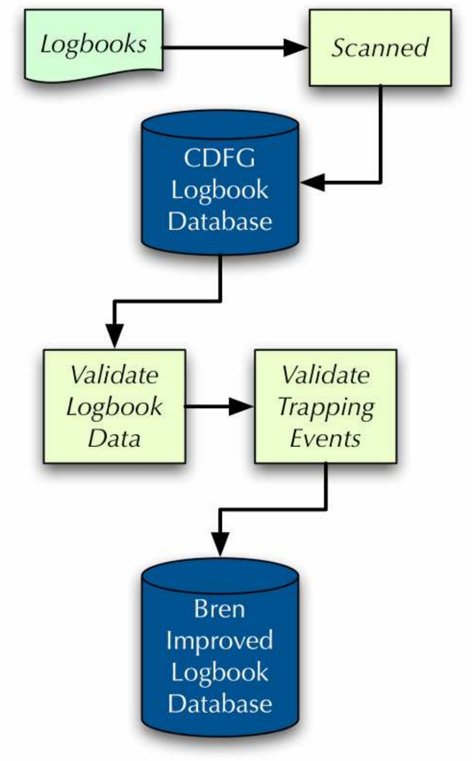


Figure 20: Database Model. Logbook Database Integration with DFG Lobster Logs Database, and Data Validation Processes.

B. Landmark Identification

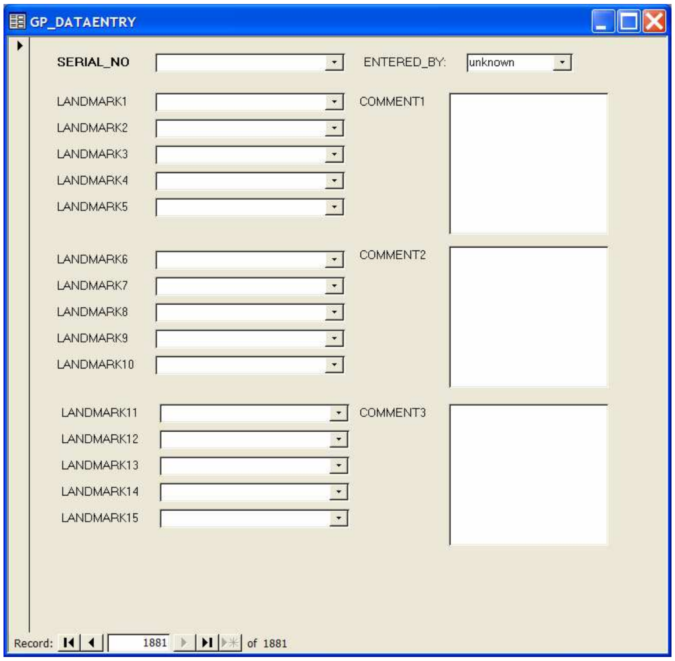
1. Obtain Original Logbook Paperwork

The DFG retrieved the original lobster logbook paperwork from storage for the 1999 – 2003 seasons. We then sorted through the paperwork to identify logbooks within our study area. We included all pertinent logbooks in our study, even if a logbook only had a single landmark within our study area. The logbook paperwork exists in 2 different forms: the current "green" form, and an older "white" form that some trappers still used after 1996. The "green" forms became the standard logbook after 1997, but some "white" forms were still submitted to and scanned by the DFG after 1997. The DFG stores the different forms separately, and we obtained the "green" paperwork. "White" forms are increasingly minimal after 1999. The data we use from 1996 to 2003 seasons for block-level and area-level analysis (Appendix I) contain both the "white" and "green" forms. For resource reasons, however, we limited our landmark-based work to the most recent 5 seasons (1999 – 2003).

2. Data Entry for Landmarks and Comments

For each logbook, we entered the logbook serial number, landmarks within our study area, the line number on which the landmarks occurred, comments and their section number, and the name of the data entry person. Figure 21 shows the database form we developed to optimize data entry.

On average, we processed over a hundred logbooks in an hour, while performing data entry for a dozen logbooks in this time (only 13% of the logbooks have landmarks in our study area). Between July – September, 2004, three group members processed nearly 15,000 logbooks and entered 1,864 logbooks into our database, for a total of 10,120 *trapping events*, 412 landmarks, and 1,051 comments.



ENTERED_BY: unknown

Record: 1881 of 1881

Figure 21: Data entry form.

C. Incentive for Landmark Consolidation

Originally, all individual lobster logbook landmark entries were inserted as separate landmarks into the Bren database, totaling more than 300 landmark entries. Some landmark names are features only the trapper community knows, or in some instances are only known by a single trapper. However, many landmarks listed are repeats. Examples of the types of landmark repeats are below, however not all examples are based on real data because of privacy issues.

Misspelled landmark

Standard name = Dos Equis
Variant names = Das Equis, Dos Equi, Dasequi

Shorthand landmark

Standard name = Sandpaper Cove on Rock Island
Variant names = S/C RI, S/P Cove, SPaper RI, Sandpaper C, and Sandpaper

Colloquia landmark
Standard name = Paddle Bay
Variant name = The Big Kahuna

Two locations per landmak
Standard name = Arch Rock
Location = Anacapa Island and Santa Cruz Island

Composite landmark
Standard name = Morse Point to Gull Island
Recorded landmark = Morse-Gull

Since the list of recorded landmarks is long and somewhat repetitive, we merged and consolidated landmark names to one official landmark list. Merging and consolidating landmark names helped assign catch data in logbooks to proper landmarks to identify sample sites for the pilot study. This shortened our list of 328 original landmarks to a more manageable list of 47 official Bren database landmarks, excluding the composite landmarks.

D. Landmark Consolidation and Merging Schemes

The approach for merging and consolidating landmark names involved consulting many references. We examined USGS nautical charts, operated a GIS map application called Chart Navigator, examined the boundaries of the DFG blocks, and utilized the Geographic Names Information System (GNIS) database (USGS, 1995). Most landmarks could be identified using USGS nautical charts and the GNIS database, however some landmarks were more difficult to locate in the reference literature and have not been identified.

The first step to merging landmarks included separating landmark names into different categories: single name landmarks, composite landmarks, unidentified landmarks, and landmarks not meeting data privacy concerns. Next, we found geographic locations and official names for all identifiable single name landmarks using the previously mentioned sources of references.

The proper spelling and geographic coordinates of official landmarks, along with the DFG block number, aided in refining other landmark names. The GNIS database provided geographic locations for official landmarks and variant names. Official landmarks were correlated with DFG block numbers written in logbooks and then compared with local landmark names used by lobster trappers.

GNIS database names
Official: Coches Prietos Anchorage
Variant: Coche Prietos Anchorage and Cochies Prietos Anchorage
Official: Bechers Bay
Variant: Beechers Bay

Shorthand landmark name
Variant: Coche
Official 1: Coche Point in 685
Official 2: Coches Prietos Anchorage in 709

DFG block numbers are useful for determining some landmarks, such as Coche Point and Coches Prietos Anchorage. However, some landmark locations are not determined as easily, and a fisherman could record DFG block 687, 688, 710, or 711 and still be fishing at Bechers Bay (Map 4).

The composite landmarks were not consolidated into single name landmarks because fishing effort cannot be assigned to landmarks using a standardized methodology. Some composite landmarks cover the span of three DFG blocks, such as Juan Columbia-Sandpaper Cove.

Example 1

Official location 1: Juan Columbia is in DFG block 687
Official location 2: Sandpaper Cove is in DFG block 685
Recorded location: DFG block 686.

The recorded DFG block number should represent the area where most of the fishing activity took place. Therefore, it is not unreasonable to assume the trappers placed most effort in DFG block 686, but still fished between Juan Columbia and Sandpaper Cove.

In other composite name cases, one landmark name and location cannot be found, while the second landmark is defined in our Gazetteer. But even with composite landmarks where all locations have been identified, we cannot standardize the methodology for distributing fishing effort across space. Another fictitious example is Yum Point-Oak Tree, where both landmarks fall within the same DFG block, 685. Due to time and resource constraints, and data privacy concerns we are not able to quantify how much fishing effort should be placed at each composite landmark.

E. Geographic Landmark Mapping

After we determined the official landmark name, we mapped the landmarks according to the geographic location provided in the GNIS database. The GNIS database provides latitude and longitude coordinates, and a landmark category type for all landmarks located in the database. Forty-four out of forty-seven official landmarks used in the commercial logbooks match landmark features in the GNIS database.

If a landmark was not located in the GNIS database, then we used nautical charts and local trapper knowledge to identify the landmark location. There are also 222 unofficial composite landmarks and other variant name landmarks in our study that are either unrecognized by the GNIS database, absent from USGS nautical charts, or unrecognizable by local trapper consultants.

V. Results

Our primary results are a historical baseline of catch and catch performance with improved spatial resolution from broad DFG blocks to an individual landmark scale. We also produced a Landmark Gazetteer.

A. Historical Baseline Data for Lobster Catch

Our approach (Section IV) yields a spatially improved historical baseline for lobster catch in our study area. Here, we compared our historical baseline with the original block data that was provided by the DFG.

In our production of this baseline dataset, we summarized data on one or more variables, such as Landmarks and Season Year. For privacy concerns, we enforced the DFG policy that at least three trappers be included in each summarization; otherwise, we do not include data for that variable(s). The historical baseline data is located in Appendix I.

For consistency, we adopted the convention that the year in which the season ended is the *Season Year*. Our historical baseline has two datasets: (1) original data covering 8 seasons (1996 – 2003), and (2) our landmark results covering 5 seasons (1999 – 2003).

1. Original Data

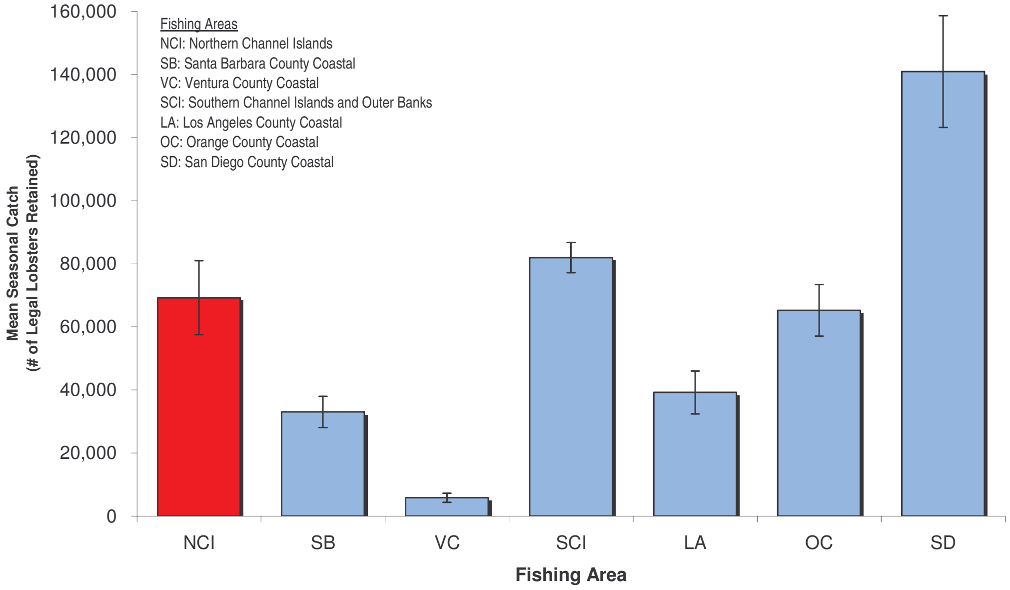
(i) By Season and Fishing Area

Comparing lobster catch across fishing areas, provided by commercial logbooks, validate that the Northern Channel Islands have comparable populations of spiny lobsters to other fishing areas in southern California. The bars in Figure 22 represent the number of legal lobsters retained; the bars in Figure 23 represent catch performance of lobsters, or the average number of lobsters per trap. The catch performance at the Northern Channel Islands is comparably high, suggesting either more numbers of individual lobsters or less fishing effort.

(ii) By Season and Block

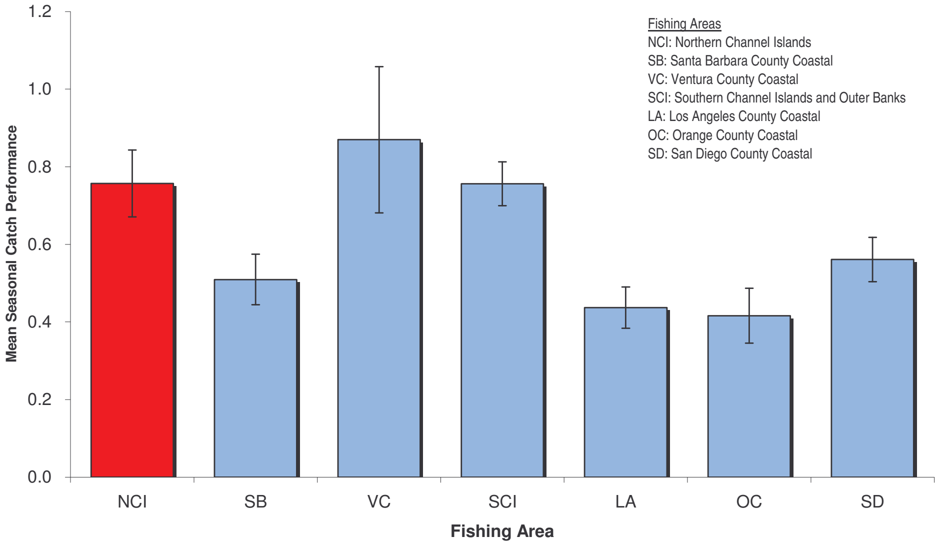
We used raw data in logbooks to analyze legal lobsters retained through time; an example of this is shown below in Map 2. The map is of our study area, showing the 12 DFG blocks with the total legal lobster catch for each commercial season from 1996 to 2003. Comparison of lobster catch records reveals fluctuations over time. In DFG blocks 688 and 711, the catch increases relatively steadily over time, while some DFG blocks such as 710 (or 707 including gaps in data) appear relatively unchanged. Other DFG blocks, like 685, 687, and 712 illustrate the fluctuations in catch over time.

Analysis of the raw data in logbooks also provided catch performance, or mean number of legal lobsters per trap, as shown in Map 3. As previously stated, Map 2 reveals that the number of legal lobsters increased over time in DFG blocks 688 and 711. However, the number of traps in these blocks increased over time as well which lessened the overall catch rate. Also, the catch of legal lobsters retained in DFG blocks 710 and 707 (Map 2) remained relatively small compared to the catch performance of DFG blocks 710 and 707 (Map 3). DFG blocks 686, 710, and 712 are noteworthy for their catch performance in Map 3. These blocks have much higher catch performance (Map 3), than legal lobsters (Map 2).



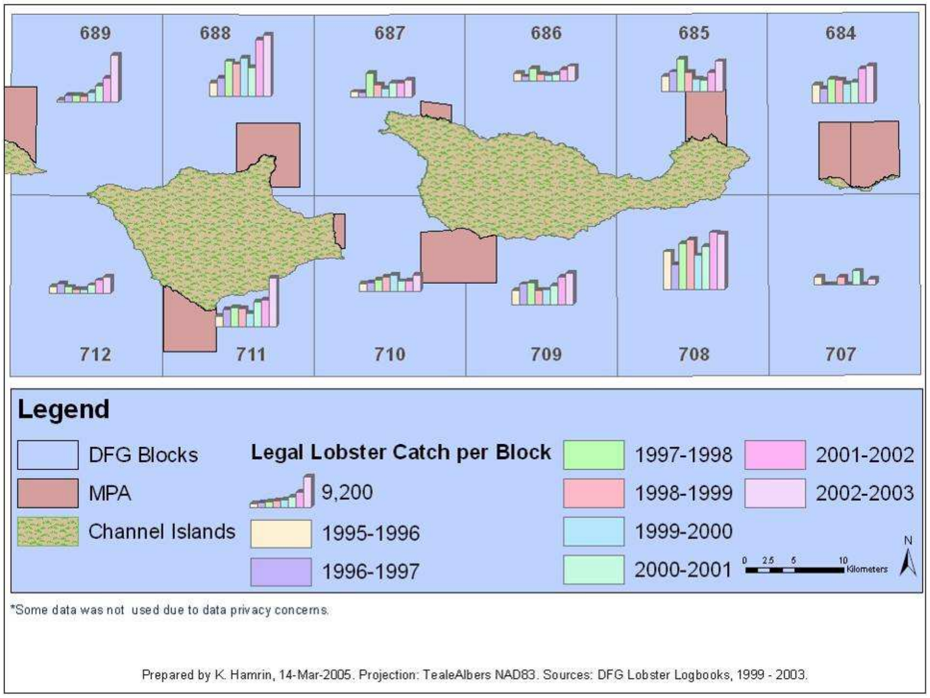
Source: (2004) CDFG Lobster Logbooks. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).

Figure 22: Mean Seasonal Catch per Fishing Area. Mean Seasonal Catch per fishing area, 1996-2003. Source: (DFG, 2003d).



*Catch Performance is the catch (number of legal lobsters) per trap. Error bars represent standard deviations between the seasonal means only.
Source: (2004) CDFG Lobster Logbooks. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).

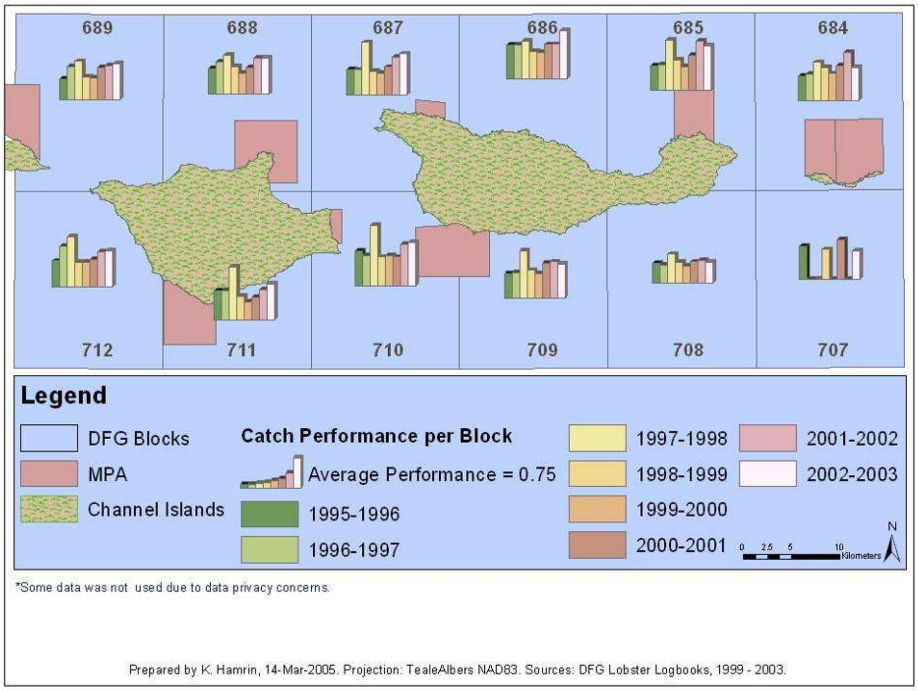
Figure 23: Mean Seasonal Catch Performance per Fishing Area. Catch Performance is the mean number of legal lobsters per trap. Source: (DFG, 2003d).



*Some data was not used due to data privacy concerns.

Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003.

Map 2: Mean Seasonal Catch per DFG block from 1996 - 2003. Each color in the bar chart represents spiny lobster catch for a different commercial season for the entire DFG block.



*Some data was not used due to data privacy concerns.

Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003.

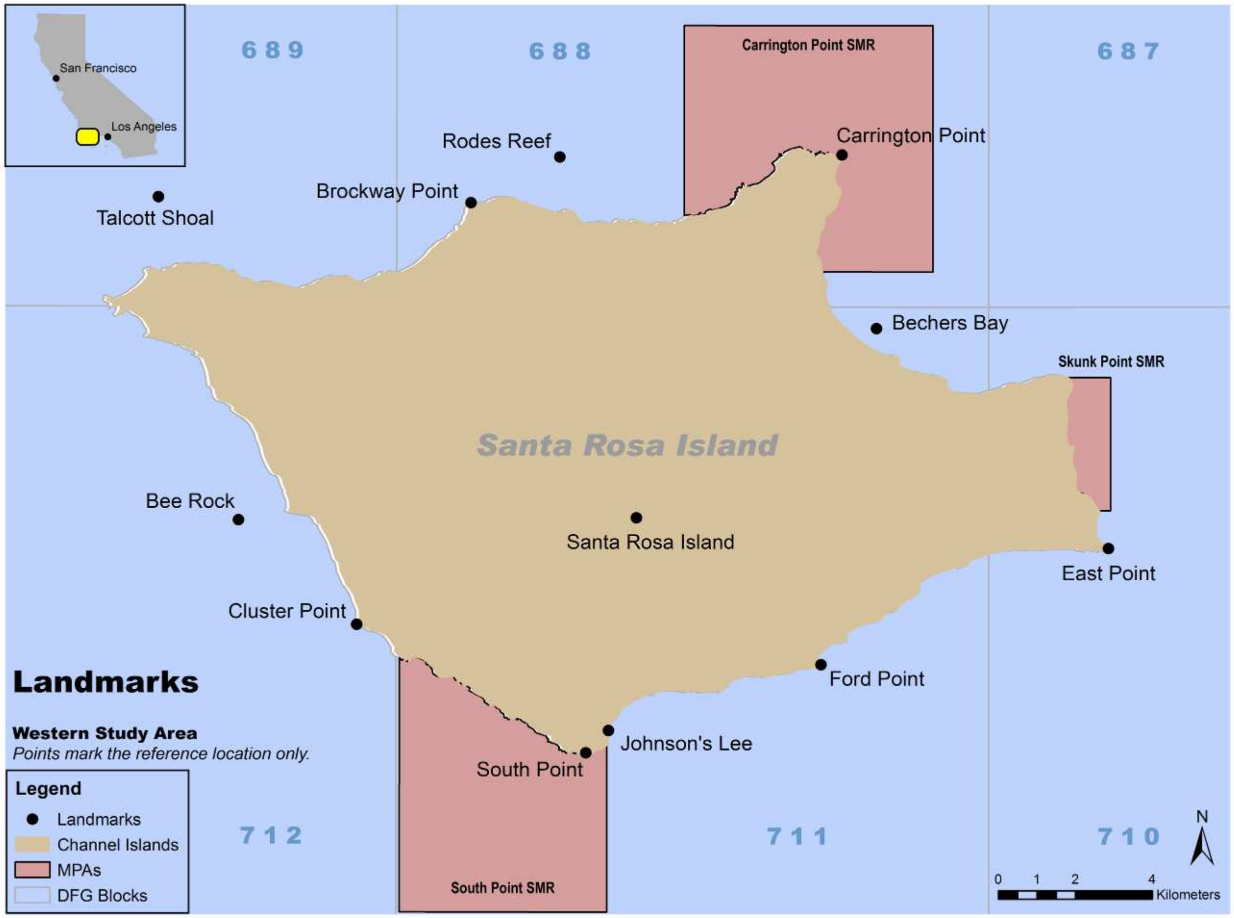
Map 3: Mean Seasonal Catch Performance per DFG block. Mean Seasonal Catch Performance per DFG block from 1996-2003. Each color in the bar chart represents spiny lobster catch performance for a different commercial season for the entire DFG block.

2. Data with Improved Resolution

The exhaustive list of trap locations listed in the DFG database identifies landmarks we used to improve the historical baseline. We have assembled and consolidated these landmark names into a gazetteer, or a standardized map guide. After integrating the landmark names with catch data, we report the catch from 1999 to 2003 within our study area on a finer-grain scale. These landmarks include areas both inside and outside the MPAs for our study area.

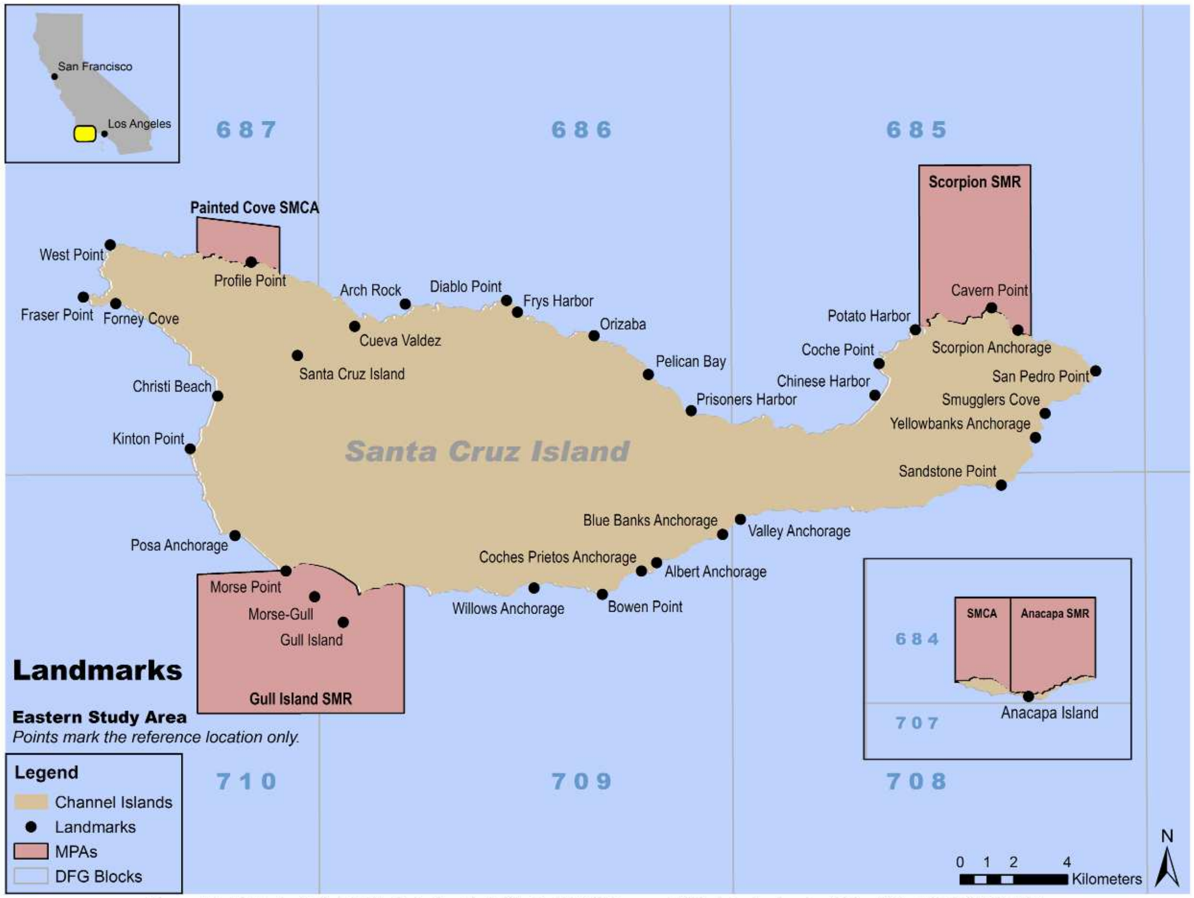
We are unable to define the size of each landmark area listed in the logbooks in this project, but we have found that several DFG blocks have at least 5 or more landmarks within one block. Therefore, we can safely assume these landmarks are smaller in area than the DFG block. In fact, by annotating the historical baseline with landmarks, we improve the spatial resolution of catch and catch performance by one order of magnitude finer than DFG blocks, from 137.4 square miles to local landmark areas ranging from under 1 square mile to a few square miles.

The catch data at each landmark also contained the depth of traps, allowing us to restrain fishing location range by ocean bathymetry from the shoreline out. Observed changes in the depth of fishing effort throughout the commercial season implies movement of lobsters between shallow and deeper waters. Assessing catch data by landmark represents the geographical location of spiny lobsters more precisely over time in our study area than block-level data. Landmark resolution data may encapsulate the spatial scale of lobster movement throughout the season.



Prepared by D. Hardy, 21-Feb-2005. Projection: TealeAlberts, NAD83. Source: DFG Lobster Logbooks, 1999 - 2003. USGS GNIS, 2004.

Map 4: Official Landmarks identified in Western Study Area. The locations of landmarks are only reference points and do not denote an accurate spatial distribution for catch data.



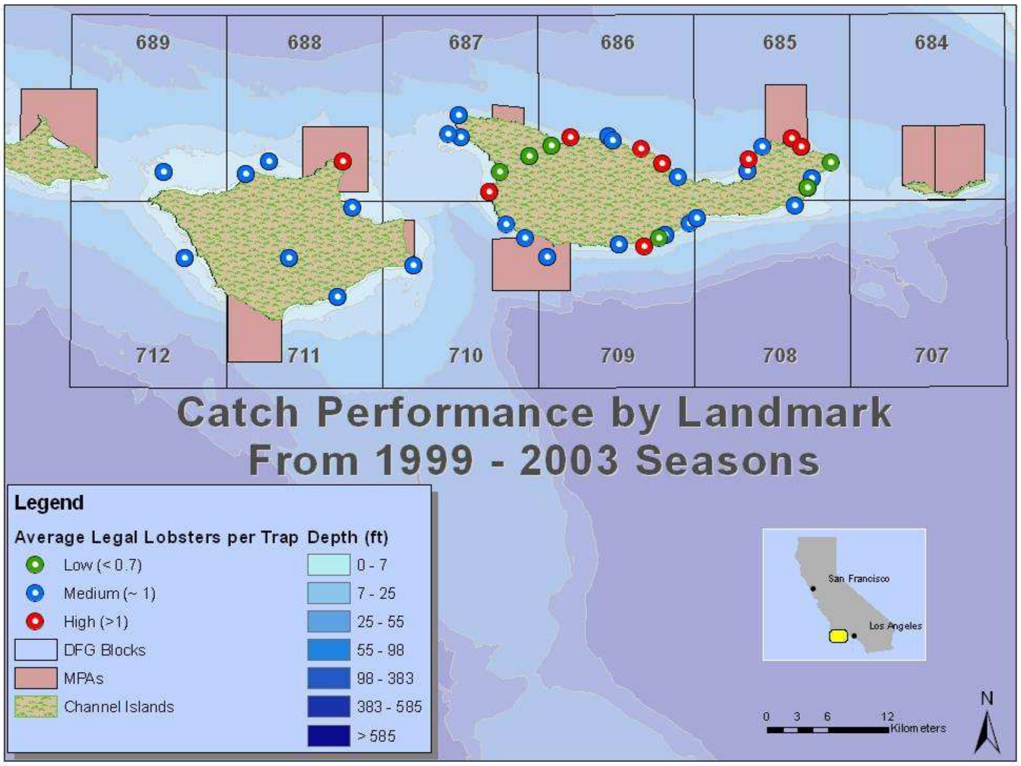
Prepared by D. Hardy, 21-Feb-2005. Projection: TealeAlberts, NAD83. Source: DFG Lobster Logbooks, 1999 - 2003. USGS GNIS, 2004.

Map 5: Official Landmarks identified in Eastern Study Area. The locations of landmarks are only reference points and do not denote an accurate spatial distribution for catch data.

(i) By Season & Landmark

In Map 6, we summarized all spiny lobster catch data from 1999-2003 commercial seasons at each landmark. The summarized spiny lobster catch is categorized and represented by catch performance, and organized into three categories: low, medium, and high. Appendix I contains maps of catch performance by landmark per individual season from 1999 to 2003.

Map 6 is useful for identifying sampling sites for the pilot study because it depicts landmarks in our study area with successful catch performance in the past. It is helpful to locate possible sample sties correlated with historical lobster catch for our pilot study so results will be more robust. We can also eliminate some sampling locations based on low, or nonexistent, lobster catch patterns over time (Appendix I). Annual catch patterns are useful for discovering other possible variables affecting lobster population demographics, abundance, and catch performance. For example, in commercial season 2000, spiny lobster catch is noticeably lower. Fewer landmarks are used for fishing in 2000 and established landmarks have quantitatively lower catch performances. This occurrence of lower catch performance in 2000 alerts us to investigate annual sea surface temperatures, ocean currents, weather patterns, and any other significant variables affecting lobster populations.



Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 6: Mean Catch Performance by Landmark. Catch Performance by Landmark, Summarized for 1999-2003 Seasons.

B. Landmark Gazetteer

Our *Landmark Gazetteer* (Appendix F) is a standardized list of 47 landmark names and attributes throughout our entire study area. The gazetteer provides location and naming details for each landmark (Appendix F), including the standard name, DFG block number, latitude and longitude coordinates, and variant names for each landmark (Appendix F). Most landmarks (91%) in our gazetteer are cross-referenced with the GNIS database (USGS, 1995). Through cross-referencing, we offer a government agency standard for landmark details, including the landmark type (e.g., cape, bay, harbor, island, etc.), USGS quadrant, county, elevation, and more. For the remaining landmarks (9%), we provide limited information that we identified through our research and in consultation with local trappers.

Landmark names can be standardized, but standardizing landmark locations is problematic because the landmark type, habitat patch size, and fishing zone size vary with each landmark. The distance from the physical landmark to the actual location where a trapper is fishing varies over time due to depth, season, environmental conditions, and a number of other factors. Additionally, for each gazetteer landmark, the spatial distribution of its fishing zone (i.e., the area where trappers fish) is largely unknown (Section Chapter 4:V.C.4).

Despite these uncertainties, our results provide a quantitative evaluation of historical catch data that is well correlated with the landmark gazetteer and its fishing zones. This data can be used as a baseline for comparison with the pilot study and future research that requires data representing the pre-MPA status of our study area. The Gazetteer can also be used by government agencies to adopt standard landmark names for commercial logbooks.

C. Discussion of Results

1. Related work

Research in the Pacific Northwest showed commercial fishery data and research catch data were statistically similar in comparison. Researchers compared catch locations, catch rates, and biomass estimates from both sources. This revealed logbook data closely resembled the National Marine Fisheries Service (NMFS) triennial trawl research data for catch patterns and relative abundance (Fox & Starr, 1996). Geographic and statistical analysis performed between commercial logbooks and NMFS research data suggest that information contained in logbooks can augment research data (Fox & Starr, 1996).

2. Limitations

The data in logbooks limits our study by the type of catch data it provides. More precise breakdowns of lobster catch by size, beyond simply legal and sublegal, into a range of different size classes would be very useful for future lobster fishery management. Catch data such as the exact size, sex, and reproductive stage of the lobsters are not recorded in the logbooks (however, the commercial lobster season starts in October, and is generally thought to be closed during the reproductive phase of spiny lobsters).

Data collected from DFG logbooks is limited by possible inaccuracies and inconsistent enforcement mechanisms. The accuracy of DFG lobster logbooks is uncertain for two reasons. First, the lobster trappers may estimate on data entered into logbooks. Second, the logbooks might not be scanned properly into the DFG database.

Recorded landing receipt number on each logbook could be a possible gauge of data accuracy, but landing receipts and logbooks use different metrics for estimating lobster catch. In landing receipts, lobsters are sold by weight (lbs.) rather than individual count. Therefore, errors in data reporting are possible because there is a lack of double-checking mechanisms.

Also, starting in the commercial season 1994-95 the California Spiny Lobster Logbook Data summary sheets include a logbook compliance statistic, which is a percentage of the number of permittees that land lobsters who also submit logbook information. Typically, there is less than 100% compliance on reporting catch data; this provides limited information to resource managers.

3. Estimating Catch Performance vs. Catch per Unit Effort

Traditionally, catch per unit effort (CPUE) is used for commercial fisheries to measure catch standards. We chose to measure catch performance instead of a standard CPUE. To estimate catch performance we divided the mean number of legal lobsters caught at one landmark location by the total number of traps dropped at that location. Unit effort is generally determined by the amount of time a uniform piece of fishing gear is in the water. However, lobster traps have a maximum holding capacity limiting the number of lobsters per trap; increasing the time a lobster trap is deployed in the water does not necessarily increase catch. We do not use CPUE because want to assume all commercial lobster traps capture an equivalent number of lobsters, leading to a standard CPUE for the whole commercial fishery, because commercial lobster traps differ in size. Commercial lobster traps also vary in trap material, mesh size, and the number of entrances that can lead to differences in CPUE. There are many variables involved with leaving commercial lobster traps soaking in the water for a length of time, including sea temperature, depth of the trap, quality of the ocean water, oceanographic conditions, and weather conditions. Therefore our unit effort calculation for catch rate depended on the number of lobster traps and not the amount of time a trap is in the water.

4. Spatial Distribution of Catch for a Landmark

Although the size of fishing areas identified by local landmark names is unknown, we assume they are significantly smaller than DFG blocks. The DFG instructs trappers to provide landmarks as the “nearest landmark location to where fishing occurs” (DFG, 1996a), so we assume trappers have a visual bearing on a landmark, weather permitting. Our integration of local trapper knowledge into the consolidation rules helps refine the landmarks, but does not address their spatial quality formally.

Our initial approach for estimating spatial catch statistics was to assign a spectrum of radii to the landmarks based on their GNIS types, where a point would have a small radius and a bay would have a large radius. However, this estimated approach proved too limiting as it did not account for the number of trappers working in each fishing ground.

We then chose to cross-reference the catch data for two landmarks with the bathymetry for the region near the landmarks to estimate landmark size more accurately. Merging these data yielded promising results. We created maps containing bathymetry lines that represent catch data, based recorded fishing depth from logbooks and thus put limits on the probability to where the landmark's region extends.

Map 7 shows Carrington Point landmark bounded by a 6 km radius to illustrate a potential spatial boundary. The 6 km radius is somewhat arbitrary, but we choose it as a representative guess for the landmark's area. We expect that the high catch region (in red with 4,508 lobsters) is relatively large, and the region's bathymetry is restrictive for fishing close to shore, such that a 5 or 6 km radius may be required. The catch extends from lowest to highest in the shallow waters to the deeper waters, with no catch deeper than 98 ft or shallower than 8 ft. Table 10 shows details of the catch data for Map 7.

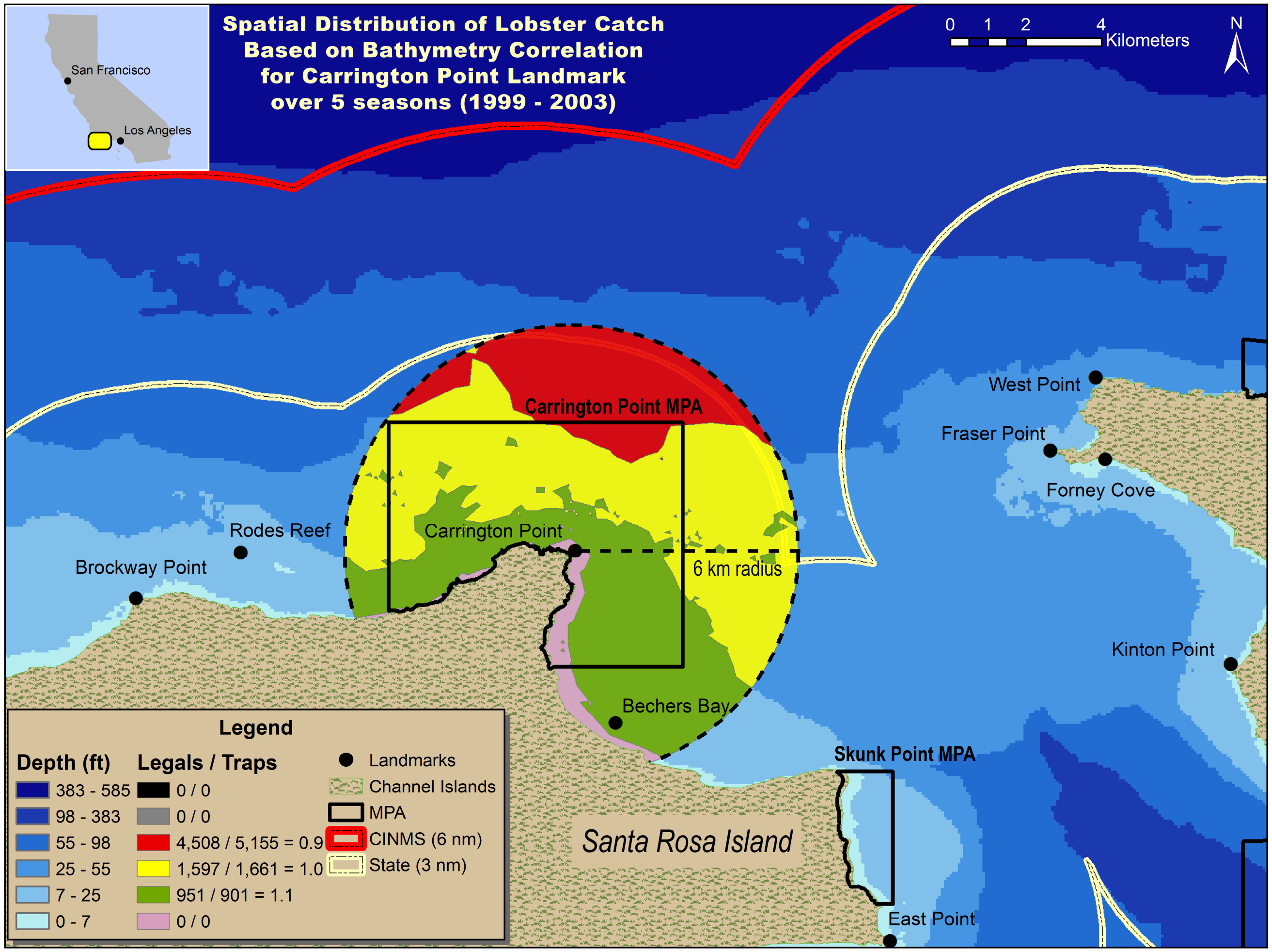
Map 8 shows Yellowbanks Anchorage landmark bounded by a 6 km radius to illustrate a potential spatial boundary. We chose this landmark as a contrast to Carrington Point because it has an eastern location and shallower bathymetry. At Yellowbanks Anchorage, the majority of catch is within the moderate depth range, which also has poorest catch performance (0.3 legal lobsters per trap). In this case, however, the 6 km radius is not as clear since the moderately deep waters are widespread and extend to western Anacapa Island. Surprisingly, the least catch (1,005 lobsters) occurs in deep waters, because these are the only waters located south of Yellowbanks Anchorage. For example, catch recorded at Yellowbanks Anchorage could be from a small fishing ground near the northern part of these deep waters, closest to Sandstone Point, and the trappers may not be aware of Sandstone Point as a landmark. Table 11 shows details of the catch data for Map 8.

VI. Applied Analysis: Economic Value of Lobster Catch

Using the *California Commercial Landings* database (DFG, 2003c), we summarized spiny lobster landings for Santa Barbara and all areas of California from 1984 to 2003 (Appendix J). Our key findings are as follows:

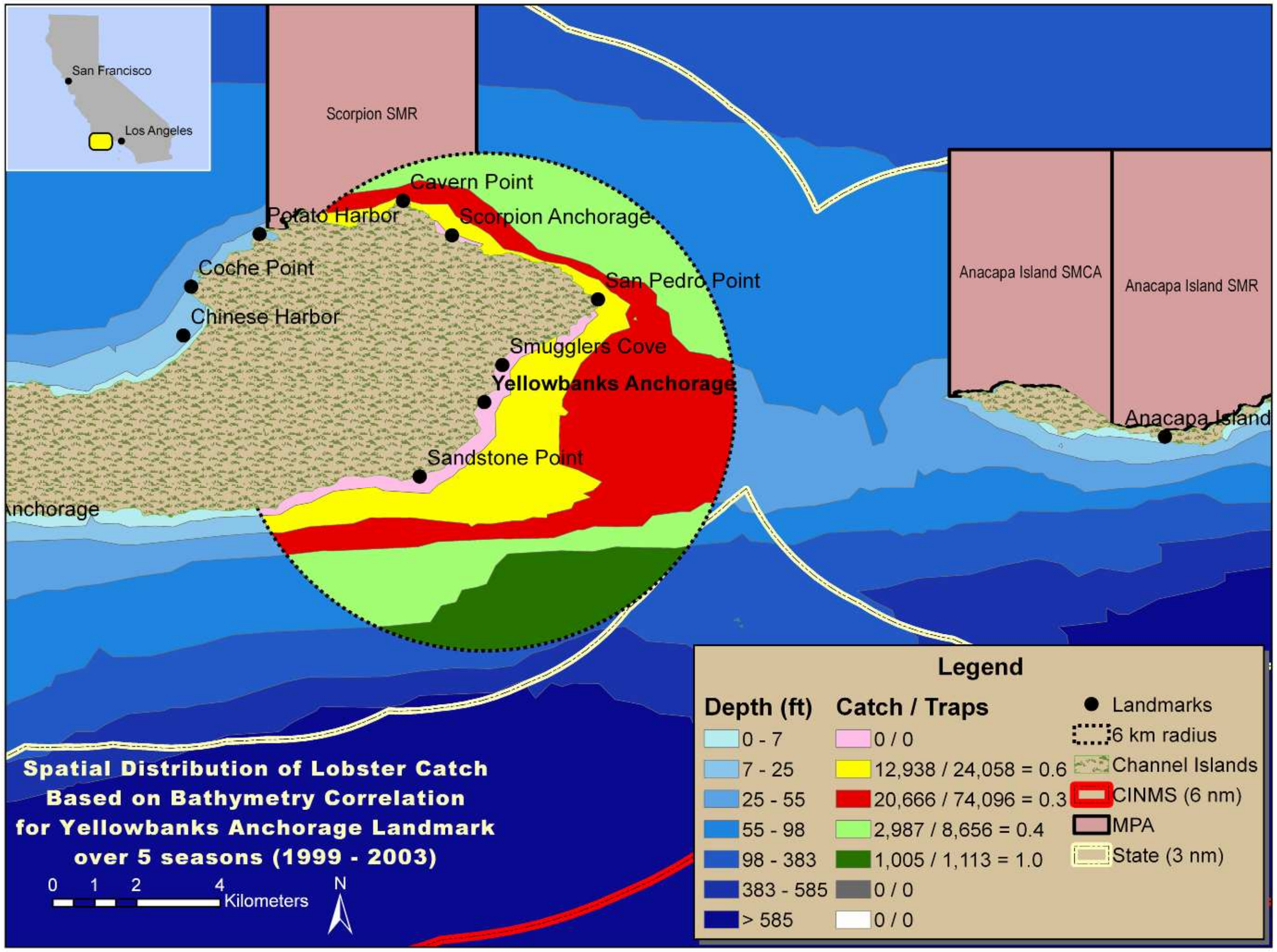
- Santa Barbara is an economically important fishing area compared to Los Angeles and San Diego fishing areas (Appendix J).
- Santa Barbara harbor offers the highest price per pound for lobsters and is used 75% of the time for landings compared to other harbors in the Santa Barbara fishing area.

Finally, we cross-reference the *California Commercial Landings* database (DFG, 2003c) with our historical baseline to provide two novel analyses. First, we show the economic value of our study area in the northern Channel Islands (Map 1) as a proportion of the Santa Barbara regional fishery (Appendix J). Second, we rank landmarks based on economic value, landing weight, catch, and catch performance (Appendix J). These analyses provide a unique perspective on the interplay between economic values and catch data for the Santa Barbara area.



Prepared by D. Hardy, 21-Feb-2005. Projection: NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 7: Spatial Distribution of Lobster Catch for Carrington Point Landmark. Spatial Distribution of Lobster Catch Based on Bathymetry Correlation for Carrington Point Landmark from 1999 - 2003 seasons. The depth ranges align with the catch data; for example, the 25 – 55 ft range has 1,597 lobster catch. Both the total catch and traps are shown, and the catch performance. A 6 km radius is shown to illustrate a potential spatial boundary for the Carrington Point catch. The red, yellow, green represent high, medium, and low catch respectively.



Prepared by D. Hardy, 24-Feb-2005. Projection: NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 8: Spatial Distribution of Lobster Catch for Yellowbanks Anchorage Landmark. Spatial Distribution of Lobster Catch Based on Bathymetry Correlation for Yellowbanks Anchorage Landmark from 1999 - 2003 seasons. The depth ranges align with the catch data. Both the total catch and traps are shown, and the catch performance. A 6 km radius is shown to illustrate a potential spatial boundary for the Yellowbanks Anchorage catch. The red, yellow, green represent high, medium, and low catch respectively.

	Depth (ft)				Catch			Catch Performance		Shorts			Traps		
Category	*Min*	*Max*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*
SHALLOW	7	25	22.31	2.91	951	36.58	34.36	1.02	0.64	497	19.12	31.46	901	34.65	18.46
MODERATE	26	55	41.13	7.92	1,597	34.72	25.15	1.56	4.17	780	16.96	21.67	1,661	36.11	21.24
DEEP	56	98	72.29	11.48	4,508	30.67	27.98	0.87	0.72	2,438	16.59	25.85	5,155	35.07	16.96

Table 10: Lobster Catch correlated with bathymetry at Carrington Point landmark. Catch statistics for Carrington Point, 1999 - 2003 seasons.

	Depth (ft)				Catch			Catch Performance		Shorts			Traps		
Category	*Min*	*Max*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*	*Total*	*Mean*	*StDev*
SHALLOW	7	25	21.42	4.32	12,938	45.40	37.31	0.57	0.43	12,927	45.36	43.24	24,058	84.41	43.80
MODERATE	26	55	35.18	6.16	20,666	35.03	24.51	0.33	0.54	24,013	40.70	27.98	74,096	125.59	47.83
DEEP	56	98	66.91	9.07	2,987	30.48	21.53	0.44	0.32	2,091	21.34	26.90	8,656	88.33	58.92
VERY DEEP	99	300	118.89	42.28	1,005	37.22	18.73	1.02	0.54	738	27.33	17.10	1,113	41.22	23.75

Table 11: Lobster Catch correlated with bathymetry at Yellowbanks Anchorage landmark. Catch statistics for Yellowbanks Anchorage, 1999 - 2003 seasons.

VII. Policy Recommendations

A. Publish historical baseline

We recommend the DFG publish our historical baseline of catch data as a public resource. This report contains the primary content of the historical baseline, such as fine-grain catch data and landmark locations from commercial seasons 1999-2003 (Chapter 4; Appendix F; Appendix I).

The historical baseline also contains electronic data and GIS layers that researchers, trappers, and others may find useful. Our historical baseline of catch data provides resource managers with fine-grain spatial data of lobster catch and provides '*before'* data for future monitoring around the northern Channel Islands.

B. Publish annual lobster logbook reports

We recommend the DFG publish annual reports by (Reid & Ramsay, 2004) summarizing lobster logbook data. The *California Commercial Landings* (DFG, 2003c) reports do not provide the same data as the logbooks.

In our research, the Reid & Ramsay (2004) reports were invaluable for basic catch data and regional comparative analysis, and provide an example of a suitable logbook report. The *California Commercial Landings* reports provide statistics on the number of active fishing participants, the number of lobsters landed during a season across all fishing areas, and the number of lobsters trapped at what depths throughout the months of a season. The summarized information contained in the *California Commercial Landings* reports could be useful for resource managers, researchers, trappers, and others interested in lobster fishery research.

C. Standardize fishing areas

We recommend standardizing fishing areas between commercial lobster logbooks and commercial landing receipts. Lobster logbooks and landing receipts do not define lobster fishing areas in the same manner.

Commercial fishing areas for spiny lobster defined by logbooks in the Southern California Bight include: Los Angeles County Coastal; Orange County Coastal; Northern Channel Islands; San Diego County Coastal; Santa Barbara County Coastal; Southern Islands and Outer Banks; and Ventura County Coastal (Reid & Ramsay, 2004). Commercial fishing areas for spiny lobster defined by landing receipts include: Morro Bay, Santa Barbara, Los Angeles, and San Diego. Within the Santa Barbara fishing area, as defined by commercial landing receipts, harbors include: Santa Barbara, Ventura, and Oxnard/Channel Islands.

The problem arising is that some fishing harbors in the Santa Barbara fishing area designated by landing receipts, fall into other designated fishing areas by commercial logbooks. For example, Ventura and Oxnard/Channel Islands harbors are both considered part of the Santa Barbara fishing area by commercial landing receipts. However, these harbors are located in Ventura County, and thus catch data is aggregated into Ventura County Coastal and other fishing areas other than Santa Barbara in the commercial logbooks. Standardizing fishing areas, or reorganizing categories of catch and landing data would be helpful for future fishery research and management to collect and compare data.

D. Improve logbook processes and data

1. Adopt Gazetteer for landmark naming

We recommend that the DFG adopt our landmark gazetteer for implementation in the logbook form (DFG, 1996a). Standardization of landmark names is a low-cost method for improving the spatial quality of catch data.

To implement this change, the DFG should distribute the gazetteer with its logbook forms, and modify the logbook instructions to indicate that the landmark field should contain the landmarks from the gazetteer where applicable. To encourage compliance, the DFG could replace the existing Landmark field with a Landmark ID field in the form, then label each landmark in the gazetteer with a Landmark ID. The form would need to include an "Other" option (or Landmark ID) for a write-in landmark.

2. Investigate GPS-based logbook data collection

We recommend the DFG investigate GPS-based logbook data collection methods, either via handheld GPS units and/or electronic logbooks. The primary advantages of GPS-based logbook data collection are (a) to augment landmark reporting with significantly more accurate spatial data, (b) to enable finer-grained temporal and spatial data collection, and (c) to enable future spatial analyses on catch data that are not possible with current data.

Modern electronic logbooks provide automated methods for collecting GPS coordinates along with catch data. Handheld GPS units provide the same basic functionality without the automation or expense. Many vendors offer electronic logbook products in domestic and foreign fishery markets (Crocker, 2004; OLRAC, 2002; SHEEL, 2003; Wilson, 2003). Relevant to the DFG on the west coast, NOAA researchers cooperatively developed with the private sector an *Electronic Fish Catch Logbook* (ELCF). In this project, "users interact with ship-based software and a shore-based web application to collect and report logbook, catch (fish ticket), biological sample and observer data" (R. Methot, Ph.D. & Jones, 2004; R. D. Methot et al., 2004).

Maine's Department of Marine Resources (DMR) offers a specific case study in the widespread use of electronic logbooks in a domestic lobster fishery. Between May 2000 and February 2003, trappers with 75 Thistle Marine electronic logbooks reported nearly 1,000,000 lobsters (Wilson, 2003). DMR compares well with DFG on scale; California trappers reported 1,251,847 lobsters caught statewide during the 2000 – 2002 seasons (DFG, 2003d).

3. Investigate additional field data for collection

We recommend collecting additional field data beyond catch and categorization into the legal or sub-legal size to establish more robust estimates of vital rates for each lobster size class. Examples include data on exact size, sex, molt stage, and reproductive characteristics (e.g., presence of eggs). Specifically, sex, reproductive stage, molting stage, and size of each individual lobster along with growth, survival, mortality, and reproductive rates would be the most useful biological information (Chapter 3). We recommend exploring these data as candidates for an additional field in the logbooks.

The DFG may request these data on a cooperative basis, and trappers may find field sampling an excessive burden for their logbook workload. Nonetheless, we consider these data appropriate for an agency to study, even if independently.

4. Improve quality of database management

We recommend improving the quality of the relational database management system for logbooks. Currently, our database is optimized for digitization purposes only and is not able to analyze or query the data to answer research questions. In our project, we created our own data model as have others (Yaremko, 2005) to work with logbook data. Our approach of using a proxy data model would provide researchers with the ability to run flexible queries without requiring them to spend time on database management tasks.

E. Support further research and applications

1. Spatial distribution of catch data for landmarks

We recommend investigating further into the depth data attached to landmarks recorded in logbooks to eliminate areas that do not correlate with known fishing depths (Section Chapter 4:V.C.4). We believe investigating the spatial distribution of lobster catch will provide more information to resource managers, trappers, and researchers interested in future lobster monitoring. The validated catch information will also provide essential fishery information that could be important for a Fishery Management Plan.

2. Extend the baseline

Ideally, a historical baseline data for spiny lobster populations should be as complete as possible, covering large areas of marine territory in the northern Channel Islands over as many years as possible. Our fine-grain historical baseline covers the 1999 – 2003 seasons, but lobster catch data dates back to over 100 years and logbook data back to 1974 (Chapter 1). Extending the historical baseline further back in time would help eliminate uncertainty in future analyses using baseline data.

3. Market value and catch correlations

We recommend further analysis of correlations between catch data and economic value (Appendix J), especially using market values. In particular, market values may better indicate how the catch and catch performance are related to consumer demand. Correlating recorded catch from logbooks and the recorded market value of lobsters sold is another metric that can be used to asses accuracy of logbooks or landing receipts. Large-scale patterns or fluctuations in the commercial scale of lobsters can also be another indicator of the natural population dynamics or environmental factors over time. We recommend using the correlation of catch data and economic value of lobsters to measure changes over time as another source of information for future monitoring.

Chapter 5: Recommendations

CINMS selected our project to help evaluate the CINMS MPAs as stipulated by the MLPA ("MLPA," 1999). Our pilot study sets a collaborative framework for fishery-related evaluation of the MPAs, which is absent from current monitoring strategies. By presenting baseline lobster fishery information and a monitoring plan, our project provides an important service to CINMS and the DFG. We suggest the following recommendations to effectively execute collaborative monitoring of spiny lobster in the CINMS MPAs.

I. Collaboration

Collaborative partnerships provide the most democratic and comprehensive approach to fisheries research by effectively involving multiple stakeholder interests (Karp et al., 2001). We provide the following recommendations for continued collaboration between agencies, trappers, and the scientific community for spiny lobster monitoring in the northern Channel Islands MPAs:

Formulate a Steering Committee

The Steering Committee should have equal representation from each participating group to guide further research. The committee should define the collaborative arrangement, goals, communication strategies, research structure, resource allocation procedures, leadership roles and decision-making process. The Steering Committee should meet before the research begins to discuss stakeholder expectations. In addition, the Steering Committee should identify a conflict resolution leader before the research begins. This individual should be a neutral party who is familiar with the research and trusted by all members of the collaborative.

Sign a contractual Memorandum of Understanding (MOU)

Research participants should draft and sign an MOU before the onset of the project to formalize the research agreement among parties before the project begins. The MOU will help ensure that members of each participating group are involved through the entirety of the project. The MOU should be a contractual agreement that is witnessed by the conflict resolution leader, or another third party.

Maintain focus on the collaborative relationship

Throughout the project all members should remain focused on the collaborative relationship. Without a strong base and trust among the parties involved, successful collaborative research is impossible.

Organize a formal fishery cooperative among the Santa Barbara trappers

This cooperative or association should have broad participation from local trappers. A representative from the association should serve as an industry leader within the Bren-Lobster Collaborative.

Incorporating these recommendations into future research partnerships will help create a solid collaborative alliance. A strong partnership will help increase the effectiveness of this project and set the stage for future collaboration among industry, scientists, and governmental agencies.

II. Pilot Study

There exists a shared objective between researchers, agencies, and lobster trappers to assess the effects of MPAs on lobster demographics and behavior in the northern Channel Islands region and evaluate the potential for spillover from within reserves to surrounding fished areas. To meet this objective, we developed a detailed pilot study as an initial step toward the creation of a long-term monitoring program.

To create the most effective long-term monitoring plan, we propose the following recommendations:

Implement pilot study

In collaboration with local lobster fishermen and scientists, a governmental agency should implement a pilot study using the methods outlined in Chapter 3. These methods will help to refine and optimize the sampling methodology for a long-term monitoring program and establish baseline population data to identify essential fishery information for spiny lobsters in the northern Channel Islands. This pilot study should be carried out as soon as possible to capture changes in lobster demographics immediately following the implementation of the reserves.

Assess data using statistical analyses

We recommend statistically analyzing this data with a nested 3-way ANOVA design to assess the mean value and variance of abundance, size distribution, sex ratio, and fecundity of lobster populations at gradient locations within, near and far from the sampled reserves. Results of the pilot study should also be used in a power analysis to refine the necessary number of sample sites and replicates for the long-term monitoring plan.

We further recommend performing the following activities if resources permit to refine the pilot study data and methodology:

Ground truth sampling sites

Ground truth selected sampling sites to confirm site suitability, ensure lobster habitat is similar between sampling locations, and identify the significant variables between sites (i.e., substrate type, presence of rocky reefs/boulders, density of kelp and/or urchins, and proximity to sandy bottom foraging areas (John M. Engle, 2004)).

Refine sampling sites using habitat maps

Use data from NOAA, PISCO, and NPS monitoring datasets to create GIS layers for use in selecting suitable habitats. Data should include key ecological criteria for lobster viability, including, but not limited to: bathymetry, sediment type classification, presence of kelp and/or urchins, and temperature (a vertical profile within the water column). Use GIS tools to generate habitat maps and mulicriteria evaluation to identify optimal habitat sites.

III. Analysis of Commercial Logbooks

Our logbook analyses provide historical catch information that can be used as baseline for future lobster monitoring in the CINMS MPAs. The commercial lobster logbooks provide previously unexplored landmark data. We reviewed 5 seasons (1999-2003) of logbook paperwork and recorded the trap locations as landmarks for the catch and catch performance data. Our results include a historical baseline of catch and catch performance with improved spatial resolution, a landmark gazetteer, and an applied analysis of the economic value of catch (Appendix K).

The key recommendations from our logbook analysis (Chapter 4) are:

Publish historical baseline and annual lobster logbook reports

The DFG should consider publishing our historical baseline data and annual lobster logbook reports as public resources. This baseline provides resource managers with 'before' data for future monitoring around the northern Channel Islands, while the annual lobster logbook reports provide statistics about the fishery.

Adopt gazetteer for landmark naming

The DFG should explore adopting the landmark gazetteer for its logbook form (DFG, 1996a). Standardizing landmark names is a low-cost method for improving the spatial quality of the catch data.

Investigate GPS-based logbook data collection

The DFG should investigate GPS-based logbook data collection methods, via handheld GPS units and/or electronic logbooks. The primary advantages for GPS-based logbook data collection are (a) to augment the landmark reporting with significantly more accurate spatial data, and (b) to enable future collaborative data collection efforts and analyses on fine grain time and spatial scales.

Glossary

Table 12: Acryonms.

Acronym	Definition	Source
ANCOVA	Analysis of Covariance	
ANOVA	Analysis of Variance	
CINMS	Channel Islands National Marine Sanctuary	www.cinms.nos.noaa.gov
COMPASS	Communication Partnership for Science and the Sea	www.compassonline.org/
CPUE	Catch Per Unit Effort	
DFG	California Department of Fish and Game	www.dfg.ca.gov
GIS	Geographic Information System	
GNIS	Geographic Names Information System	geonames.usgs.gov/
MLMA	Marine Life Management Act	www.dfg.ca.gov/mrd/mlma/
MLPA	Marine Life Protection Act	www.dfg.ca.gov/mrd/mlpa/
MOU	Memorandum of Understanding	
MPA	Marine Protected Area	
MSC	Marine Stewardship Council	www.msc.org
NCEAS	National Center for Ecological Analysis and Synthesis	www.nceas.ucsb.edu/
NMFS	National Marine Fisheries Service	www.nmfs.noaa.gov
NOAA	National Oceanic and Atmospheric Administration	
PISCO	Partnership of Interdisciplinary Studies of Coastal Oceans	www.piscoweb.org/
SCUBA	Self-Contained Underwater Breathing Apparatus	
SMR	State Marine Reserve	
UCSB	University of California, Santa Barbara	
UNH	University of New Hampshire	
USGS	United States Geological Survey	www.usgs.gov

Table 13: Glossary of Terms.

TERM	DEFINITION	SOURCE
Berried	Female lobsters carrying fertile eggs.	
Bren-Lobster Collaborative	Bren researchers and Santa Barbara lobster trappers working collectively to design a monitoring program for spiny lobster in the northern Channel Islands MPAs	
Carapace	The hard shell covering the body of a lobster, measured from behind the eye socket to the rear of the main shell to ensure it is of legal size.	www.theworldwidegourmet.com/fish/lobster/glossary.htm
Catch	The number of legal lobsters caught. The DFG defines lobsters as legal when the carapace length is greater than 3 1/4 inches.	Preferred terminology
Catch Per Unit Effort (CPUE)	A measure of catch performance using fishing effort, such as time and cost, as its basis. Typically, effort is a combination of gear type, gear size, and the length of time that the gear is used (e.g., catch/tow or catch/hour for a trawl). CPUE is often used as a measurement of relative abundance.	http://www.orangeroughynz.com/glossary.html
Catch Performance	Number of legal lobsters caught per trap -- typically, reported as a mean.	Preferred terminology
Collaboration	Working together in a joint-intellectual effort	
Colloquia landmark name	Landmarks not recognizable by standard maps but used by trappers	
Compensatory Fishing	Fishermen are allowed to fish after research in a closed area or during a seasonal closure is completed, and sell their catch for compensation to offset research costs	Karp et al, 2001
Composite landmark name	Name consisting of more than one landmark describing the area of fishing effort	
Cooperation	An association of persons or businesses for common, usually economic, benefit	SeaGrant, 2005
DFG Block	An area of ocean off the California coast used for reporting catch and other data to the DFG. Most blocks cover a 10 x 10 minute area, and all blocks are identified by a 3- or 4- digit number.	http://www.dfg.ca.gov/itbweb/gis/mr_gov_units.htm

TERM	DEFINITION	SOURCE
Fishery	A unit determined by an authority or other entity that is engaged in raising and/or harvesting fish. Typically, the unit is defined in terms of some or all of the following: people involved, species or type of fish, area of water or seabed, method of fishing, class of boats and purpose of the activities.	http://www.fao.org/fi/glossary/default.asp
Fishing industry	Includes both recreational, subsistence and commercial fishing, and the harvesting, processing, and marketing sectors.	http://www.fao.org/fi/glossary/default.asp
Gazetteer	A dictionary of geographical information and data about places. In this report, the landmark gazetteer includes at least geographic location, type, and numbers of variant DFG blocks and names for each official landmark.	
Geographic Names Information System	The Geographic Names Information System, developed by the USGS in cooperation with the U.S. Board on Geographic Names (BGN), contains information for almost 2 million physical and cultural geographic features in the United States and its territories.	http://geonames.usgs.gov/
Gradient location	Used to describe a sampling area along a gradient at three locations with suitable lobster habitat: (a) at a treatment area within the MPA (i.e., within), (b) a control area at the edge of the MPA (i.e., near), and (c) a control area at least two kilometers from the MPA (i.e., far).	
Landmark	A conspicuous object, natural or man-made, located near or on land, which aids in fixing the position of an observer.	
Legals	No spiny lobster less than three and one-quarter inches (82.5 mm) in length (of carapace) measured in a straight line from the rear edge of the eye socket to the rear edge of the body shell, both points to be on the midline of the back, may be taken, possessed, purchased or sold. The term "legals" is used throughout this report, referring to the legal size.	Fish and Game Code and Title 14, California Code of Regulations Part 2, Section 8252; http://www.dfg.ca.gov/licensing/pdffiles/2005CommercialDigestPages50-81.pdf
Lobster fishery	California spiny lobster fishery in the northern Channel Islands unless stated otherwise. See fishery.	Preferred terminology
Lobster industry	Used interchangeably with Lobster fishery.	Preferred terminology

TERM	DEFINITION	SOURCE
Local Ecological Knowledge	The body of knowledge held by a specific group of people about their local ecosystem	Scholz, 2003
Marine Protected Area (MPA)	Any area of the marine environment that has been reserved by Federal, State, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein. Used interchangeably with marine reserve throughout this report.	www.coris.noaa.gov/glossary/glossary_l_z.html
Marine Reserve	An area of the sea which is completely protected from all extractive activities. Within a reserve, biological resources are generally protected through prohibitions on fishing and the removal or disturbance of living and non-living marine resources, except as necessary for monitoring or research to evaluate reserve effectiveness. Marine reserves are a special category of marine protected areas (see above).	research.amnh.org/biodiversity/symposia/archives/seascapes/glossary.html
Mark-recapture	The tagging and releasing of fish to be recaptured later in their life cycles. These studies are used to study fish movement, migration, mortality, and growth, and to estimate population size.	www.ncfisheries.net/stocks/defsl_n.htm
Monitoring plan	A long-term plan to monitor the effects of MPAs on lobster population demographics and behavior.	Preferred terminology
Multicriteria Evaluation	Evaluating a set of alternatives on the basis of conflicting criteria.	Malczewski, Jacek.
Official Landmarks	A list of landmarks identified by Bren students and deemed as the official name.	
Off-season	The time of year when the lobster fishery is closed for commericial fishing, from mid-March to early October.	
Pilot study	The initial study examining a new method or treatment.	www.stjude.org/glossary
Power Analysis	Compute power of test, or determine parameters to obtain target power. (See statistical power.)	R Software help index
Replicate	Repeated sampling effort within a specified period of time.	Preferred terminology

TERM	DEFINITION	SOURCE
Sea Grant	Sea Grant is a nationwide network (administered through the National Oceanic and Atmospheric Administration [NOAA]), of 30 university-based programs that work with coastal communities to promote better understanding, conservation and use of America's coastal resources.	http://www.nsgo.seagrant.org/aboutsg/aboutsg.html
Season Year	The year in which a fishing season ended. For example, the lobster season of October 2003 through March 2004 has a "Season Year" of 2004.	Preferred terminology
Set of traps	Commercial lobster traps placed in the water at varying distances from each other for fishing connected by one rope.	
Setose	Female lobsters with long fine hair-like filaments, or setae, underneath their tails. The 'hair' grows on the inner forked structures (endopodites) which form part of their swimmerets. This is one sign that females are ready to spawn.	http://www.fish.wa.gov.au/rec/broc/rocklob/rlsetose.html
Shorts	Lobsters under the legal limit of 82.5 mm carapace length, as defined by the DFG.	
Southern California Bight	A 300 km long bend in California's coastline between Point Conception in Santa Barbara County and Cabo Colnett, in Baja Mexico.	http://www.sccwrp.org/regional/94scbpp/exesumry/exesum.htm
Spermatophore	During mating, the male transfers a spermatophore to the female. Males of the spiny and slipper lobsters plaster the spermatophore to the outside of the hard-shelled female's abdomen, where it darkens and becomes known as the "tar".	http://www.lobsters.org/tlcbio/biology5.html
Spillover	The export of larvae and adult organisms from within MPAs to fished areas. Only refers to adult and juvenile lobsters in this report because lobster larval dispersal processes are unknown.	
Statistical Effect Size	A statistical effect expressed in convenient standardized units. For example, the standardized effect in a 2 Sample t-test is the difference between the two means, divided by the standard deviation.	http://www.statsoft.com/textbook/gloss.html#Statistical%20Power
Statistical Power	The probability of rejecting a false statistical null hypothesis. (The lower the alpha (see Type 1 Error Rate), the higher the power.) Ideally, power should be at least .80 to detect a reasonable departure from the null hypothesis.	http://www.statsoft.com/textbook/gloss.html#Statistical%20Power

TERM	DEFINITION	SOURCE
Strata	Areas of habitat known to be suitable for sampling.	
Stratified random sampling	Random sampling within strata, or areas of known suitable habitat that share the same characteristics.	http://www.statpac.com/surveys/sampling.htm
Total Allowable Catch	The amount of fish of a particular species that can be taken from a fishery in defined time period or fishing season	www.afma.gov.au/reports/annual%20report%201999-2000/glossary.php
Trap-and-Tag	See Mark-recapture.	
Trapper	A person who catches lobster using traps. In this report, we refer to lobster trappers of the northern Channel Islands.	Preferred terminology
Trapping event	A single line in commercial logbooks, or an event where traps from the same location are hauled on the same exact date.	
Type 1 Error Rate (alpha)	The probability of incorrectly rejecting a true statistical null hypothesis.	http://www.statsoft.com/textbook/gloss.html#Statistical%20Power
Variant landmark names	Non-standard names for landmarks. Some variant names are recognized by governmental agencies, such as the USGS and some variant names are not recognized.	

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Appendix A: Collaborative Parties

The Bren-Lobster Collaborative consists of a core group intimately involved in the research project, as well as other peripheral parties. The core group, referred to as the Bren-Lobster Collaborative, includes Bren researchers, Santa Barbara lobster trappers, and Sea Grant representatives. Peripheral to the Bren-Lobster Collaborative are parties that act as consultants to the core group; these include: DFG and CINMS representatives, UCSB researchers, USC researchers, and other researchers. The peripheral parties are not involved in the daily research tasks of the core group, but are called on by members of the Bren-Lobster Collaborative when their expertise is needed.

I. Core Group

A. Santa Barbara Lobster Trappers

1. Background

The Santa Barbara lobster trappers fish from October to March. They fish in an area extending from Ventura to Point Conception along the mainland coast, and around the northern Channel Islands offshore.

2. Individual Collaborators within party

(i) Chris Miller, Vice President California Lobster and Trap Fisherman's Association
(ii) John Becker, lobster trapper
(iii) Mark Becker, lobster trapper
(iv) Ken Bortelozzo, lobster trapper
(v) Ray Kennedy, lobster trapper
(vi) Stanley Davis, lobster trapper
(vii) Scott Jarvis, lobster trapper
(viii) Jerry Peters, lobster trapper
(ix) Nick Voss, lobster trapper

B. Bren School of Environmental Science and Management

1. Mission

The mission of the Bren school is "to play a leading role in researching environmental issues, identifying and solving environmental problems, and training research scientists and environmental management professionals" (2005).

2. Responsibilities

Student researchers from the Bren school are responsible for coordinating, directing, and implementing this program, while Bren faculty serve as advisors to the student researchers.

3. Background

In 1991, the Regents of the University of California established the School of Environmental Science & Management at UC Santa Barbara in response to a report issued by the state of California declaring the increasing need for trained environmental professionals. The program provides an interdisciplinary education that focuses on both natural and social sciences, preparing graduate students for careers in environmental problem-solving. The school opened to master's students in the fall of 1996, and PhD students in the fall of 1998 (2005).

4. Individual Collaborators within party

- *(i) Dr. Hunter Lenihan, Advisor*
- *(ii) Dr. James Frew, Advisor*
- *(iii) Sarah Abramson, master's candidate*
- *(iv) Christina Cairns, master's candidate*
- *(v) Katie DeLeuw, master's candidate*
- *(vi) Sofia Hamrin, master's candidate*
- *(vii) Darren Hardy, master's candidate*
- *(viii) Matt Kay, research technician*

II. Peripheral Parties

A. The California Department of Fish and Game (DFG), Marine Region, Santa Barbara

1. Mission

The division of the DFG along California's coast is known as the Marine Region. The mission of the Marine Region is to protect, maintain, enhance, and restore California's marine ecosystems for their ecological values and their use and enjoyment by the public (2005).

2. Responsibilities of the Marine Region

Responsibilities of the Marine Region include managing and protecting California's marine resources under the authority of laws and regulations created by the State Legislature, the Fish and Game Commission, and the Pacific Fishery Management Council (2005).

3. Background

The Marine Region was established in November 1997, resulting from planning actions in the mid-1990s by the DFG to increase its effectiveness. The Marine Region is a unique area within the DFG because it has dual responsibility for both policy and operational issues within the state waters. It was created with the goal of improving marine resources management by integrating law enforcement functions, fisheries and habitat programs, environmental review, and water quality monitoring. The marine region is designed to help the DFG foster effective, inclusive, comprehensive, and collaborative marine management (2005).

4. Individual Collaborators within party

- *(i) John Ugoretz, Senior Marine Biologist*
- *(ii) Kristine Barsky, Marine Invertebrate Specialist*

B. The Channel Islands National Marine Sanctuary (CINMS)

1. Mission of CINMS

The mission of NOAA's National Marine Sanctuary Program is to conserve, protect, and enhance the biodiversity, ecological integrity and cultural legacy of our nation's waters (2005).

2. Responsibilities of CINMS

Sanctuary management includes research, public education, and resource protection, specifically improving the general understanding of related resources, and promoting wise resource use (2005).

3. Background

Recognizing the ecological and anthropological importance of the California Channel Islands and need for protection, a 1,252-square-nautical-mile portion of the Santa Barbara Channel, the CINMS was designated in 1980 under the National Marine Sanctuaries Act. CINMS is an area of national significance because of its extraordinary natural beauty and diversity of resources. It encompasses the waters surrounding Anacapa, Santa Cruz, Santa Rosa, San Miguel and Santa Barbara Islands, extending from the mean high tide line to six nautical miles offshore around each of the five islands.

4. Individual Collaborators within party

(i) Sean Hastings, Resource Protection Coordinator
(ii) Satie Airame, Scientific Advisor

C. University of Southern California (USC) Wrigley Marine Science Center

1. Mission

The mission of the USC Wrigley Institute is "to encourage responsible and creative decisions in society by providing an objective source of marine and environmental science and fostering an understanding of the natural world among people of all ages" (2005).

2. Responsibilities

Dr. Kathy Ann Miller's research examines the effects of two different marine reserve designs on spiny lobster populations at Catalina Island, through a mark-and-recapture trap-and-tag study (Iacchei et al., 2003). As collaborators, the researchers at the Wrigley Institute helped advise Bren researchers on experimental methods and trapper collaboration.

3. Background

In 1965, USC created a marine lab on Catalina Island, now known as the Wrigley Marine Science Center. The Wrigley Institute was created to unify and advance USC's efforts in environmental education and research. It acts as a headquarters for researchers from diverse backgrounds to come together and work to understand and solve today's environmental problems, as well as prepare for future issues. The Institute promotes communication of research findings between researchers and the public (2005).

4. Individual Collaborators within Party

- *(i) Matthew Iacchei, researcher*
- *(ii) Patrick Robinson, researcher*

D. California Sea Grant researchers

1. Mission

California Sea Grant is dedicated to enhancing the understanding, conservation, and sustainable use of California's coastal and marine resources (2005).

2. Responsibilities

The Sea Grant Marine Advisors form a direct link for communication between the university, industry, and the public. By sponsoring research Sea Grant contributes to the growing body of knowledge about coastal and marine resources and helps solve contemporary marine-related problems. Through its Extension and Communications programs, information about research and new technologies are communicated to industry, government, and the public (2005). In this project, the Sea Grant Advisor is providing research advice and helping foster communications between industry, researchers, and government.

3. Background

Sea Grant's parent organization, NOAA, designated the University of California as an official Sea Grant "College Program" in 1973. California was the nation's seventh Sea Grant College and is now the largest. The primary goal of Sea Grant is to understand how to best use the ocean while preserving it – a difficult and delicate balancing act (2005).

4. Individual Collaborators within Party

- *(i) Dr. John Richards, Marine Advisor Emeritus, California Sea Grant Extension Program, Santa Barbara*
- *(ii) Carrie Culver, Marine Advisor, California Sea Grant Extension Program, Santa Barbara*

Appendix B: Collaborative Events

I. Working session meetings with trappers

Collaboration with local lobster trappers began with two introductory meetings at the Waterfront Center Community Meeting Room in May 2004. These informal working sessions were held with 5 veteran trappers: Chris Miller, Kenny Bortolozzo, Ray Kennedy/Stanley Davis, Mark Becker, and John Becker. At the working sessions, we shared the goals, objectives, and basic approach of our project with the trappers and in turn received from them identification of effective locations for lobster sampling sites based on their local knowledge and feedback regarding there interests in a monitoring plan. Through these informal sessions, we established initial relationships with local lobster trappers to encourage their participation and facilitate information sharing between stakeholders in the future.

II. Visit to the Wrigley Marine Science Center

On the weekend of May 14-16, 2004 the Bren master's candidates traveled to the USC Wrigley Marine Science Center. During the visit we worked with Matthew Iacchei and Patrick Robinson, two researchers conducting a lobster monitoring program examining movement and lobster demographics in fished and unfished areas surrounding Catalina Island under the direction of Kathy Ann Miller. We spent the weekend learning about, observing, and assisting with their study. We each gained experience with tagging lobster and collecting data including size, sex, fecundity (presence of spermatophores/eggs), and other observations about the lobster. This trip was valuable because we learned their methodology and hope to follow it as close as possible with our study so the results are comparable in the future. The connection we formed with these researchers gives a basis for future collaboration.

III. External Review

Our master's project External Review was held on June 14, 2004 at UCSB. The review team consisted of a broad panel of state and federal government staff marine scientists, UCSB researchers, USC researchers, and lobster trappers convening to discuss our research. Attendees included Satie Airame, Sarah Fangman, Sean Hastings, John Ugoretz, Kristine Barsky, David Kushner, Dan Reed, Hunter Lenihan, Bruce Kendall, Andy Brooks, Ken Bortolazzo, Stanley Davis, John Becker, and Chris Miller.

The meeting was a conduit for comments, questions, and advice concerning our project proposal. The combination of education, intelligence, and experience of attendees provided insightful feedback about the scope, research questions, and experimental design of our project. In addition, this meeting served as a preliminary collaborative effort between interested stakeholders, setting the stage for future monitoring collaboration.

IV. Post-Summer update meeting

After a summer dedicated to developing a database and gathering information from DFG lobster logbooks to provide baseline information about the lobster fishery before establishment of the MPAs, we reconvened with 5 trappers (Chris Miller, Kenny Bortolozzo, Nick Voss?, Jerry Peters?, and John Becker) and John Richards, a SeaGrant Marine Advisor Emeritus to provide a project update. We met at the home of John Becker, a local lobster trapper, on 21 September 2004. Again, we opened up the table for comments about what their goals and objectives associated with our project. The trappers were supportive our research, and willing to help. At this meeting trappers suggested conducting interviews with members of the fishery, conducting port sampling, and looking at coastal catch in addition to catch from the northern Channel Islands. We also discussed the issues of insurance and licensing associated with having researchers onboard commercial fishing vessels. A few of the trappers who would like to be involved in the implementation of the collaborative monitoring study have already begun to update their license to a 6-pack, which is necessary for boats taking researchers on board.

V. Harbor visits for observation of the landing process

Bren master's students visited Santa Barbara harbor on 18 October 2004 during the second week of the lobster season to observe the landing process - what happens to the lobster after they are brought to the harbor - and observe the exchange of lobster between trapper and receiver. During this visit we took photos of local trappers' (John Becker and Chris Miller) boats and catch, as well as the landing process.

VI. Mid-Quarter Presentation

The Mid-Quarter Presentation was an informative session held on 5 November 2004 at Bren. The objective of this presentation was to inform 1st year Bren master's students about our thesis project and update faculty and stakeholders about our project. Feedback regarding our research was offered by Bren staff, faculty, and students.

VII. Meeting to discuss future collaboration and port sampling

We met with John Richards and Hunter Lenihan's technician, Matt Kay on 8 October 2004 to discuss the future of our research. It was suggested that we conduct port sampling of lobster catch to identify demographic variability between lobster at island and mainland fishing areas. Both trappers and researchers are willing to participate in port sampling. Chris Miller and Matt Kay agreed to coordinate the port sampling schedule and inform the participating trappers of the procedures. Bren researchers will create a data sheet, organize a sampling team, and gather the tools necessary for the research. We also discussed the potential for future Bren master's students or other researchers to continue this research project, and strategies to ensure project continuation.

VIII. Port Sampling

Between November 2004 and February 2005 Bren master's students, John Richard and Matt Kay sampled lobster landings from Chris Miller, Nick Voss, and ??? at the Santa Barbara Harbor to get a general idea of the variation in lobster demographics between northern Channel Islands sites and the mainland. Islands were divided into multiple sections (3-5 depending on the island) to gain a somewhat spatial resolution. This preliminary sampling serves as a method of familiarizing the trappers with our study and providing them with some data regarding their catch that may be used for future fisheries analyses. Following this preliminary project, researchers will be able to make procedural recommendations for future port sampling.

Appendix C: Pilot Study Agenda

February

- Begin Project Organization
- Review guidelines for pilot study framework
- Assemble equipment for field research
- Assess cooperative effort by fishers to aid project

April

- Conduct field training on data collection techniques

May

- Conclude logistical coordination of research vessels, monitoring equipment, and stakeholder participation

June *(Exact dates depend on moon phase)*

- Begin first sampling round of field research
- Complete first round of field research

September *(Exact dates depend on moon phase)*

- Begin second sampling round to detect changes in population and size frequency after molting period
- Conclude second and final round of field research- lobster season opens October 1st

November

- Review and synthesize field data and organize findings
- Collect outstanding data from participating trappers
- Data Analysis- Analyze and interpret collected data
- Review variance in information to assure future monitoring methods are effective

December

- Create database through public and/or private collaboration (may outsource)
- Prepare policy and management recommendations for lobster industry, CINMS, DFG.

Appendix D: Pilot Study Datasheet

Lobster Field Sampling Datasheet

Date: ____________________
Boat: ____________________
Trapper/s: ____________________
Name of Recorder: ____________________
Name of Measurer: ____________________
MPA: ____________________
Gradient Location (Landmark): ____________________
Sample Block # (DFG): ____________________

Trap Location (GPS Coords)______________

Depth (m) _________

Lobster Tag #	Carapace Length (mm)	Gender (M,F)	Eggs, Spermataphore (E,S)	Injury (Y,N)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				

Total Lobsters Per Trap:
 # Lobsters Tagged:
 # Recaptured Lobsters:

Trap Location (GPS Coords)______________

Depth (m) _________

Lobster Tag #	Carapace Length (mm)	Gender (M,F)	Eggs, Spermataphore (E,S)	Injury (Y,N)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				

Total Lobsters Per Trap:
 # Lobsters Tagged:
 # Recaptured Lobsters:

Total Lobsters Per Gradient Location:

Comments: (Bycatch, Temp. at 10 m, Wind direction and speed, Swell direction and height)

Field Sampling, 3/17/05, ccairns

Appendix E: Pilot Study Power Analysis

I. Description of Power Analysis

Compute power of test, or determine parameters to obtain target power.

II. Usage

```
> power.t.test(n=NULL, delta=NULL, sd=1, sig.level=0.05,
power=NULL, type=c("two.sample", "one.sample", "paired"),
alternative=c("two.sided", "one.sided"), strict=FALSE)
```

Arguments	
n	Number of observations (per group)
delta	True difference in means
sd	Standard deviation
sig.level	Significance level (Type I error probability)
power	Power of test (1 minus Type II error probability)
type	Type of t test
alternative	One- or two-sided test
strict	Use strict interpretation in two-sided case

III. 'R' Code

The following is an implementation using the statistical package R (www.r-project.org).

```
> power.t.test(delta=1,sd=1,power=.9,alt="one.sided")

     Two-sample t test power calculation
              n = 17.84713
          delta = 1
             sd = 1
      sig.level = 0.05
          power = 0.9
    alternative = one.sided

 NOTE: n is number in *each* group

> power.t.test(delta=1,sd=1,n=5:20,alt="one.sided")

     Two-sample t test power calculation

              n =  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
17, 18, 19, 20
          delta = 1
```

```
             sd = 1
      sig.level = 0.05
          power = 0.4214483, 0.4875761, 0.5474497, 0.6014906,
0.6500703, 0.6935575, 0.7323267, 0.7667561, 0.7972207, 0.8240859,
0.8477025, 0.8684025, 0.8864966, 0.9022725, 0.9159942, 0.9279025
    alternative = one.sided

 NOTE: n is number in *each* group

> x<-power.t.test(delta=1,sd=1,n=5:20,alt="one.sided")
> names(x)
[1] "n"           "delta"       "sd"          "sig.level"
"power"
[6] "alternative" "note"        "method"
> plot(x$n,x$power)
```

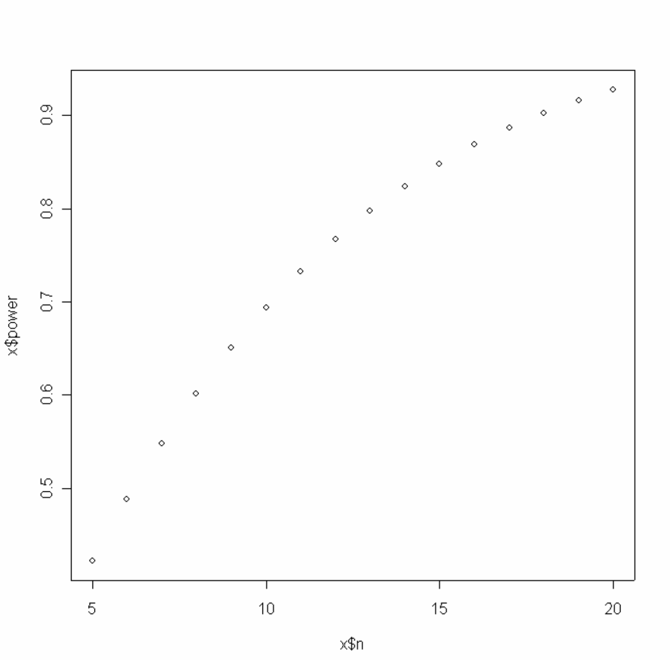

Figure 24: Required Number of Traps for Desired Power. The necessary number of traps for each level of power desired (delta=1, sd=1, n=5:20, type of test="one.sided").

```
> x <- power.t.test(delta=(1:20)/10,sd=1,n=18,alt="one.sided")
> plot(x$delta,x$power)
```

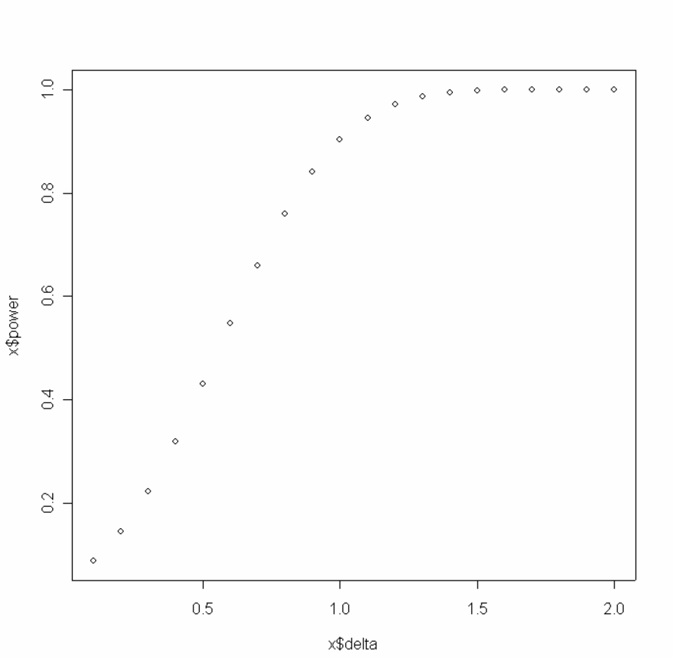

Figure 25: Expected Measure of Delta for Desired Power. The expected difference in number of lobster trapped between trap sites for each level of power desired (delta=1 to 20, sd=1, n=18, type of test="one.sided").

```
> x1 <- power.t.test(delta=1,sd=1:8,n=18,alt="one.sided")
> plot(x1$sd,x1$power)
```

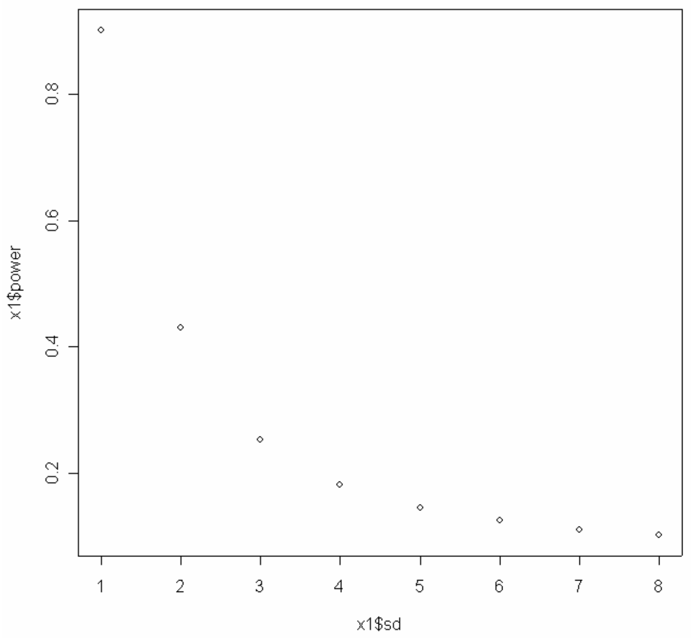

Figure 26: Expected Measure of Standard Deviation for Desired Power. The expected standard deviation from the mean number of lobster trapped in each trapping event versus each level of power desired (delta=1, sd=1 to 8, n=18, type of test="one.sided").

Appendix F: Pilot Study Budget and Equipment Sources

We created four different budgets based on the number of boats available to researchers and whether researchers would be buying all equipment or borrowing some equipment from local lobster trappers. Total budgets include all tagging and trapping equipment, boat charter and equipment, and additional costs (e.g., permits). Varying these factors results in total budgets ranging from approximately $29,500 to $50,100.

I. One Boat; Buying Equipment

In this scenario, researchers only have access to one boat, which would be chartered for 12 consecutive nights in each of two sampling periods. This budget accounts for all traps and ropes that researchers must purchase if they cannot borrow this equipment from trappers, as well as the cost of renting a UCSB boat to haul traps back from the islands or pay trappers to bring traps back.

Table 14: Pilot study budget scenario for one boat and buying all equipment.

Equipment	Individual cost	Amount	Total cost
Floy tags	$ 0.43	1000	$ 425.00
Tagging guns	$ 58.00	3	$ 174.00
Extra needles	$ 12.00	6	$ 72.00
Charge for cost less than $1000 order	$ 50.00	1	$ 50.00
U.S. Customs Charge	$ 50.00	1	$ 50.00
		Subtotal	$ 771.00
Buoys (floats)	$ 4.31	120	$ 517.20
Mesh for trap mending/closures	$ 2.02	12	$ 24.24
6.5% sales tax (for WA)	N/A	N/A	$ 35.19
Shipping and Handling	N/A	N/A	$ 12.00
		Subtotal	$ 588.63
Vernier Calipers	$ 50.00	2	$ 100.00
Traps	$ 98.99	90	$ 8,909.10
Ropes	$ 0.19	16732	$ 9,808.43
		Subtotal	$ 18,817.53
		Subtotal Equipment	$ 20,177.17

Boat	Individual cost (per day)	Sample Period	Sample days	Number of Boats	Total cost
Charter	$ 800.00	2	12	1	$ 19,200.00
Gas	$ 100.00	2	12	1	$ 2,400.00
Bait	$ 50.00	2	12	1	$ 1,200.00
Misc. costs (repair or replace equipment)	$ 300.00	2	N/A	N/A	$ 600.00
Cost for hauling traps out to the Islands	$ 162.80	2	1	1	$ 325.60
Cost for hauling traps back from the Islands	$ 162.80	2	1	1	$ 325.60
SCUBA ground-truthing	$ 510.80	N/A	8	1	$ 4,086.40
				Subtotal Boats	$ 28,137.60

Additional	Individual cost	Individual Number	Number of Weeks	Total cost
GPS (cost per week)	$ 100.00	1	2	$ 200.00
DFG Permit	$ 16.25	2	N/A	$ 32.50
			Subtotal Additionals	$ 232.50
			Working Grand Total	$ 48,547.27

II. One Boat; Borrowing Equipment

This budget shows the costs associated with one boat available to researchers and the use of major equipment by borrowing from trappers. In this scenario, costs from buying traps, buying ropes, and hauling traps back from the islands are removed. Researchers can use the trappers' traps and ropes, and the cost of bringing traps back to the mainland at the end of the sampling period has been folded into the charter cost for the day.

Table 15: Pilot study budget scenario for one boat and borrowing major equipment (e.g., traps, rope) from trappers.

Equipment	Individual cost	Amount	Total cost
Floy tags	$ 0.43	1000	$ 425.00
Tagging guns	$ 58.00	3	$ 174.00
Extra needles	$ 12.00	6	$ 72.00
Charge for cost less than $1000 order	$ 50.00	1	$ 50.00
U.S. Customs Charge	$ 50.00	1	$ 50.00
		Subtotal	$ 771.00
Buoys (floats)	$ 4.31	120	$ 517.20
Mesh for trap mending/closures	$ 2.02	12	$ 24.24
6.5% sales tax (for WA)	N/A	N/A	$ 35.19
Shipping and Handling	N/A	N/A	$ 12.00
		Subtotal	$ 588.63
Vernier Calipers	$ 50.00	2	$ 100.00
		Subtotal	$ 100.00
		Subtotal Equipment	$ 1,459.63

Boat	Individual cost (per day)	Sample Period	Sample days	Number of Boats	Total cost
Charter	$ 800.00	2	12	1	$ 19,200.00
Gas	$ 100.00	2	12	1	$ 2,400.00
Bait	$ 50.00	2	12	1	$ 1,200.00
Misc. costs (repair or replace equipment)	$ 300.00	2	N/A	N/A	$ 600.00
Cost for hauling traps out to the Islands	$ 162.80	2	1	1	$ 325.60
SCUBA ground-truthing	$ 510.80	N/A	8	1	$ 4,086.40
				Subtotal Boats	$ 27,812.00

Additional	Individual cost	Individual Number	Number of Weeks	Total cost
GPS (cost per week)	$ 100.00	1	2	$ 200.00
DFG Permit	$ 16.25	2	N/A	$ 32.50
			Subtotal Additionals	$ 232.50
			Working Grand Total	$ 29,504.13

III. Three Boats; Buying Equipment

This budget scenario assumes that researchers can charter three boats simultaneously, but still must buy all traps and ropes, and must pay an additional fee to haul this equipment back from the islands or else rent UCSB boats for this purpose. Researchers will charter each of the three boats for two 4-day sampling periods, enabling researchers to gather samples at all three MPAs concurrently.

Table 16: Pilot study budget scenario with three boats and buying all equipment.

Equipment	Individual cost	Amount			Total cost
Floy tags	$ 0.43	1000			$ 425.00
Tagging guns	$ 58.00	3			$ 174.00
Extra needles	$ 12.00	6			$ 72.00
Charge for cost less than $1000 order	$ 50.00	1			$ 50.00
U.S. Customs Charge	$ 50.00	1			$ 50.00
				Subtotal	$ 771.00
Buoys (floats)	$ 4.31	120			$ 517.20
Mesh for trap mending/closures	$ 2.02	12			$ 24.24
6.5% sales tax (for WA)	N/A	N/A			$ 35.19
Shipping and Handling	N/A	N/A			$ 12.00
				Subtotal	$ 588.63
Vernier Calipers	$ 50.00	4			$ 200.00
Traps	$ 98.99	90			$ 8,909.10
Ropes	$ 0.19	16732			$ 9,808.43
				Subtotal	$ 18,917.53
				Subtotal Equipment	$ 20,277.17
Boat	**Individual cost (per day)**	**Sample Period**	**Sample days**	**Number of Boats**	**Total cost**
Charter	$ 800.00	2	4	3	$ 19,200.00
Gas	$ 100.00	2	4	3	$ 2,400.00
Bait	$ 50.00	2	4	3	$ 1,200.00
Misc. costs (repair or replace equipment)	$ 300.00	2	N/A	N/A	$ 600.00
Cost for hauling traps out to the Islands	$ 162.80	2	1	3	$ 976.80
Cost for hauling traps back from the Islands	$ 162.80	2	1	3	$ 976.80
SCUBA ground-truthing	$ 510.80	N/A	8	1	$ 4,086.40
				Subtotal Boats	$ 29,440.00
Additional	**Individual cost**	**Individual Number**		**Number of Weeks**	**Total cost**
GPS (cost per week)	$ 100.00	3		1	$ 300.00
DFG Permit	$ 16.25	6		N/A	$ 97.50
				Subtotal Additionals	$ 397.50
				Working Grand Total	$ 50,114.67

IV. Three Boats; Borrowing Equipment

This final budget scenario shows costs for chartering three boats simultaneously, with the costs of ropes, traps, and hauling the traps back from the islands folded into the charter costs. Ideally, this is the budget that researchers will encounter because we recommend sampling with three boats at three MPAs simultaneously, and using trappers' equipment to cut costs.

Table 17: Pilot study budget scenario with three boats and borrowing major equipment (e.g., traps, rope) from trappers.

Equipment	Individual cost	Amount			Total cost
Floy tags	$ 0.43	1000			$ 425.00
Tagging guns	$ 58.00	3			$ 174.00
Extra needles	$ 12.00	6			$ 72.00
Charge for cost less than $1000 order	$ 50.00	1			$ 50.00
U.S. Customs Charge	$ 50.00	1			$ 50.00
				Subtotal	$ 771.00
Buoys (floats)	$ 4.31	120			$ 517.20
Mesh for trap mending/closures	$ 2.02	12			$ 24.24
6.5% sales tax (for WA)	N/A	N/A			$ 35.19
Shipping and Handling	N/A	N/A			$ 12.00
				Subtotal	$ 588.63
Vernier Calipers	$ 50.00	4			$ 200.00
				Subtotal	$ 200.00
				Subtotal Equipment	$ 1,559.63
Boat	**Individual cost (per day)**	**Sample Period**	**Sample days**	**Number of Boats**	**Total cost**
Charter	$ 800.00	2	4	3	$ 19,200.00
Gas	$ 100.00	2	4	3	$ 2,400.00
Bait	$ 50.00	2	4	3	$ 1,200.00
Misc. costs (repair or replace equipment)	$ 300.00	2	N/A	N/A	$ 600.00
Cost for hauling traps out to the Islands	$ 162.80	2	1	3	$ 976.80
SCUBA ground-truthing	$ 510.80	N/A	8	1	$ 4,086.40
				Subtotal Boats	$ 28,463.20
Additional	**Individual cost**	**Individual Number**		**Number of Weeks**	**Total cost**
GPS (cost per week)	$ 100.00	3		2	$ 600.00
DFG Permit	$ 16.25	6		N/A	$ 97.50
				Subtotal Additionals	$ 697.50
				Working Grand Total	$ 30,720.33

V. Budget Sources

Table 18: Pilot study budget sources.

Equipment	Source and Comments
Floy tags	These have already been purchased (from Hallprint Pty Ltd) and are in Hunter Lenihan's lab in Bren Hall, UCSB.
Tagging guns	
Extra needles	
Charge for cost less than $1000 order	
U.S. Customs Charge	
Buoys (floats)	These have already been purchased (from Seattle Marine and Fishing Supply Company) and are in Hunter Lenihan's lab in Bren Hall, UCSB.
Mesh for trap mending/closures	
6.5% sales tax (for WA)	
Shipping and Handling	
Vernier Calipers	Fisher Scientific
Traps	Blue Ocean Tackle
Ropes	
Boats	**Source and Comments**
Charter	Estimates from local lobster trappers.
Gas	
Bait	
Misc. costs (repair or replace equipment)	
Cost for hauling traps out to the Islands	This is based on using UCSB boats from Marine Operations at UCSB
Cost for hauling traps back from the Islands	
SCUBA ground-truthing	UCSB boat +10 tanks =2 dives/day; 5 people.
Additional	**Source and Comments**
GPS (cost per week)	Rentals: http://www.phonerentalusa.com
DFG Permit	DFG

Appendix G: Pilot Study Depth Data

I. Determining Depths

The table below shows the commercial lobster logbook data used to determine sampling depths. We used the number of traps and the number of legal lobsters caught in each October from the 1999 to 2003 lobster fishing seasons. We only used data from each October because water temperature in this month is most similar to water temperature in the summer months, when sampling will occur (Abramson et al., 2004). During this first month of the lobster fishing season, trappers generally fish in shallower water than during any other month of the season (Abramson et al., 2004). October best represents the conditions that will be present during pilot study sampling periods.

We chose these depth ranges because the number of traps and number of legal lobsters are most evenly distributed in these three depth ranges. The data reveal spikes at 6.1 m (20 feet), 7.6 m (25 feet), and 9.1 m (25 feet), which we attribute to approximations made by trappers when recording fishing depths.

Table 19: Pilot Study Depth Data. This table shows each depth at which legal lobsters were caught in the month of October from the 1999-2003 lobster fishing seasons. Data are from the DFG commercial lobster logbooks discussed in Chapter 4. The number of Legal lobsters per trap, or LLPT, is also shown in the table for comparison between depths.

Depth in Meters	Depth in Feet	No. Traps	% of Total Traps	No. Legals	% of Legals	Mean LLPT	SD LLPT
3.05	10	296	0.20%	194	0.21%	0.56	0.24
3.66	12	1,533	1.05%	1,328	1.43%	0.99	0.98
3.96	13	77	0.05%	67	0.07%	0.82	0.25
4.57	15	2,200	1.51%	1,395	1.50%	0.62	0.59
5.49	18	5,811	3.99%	3,664	3.95%	0.65	0.53
6.10	20	30,251	20.75%	23,228	25.03%	0.82	0.52
6.40	21	82	0.06%	91	0.10%	1.11	
6.71	22	1,142	0.78%	740	0.80%	0.84	0.69
SHALLOW = 3 - 6.9 m						**AVG**	
Subtotal		**41,392**	**28.39%**	**30,707**	**33.09%**	**0.80**	**0.54**
7.01	23	120	0.08%	69	0.07%	0.89	0.66
7.32	24	284	0.19%	189	0.20%	0.68	0.46
7.62	25	26,400	18.10%	15,853	17.08%	0.69	0.77
7.92	26	140	0.10%	31	0.03%	0.22	
8.23	27	70	0.05%	8	0.01%	0.11	
9.14	30	32,363	22.19%	19,437	20.95%	0.68	0.48
9.75	32	51	0.03%	21	0.02%	0.41	
MIDWATER = 7 - 9.9 m						**AVG**	
Subtotal		**59,428**	**40.75%**	**35,608**	**38.37%**	**0.53**	**0.59**
10.06	33	155	0.11%	52	0.06%	0.63	0.61
10.67	35	12,718	8.72%	5,083	5.48%	0.48	0.39
10.97	36	309	0.21%	178	0.19%	0.60	0.19
11.89	39	130	0.09%	26	0.03%	0.20	
12.19	40	8,212	5.63%	5,486	5.91%	0.70	0.40
12.80	42	145	0.10%	59	0.06%	0.53	0.39
13.72	45	884	0.61%	615	0.66%	0.71	0.63
14.63	48	97	0.07%	34	0.04%	0.86	0.91
15.24	50	5,916	4.06%	3,969	4.28%	0.80	0.51
16.76	55	40	0.03%	13	0.01%	0.33	0.04
17.07	56	25	0.02%	64	0.07%	2.56	
18.29	60	13,409	9.20%	8,821	9.51%	0.73	0.63
19.81	65	10	0.01%	6	0.01%	0.60	
DEEP = 10 - 19.9 m						**AVG**	
Subtotal		**42,050**	**28.84%**	**24,406**	**26.30%**	**0.75**	**0.47**
TOTALS		**142,870**	**97.98%**	**90,721**	**97.76%**		

Appendix H: Pilot Study Data Collection

I. Data to be Collected

Table 20: Data Categories and Measurements. This table shows each measurement and piece of information researchers should record while sampling. These measurements will be used to compare growth rates, size and sex distribution, and changes in abundance over time between each gradient location. This data may also indicate the effects of juvenile and adult spillover from within reserves to outside reserves over time.

Category	Measurement
Movement	GPS location of trap pull Depth and date of trap pull Number of recaptured lobsters Tag numbers of tagged lobsters Tag number of recaptured lobsters
Abundance	Total number of lobsters per trap
Size Characteristics	Carapace length
Sex Characteristics	Sex Setose Egg-bearing Plastered (Spermatophore)
Other Variables	Injuries Bycatch Temperature at 10 m Salinity Swell Direction Swell Height Barometric Pressure Moon Phase

Figure 27: Berried Female Lobster. This photo shows the egg clutch of a berried female lobster.

II. Collection Procedures

To reduce bias from human error, responsibilities for collecting data should remain with the same person throughout the sampling period. One group member will measure carapace length (CL) with vernier calipers to the nearest 0.1-millimeter, and determine sex, female reproductive characteristics (egg-bearing, spermataphore), and injuries. Another individual will record all data, including oceanographic and environmental conditions, and biological measurements taken by the data collector. See Appendix D for a sample of the field sampling datasheet.

Figure 28: Carapace Length. In this photo, a Bren researcher is measuring the carapace length of a lobster with vernier calipers.

III. Marking Procedure

A. Tagging

We recommend tagging all trapped lobsters within the MPAs, to increase the chances of tagged lobsters from within the MPAs to be recaptured. This information will be valuable for detecting juvenile and adult spillover. At the sampling locations outside of the MPAs, we recommend tagging all lobsters possible before tags are depleted. Each lobster will receive one tag.

After consulting literature and current research on Santa Catalina Island (Iacchei et al., 2004) we recommend yellow T-bar anchor tags with a 20 mm filament length and a 50 mm marker length. Each marker has a marker number, sequenced from 1 to 1000, and reads: "Bren Monitoring Project" followed by a contact phone number. 10 mm are left unprinted at the distal end of the marker to allow for tag-chewing by other species, such as Sheephead, or other destruction while inserted on lobster. Tags will be inserted with a Mark III TagFast Pistol Grip Swiftach Tool applicator. We chose a tagging gun rather than single-tag applicator to increase efficiency and reduce human error.

Tags will be inserted laterally into the abdominal muscle block of the lobster, between the carapace and abdomen. The lateral position of the tags will minimize the effects of tail flipping and rubbing on rock ledges or substrates (Stadler, 2004). A ventral tag insertion point will ensure consistency with Santa Catalina Island research (Iacchei et al., 2004). Research in Biscayne Bay, Florida, has shown that most tags survive at least three molts (G. E. Davis, 1978)

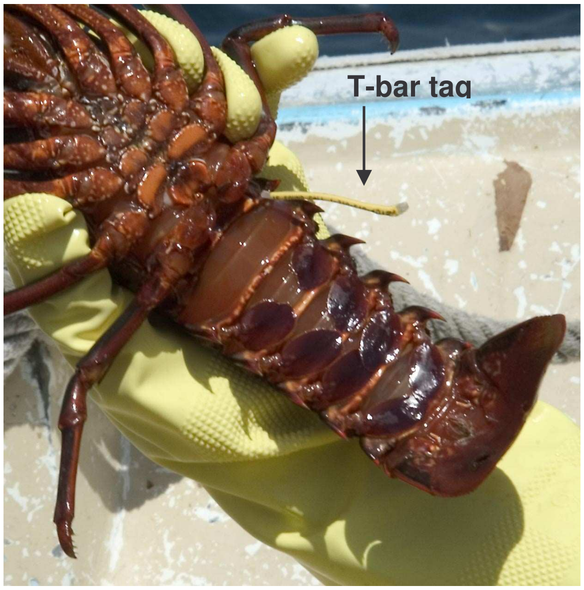

Figure 29: Tagged Lobster. A Bren researcher holds a lobster tagged with a T-bar anchor tag.

B. Additional Markings

We also recommend marking the pleopods with a single hole-punch to determine if a tagged lobster has molted. Unique pleopod designs will distinguish lobsters trapped within each MPA from lobsters trapped outside each MPA for a total of six designs. Tissue growth around this hole will reveal molt and growth conditions.

Figure 30: Unique Pleopod Marking. This photo shows a lobster pleopod marked with a single hole-punch, as our pilot study recommends in addition to tagging each lobster.

C. Conditions

Lobsters should be returned to the sea as quickly as possible, exposing to the air for no longer then fifteen minutes. To minimize stress to lobsters, they will be kept under cool, dark conditions until they are released. Lobsters will be returned as close as possible to the location where they were caught.

Appendix I: Landmark Gazetteer

This appendix includes the Landmark Gazetteer in Table 21 (Anacapa Island), Table 22 (Santa Cruz Island), Table 23 (Santa Rosa Island), and Table 24 (Variants).

Although we include the landmarks named *Anacapa Island*, *Santa Cruz Island*, and *Santa Rosa Island* in the gazetteer for completeness, we do not consider them preferred landmarks due to their non-specific nature. That is, these landmarks derive from trap locations that are too vague; for example, trappers often write down "Santa Cruz" for the trap location rather than a specific local landmark and we consolidate this location to the landmark *Santa Cruz Island*.

The attributes *Type* (i.e., island, bay, harbor, cape, beach), *Lat*, *Lon*, and *USGS Quad* for landmarks with a valid *GNIS* value (i.e., a GNIS identification number) come from GNIS (1995); otherwise, they come from our own research. Note that the latitude (*Lat*) and longitude (*Lon*) data use the NAD 1927 datum.

Table 24 lists all of the variant name and block number pairs we use to consolidate landmarks (Chapter 4, Chapter 4:IV.C); the variant name "Others" means that other variant names and blocks were used but we are not able to release those data due to privacy concerns.

Table 21: Landmark Gazetteer for Anacapa Island. All landmarks are in Ventura county.

Landmark	Block	Lat	Lon	GNIS	Type	USGS Quad	Variant Names5	Variant Blocks6	MPA	Gradient
Anacapa Island**	684	34.004	-119.399	238595	island	Anacapa Island	2	5	Anacapa	NEAR

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5 *Variant Names* is the number of unique names that trapped used to describe this landmark.
6 *Variant blocks* is the number of unique Block Numbers that trappers used in the variant names for this landmark.
** Not a preferred landmark due to its non-specific nature.

Table 22: Landmark Gazetteer for Santa Cruz Island. All landmarks are in Santa Barbara county.

Landmark	Block	Lat	Lon	GNIS	Type	USGS Quad	Variant Names	Variant Blocks	MPA	Gradient
Albert Anchorage	709	33.970	-119.698	238481	bay	Santa Cruz Island C	2	4		
Arch Rock	686	34.058	-119.799	255269	island	Santa Cruz Island B	5	4	Painted Cave	NEAR
Blue Banks Anchorage	709	33.980	-119.671	253303	harbor	Santa Cruz Island C	2	2		
Bowen Point	709	33.960	-119.720	239615	cape	Santa Cruz Island C	5	3	Scorpion	FAR
Cavern Point	685	34.056	-119.563	240372	cape	Santa Cruz Island D	6	4	Scorpion	WITHIN
Chinese Harbor	685	34.026	-119.610	240560	bay	Santa Cruz Island C	4	3	Scorpion	NEAR
Christi Beach	687	34.027	-119.875	1702828	beach	Santa Cruz Island A	4	2		
Coche Point	685	34.037	-119.608	240739	cape	Santa Cruz Island C	5	2	Scorpion	NEAR
Coches Prietos Anchorage	709	33.968	-119.704	255484	bay	Santa Cruz Island C	4	2	Scorpion	FAR
Cueva Valdez	686	34.050	-119.820		cape		3	5		
Diablo Point	686	34.059	-119.758	241483	cape	Santa Cruz Island C	2	5		
Forney Cove	687	34.058	-119.916	242371	bay	Santa Cruz Island A	2	5	Painted Cave	NEAR
Fraser Point	687	34.060	-119.929	242460	cape	Santa Cruz Island A	5	6	Painted Cave	NEAR
Frys Harbor	686	34.055	-119.754	242531	bay	Santa Cruz Island C	1	4	Scorpion	FAR
Gull Island	709	33.951	-119.824	243083	island	Santa Cruz Island B	5	4	Gull Island	WITHIN
Kinton Point	687	34.009	-119.886	244331	cape	Santa Cruz Island A	7	4		
Morse Point	710	33.968	-119.848	246233	cape	Santa Cruz Island A	3	2	Gull Island	WITHIN
Morse-Gull	710	33.959	-119.836		composite		2	1	Gull Island	WITHIN
Orizaba	686	34.047	-119.723		cape		1	1	Scorpion	FAR
Pelican Bay	686	34.034	-119.701	247358	bay	Santa Cruz Island C	2	2	Scorpion	FAR

Landmark	Block	Lat	Lon	GNIS	Type	USGS Quad	Variant Names	Variant Blocks	MPA	Gradient
Posa Anchorage	710	33.980	-119.868	247715	bay	Santa Cruz Island A	8	3		
Potato Harbor	685	34.048	-119.593	254168	bay	Santa Cruz Island C	6	3		
Prisoners Harbor	686	34.021	-119.684	247793	bay	Santa Cruz Island C	1	4	Scorpion	FAR
Profile Point	687	34.072	-119.861	254174	cape	Santa Cruz Island A	5	3		
San Pedro Point	685	34.034	-119.521	248955	cape	Santa Cruz Island D	3	3		
Sandstone Point	708	33.996	-119.559	249013	cape	Santa Cruz Island D	4	3	Scorpion	NEAR
Santa Cruz Island**	687	34.040	-119.843	254217	island	Santa Cruz Island A	3	9	Scorpion	FAR
Scorpion Anchorage	685	34.048	-119.552	254227	bay	Santa Cruz Island D	8	2	Scorpion	WITHIN
Smugglers Cove	685	34.020	-119.541	249615	bay	Santa Cruz Island D	1	4	Scorpion	NEAR
Valley Anchorage	708	33.985	-119.664	250908	bay	Santa Cruz Island C	2	3	Scorpion	FAR
West Point	687	34.078	-119.918	251368	cape	Santa Cruz Island A	8	6	Painted Cave	NEAR
Willows Anchorage	709	33.962	-119.748	251668	bay	Santa Cruz Island C	4	5	Gull Island	NEAR
Yellowbanks Anchorage	685	34.012	-119.545	251856	bay	Santa Cruz Island D	4	5		

** Not a preferred landmark due to its non-specific nature.

Table 23: Landmark Gazetteer for Santa Rosa Island. All landmarks are in Santa Barbara county.

Landmark	Block	Lat	Lon	GNIS	Type	USGS Quad	Variant Names	Variant Blocks	MPA	Gradient
Bechers Bay	711	33.995	-120.033	1667294	bay	Santa Rosa Island North	6	2	Carrington Pt.	NEAR
Bee Rock	712	33.949	-120.212	239148	island	Santa Rosa Island West	3	6	Judith Rock	FAR
Brockway Point	688	34.025	-120.147	255374	cape	Santa Rosa Island North OE W	3	5	Carrington Pt.	NEAR
Carrington Point	688	34.036	-120.042	240268	cape	Santa Rosa Island North	3	5	Carrington Pt.	WITHIN
Cluster Point	712	33.925	-120.179	240719	cape	Santa Rosa Island West	2	2		
East Point	710	33.943	-119.967	241782	cape	Santa Rosa Island East	3	2		
Ford Point	711	33.915	-120.048	242359	cape	Santa Rosa Island South	2	3	Judith Rock	FAR
Johnsons Lee	711	33.900	-120.108	244117	bay	Santa Rosa Island South	6	2		
Rodes Reef	688	34.036	-120.122	253304	bar	Santa Rosa Island North	5	2	Carrington Pt.	NEAR
Santa Rosa Island**	711	33.950	-120.100	249112	island	Santa Rosa Island North	4	7	Carrington Pt.	FAR
South Point	711	33.894	-120.114	249751	cape	Santa Rosa Island South	2	2		
Talcott Shoal	689	34.026	-120.235		bar		3	8	Carrington Pt.	FAR

** Not a preferred landmark due to its non-specific nature.

Table 24: Landmark variants. “Others” means one or more variant and block pairs were used.

Landmark	Variant	Block
Albert Anchorage	Alberts	708
Albert Anchorage	Alberts	709
Albert Anchorage	Alberts	710
Albert Anchorage	Others	
Anacapa Island	Anacapa	684
Anacapa Island	Anacapa	707
Anacapa Island	Others	
Arch Rock	Arch Rock	686
Arch Rock	Others	
Bechers Bay	Bechers	688
Bechers Bay	Others	
Bee Rock	Bee Rock	711
Bee Rock	Bee Rock	712
Bee Rock	Others	
Bowen Point	Bowen	709
Bowen Point	Bowen	710
Bowen Point	Others	
Brockway Point	Brockway	688
Brockway Point	Brockway	689
Brockway Point	Others	
Carrington Point	Carrington	687
Carrington Point	Carrington	688
Carrington Point	Others	
Cavern Point	Cavern	685
Cavern Point	Cavern Point	685
Cavern Point	Others	
Chinese Harbor	China	685
Chinese Harbor	Chinese	685
Chinese Harbor	Chinese	686
Chinese Harbor	Others	
Cluster Point	Cluster	712
Cluster Point	Others	
Coche Point	Coche	685
Coche Point	Others	
Coches Prietos Anchorage	Coche	709
Coches Prietos Anchorage	Others	
Cueva Valdez	Cueva Valdez	687
Cueva Valdez	Valdez	686
Cueva Valdez	Others	
Diablo Point	Diablo	686
Diablo Point	Others	
East Point	East	710
East Point	East Point	710
East Point	East Point	711
East Point	Others	
Ford Point	Ford	711
Ford Point	Ford Pt	711
Forney Cove	Forney	687
Forney Cove	Forneys	687
Fraser Point	Fraser Point	687
Fraser Point	Others	
Frys Harbor	Frys	686
Gull Island	Gull	710
Gull Island	Gull Island	708
Gull Island	Gull Island	709
Gull Island	Gull Island	710
Gull Island	Others	
Kinton Point	Kinton	687
Kinton Point	Kinton	710
Kinton Point	Others	
Morse Point	Morse	710
Morse Point	Others	
Morse-Gull	Morse-Gull	710
Morse-Gull	Others	

Landmark	Variant	Block
Orizaba	Orazaba	686
Pelican Bay	Pelican	686
Pelican Bay	Others	
Potato Harbor	Potato	685
Potato Harbor	Others	
Prisoners Harbor	Prisoners	685
Prisoners Harbor	Prisoners	686
Profile Point	Profile Point	687
Profile Point	Others	
Rodes Reef	Rhodes	688
Rodes Reef	Others	
San Pedro Point	Pedro	685
San Pedro Point	Pedro Point	685
San Pedro Point	Others	
Sandstone Point	Sandstone	708
Sandstone Point	Others	
Santa Cruz Island	Santa Cruz	685
Santa Cruz Island	Santa Cruz	687
Santa Cruz Island	Santa Cruz	708
Santa Cruz Island	Others	
Santa Rosa Island	Santa Rosa	688
Santa Rosa Island	Santa Rosa	689
Santa Rosa Island	Santa Rosa	710
Santa Rosa Island	Santa Rosa	711
Santa Rosa Island	Santa Rosa	712
Santa Rosa Island	Others	
Scorpion Anchorage	Scorpion	685
Scorpion Anchorage	Scorpion	686

Landmark	Variant	Block
Scorpion Anchorage	Others	
Smugglers Cove	Smugglers	685
Smugglers Cove	Smugglers	708
South Point	South Pt	711
South Point	Others	
Talcott Shoal	Talchott	688
Talcott Shoal	Talchott	689
Talcott Shoal	Talcot	689
Talcott Shoal	Others	
Valley Anchorage	Valley	708
Valley Anchorage	Valley	709
Valley Anchorage	Valley Anch.	709
West Point	West End	687
West Point	West End	688
West Point	West End	689
West Point	West End Cruz	687
West Point	Westend	687
West Point	Others	
Willows Anchorage	Willows	709
Willows Anchorage	Willows	710
Willows Anchorage	Others	
Yellowbanks Anchorage	Yellow Banks	708
Yellowbanks Anchorage	Yellowbanks	708
Yellowbanks Anchorage	Others	

Appendix J: Historical Baseline Data & Analysis

In this appendix, we provide the historical baseline data and other analysis. The data include subtotals, arithmetic means, and standard deviations (abbreviated as "StDev") where appropriate. The variables we provide are defined in Table 25.

For privacy reasons, some summarized data in the historical baseline are not included, as denoted by an asterisk (*); whereas, a black square (■) represents data that meet the criteria to be included in the historical baseline, but are not included to protect privacy.

The historical baseline data are available online at:

http://www.bren.ucsb.edu/~lobster

Table 25: Historical baseline Variables.

Variable	Definition
Catch	The number of legal lobsters retained.
Catch Performance	The number of legal lobsters retained per trap.
Traps	The number of lobster traps that were set and pulled.
Shorts Released	The number of lobsters that were released because they were under the legal size limit.
Nights Soaked	The number of nights the traps was soaked.
Depth	The depth at which the traps were set.
Trapping Event	A single logbook entry.

I. Historical Baseline Data by Fishing Area

Table 26: Abbreviations for Fishing Areas in Historical Baseline.

Abbreviation	Fishing Area
LA	Los Angeles County Coastal
NCI	Northern Channel Islands
OC	Orange County Coastal
SB	Santa Barbara County Coastal
SCI	Southern Channel Islands and Outer Banks
SD	San Diego County Coastal
VC	Ventura County Coastal

Table 27: Total Catch By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Total
NCI	43,721	46,978	73,799	61,820	56,756	66,506	90,362	114,114	554,056
SB	25,501	25,092	52,410	36,410	20,896	30,842	35,289	37,910	264,350
VC	3,339	2,847	11,687	6,075	5,011	7,740	3,751	6,158	46,608
SCI	79,328	79,145	78,287	68,352	78,044	89,796	82,021	100,671	655,644
LA	33,878	35,913	69,240	34,205	20,763	39,159	39,770	40,822	313,750
OC	52,339	78,034	99,034	58,251	57,894	68,503	49,602	58,314	521,971
SD	137,400	147,156	205,274	122,127	87,671	170,042	140,188	117,679	1,127,537
Total	375,506	415,165	589,731	387,240	327,035	472,588	440,983	475,668	**3,483,916**

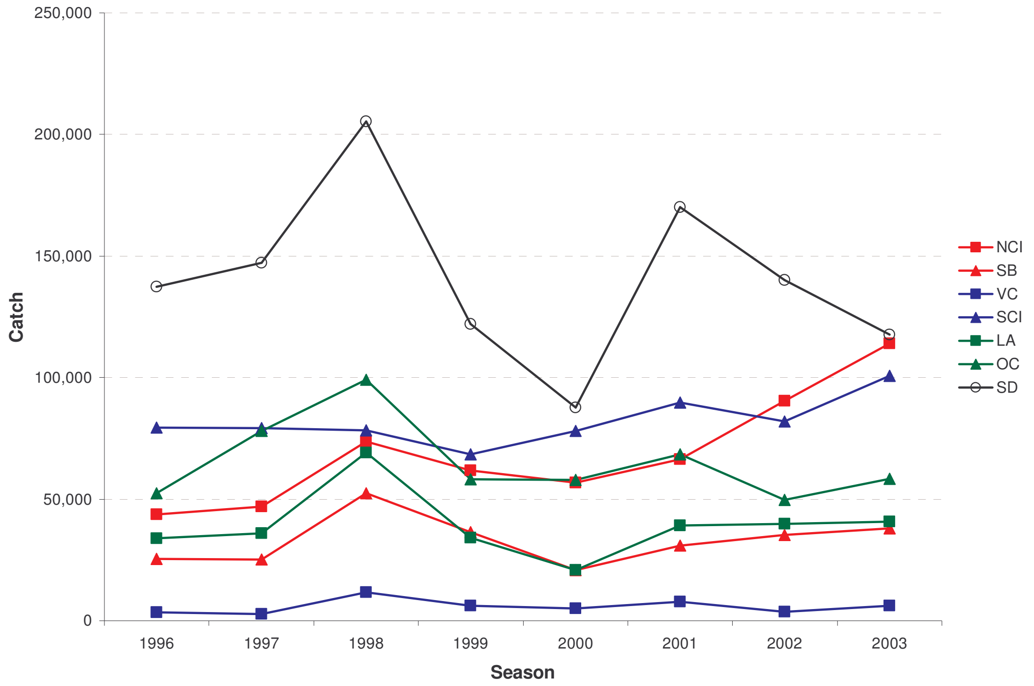


Figure 31: Total Catch By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Table 28: Mean Seasonal Catch Performance By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Mean
NCI	0.632	0.650	1.068	0.651	0.562	0.720	0.890	0.883	0.757
SB	0.377	0.429	0.729	0.456	0.356	0.535	0.551	0.642	0.509
VC	0.373	0.526	1.313	0.582	0.651	1.301	1.149	1.062	0.870
SCI	0.680	0.701	0.753	0.624	0.725	0.839	0.990	0.736	0.756
LA	0.338	0.443	0.613	0.318	0.338	0.557	0.448	0.440	0.437
OC	0.384	0.516	0.719	0.352	0.287	0.384	0.297	0.389	0.416
SD	0.475	0.581	0.770	0.489	0.420	0.676	0.556	0.523	0.561
Mean	0.466	0.549	0.852	0.496	0.477	0.716	0.697	0.668	**0.615**

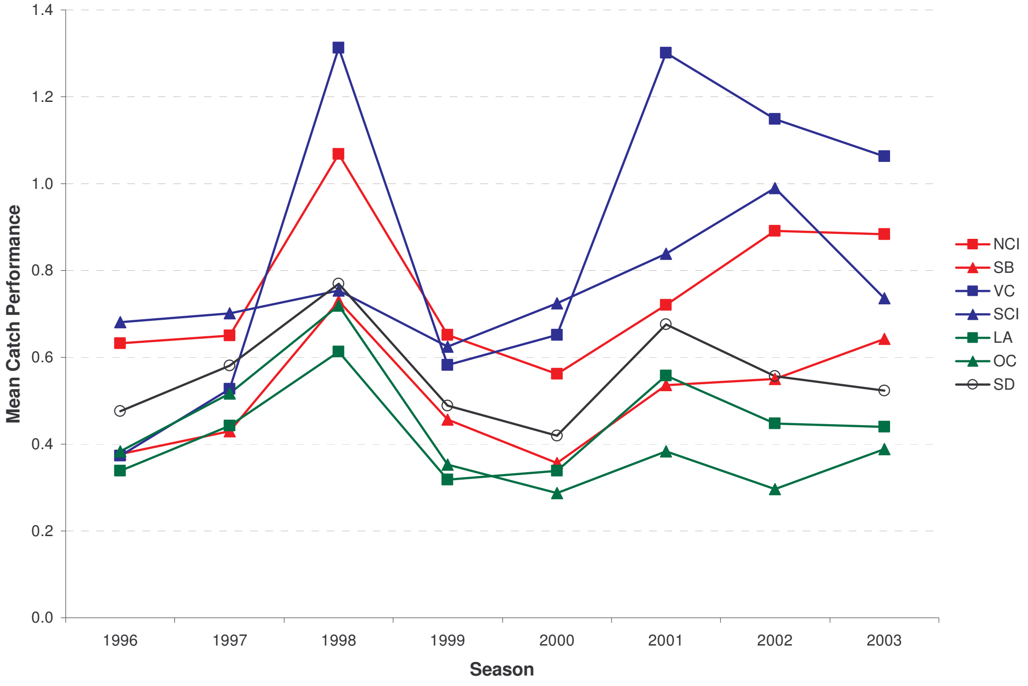


Figure 32: Mean Seasonal Catch Performance By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Table 29: Traps Pulled By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Total
NCI	78,977	76,985	87,913	112,361	118,577	111,008	124,540	161,957	872,318
SB	66,245	56,429	75,915	80,925	62,148	58,239	62,511	65,021	527,433
VC	8,858	4,655	13,561	13,871	11,918	8,411	4,179	7,204	72,657
SCI	118,917	113,518	105,567	106,782	115,839	116,523	96,919	127,209	901,274
LA	112,184	98,748	145,486	127,847	73,463	77,972	93,409	94,063	823,172
OC	141,091	145,777	129,231	160,976	192,449	174,862	152,944	154,234	1,251,564
SD	292,258	247,504	264,902	239,949	209,909	241,185	239,901	227,703	1,963,311
Total	818,530	743,616	822,575	842,711	784,303	788,200	774,403	837,391	**6,411,729**

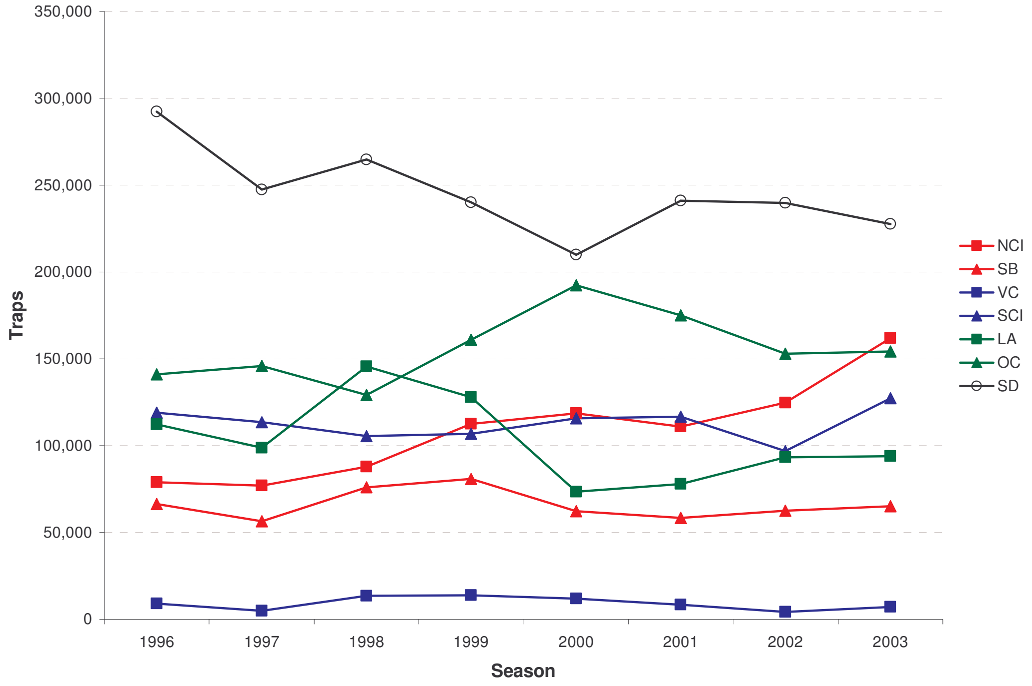


Figure 33: Traps Pulled By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Table 30: Shorts Released By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Total
NCI	25,727	20,754	24,570	33,724	31,774	45,452	43,425	57,635	283,061
SB	31,982	34,067	50,850	57,314	29,507	41,424	41,168	46,891	333,203
VC	1,691	1,363	5,120	2,859	6,076	7,566	3,046	6,264	33,985
SCI	108,385	123,240	102,573	98,530	134,725	141,527	138,450	202,756	1,050,186
LA	39,363	43,633	64,017	34,300	26,483	49,736	48,342	50,273	356,147
OC	124,211	197,190	161,748	141,848	155,416	168,122	123,076	171,210	1,242,821
SD	515,822	477,471	505,662	435,047	390,409	586,916	567,039	594,308	4,072,674
Total	847,181	897,718	914,540	803,622	774,390	1,040,743	964,546	1,129,337	**7,372,077**

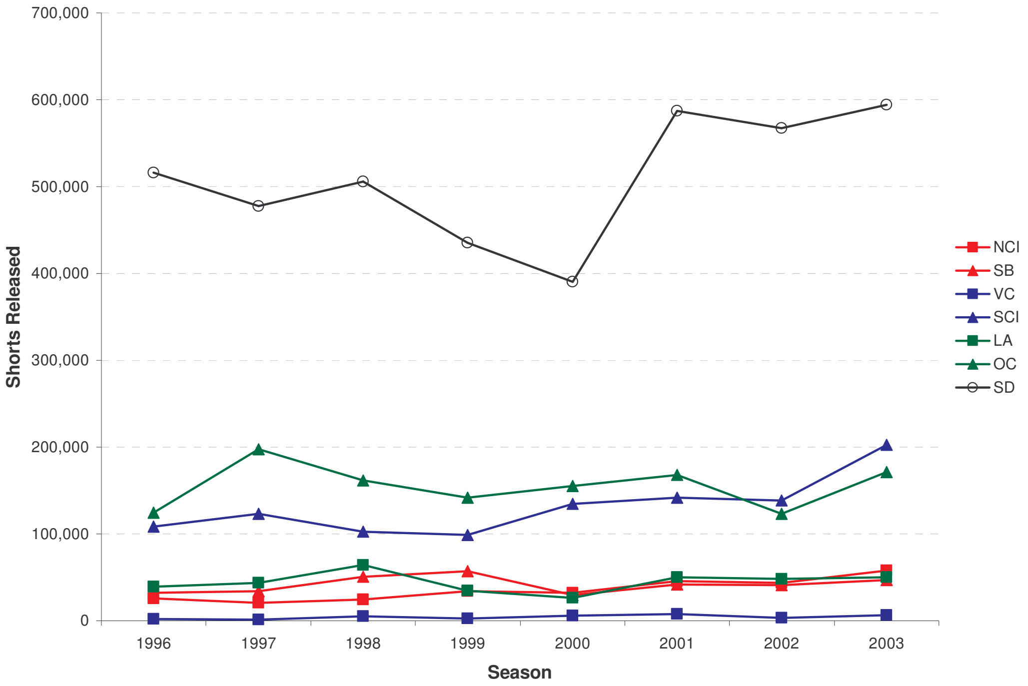


Figure 34: Shorts Released By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Table 31: Mean Depth By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Mean
NCI	52.24	49.43	59.87	55.13	51.94	50.71	52.05	49.14	52.56
SB	36.07	37.36	48.69	44.33	43.26	49.77	45.32	43.87	43.58
VC	49.66	61.17	73.22	62.51	40.46	44.33	53.56	50.30	54.40
SCI	60.26	63.28	74.66	72.44	67.45	59.96	60.14	63.64	65.23
LA	61.92	70.92	87.94	73.21	63.47	63.43	61.95	62.51	68.17
OC	38.55	36.23	44.18	38.86	34.92	34.31	34.17	34.30	36.94
SD	51.16	50.87	65.66	58.34	44.59	48.36	47.89	47.93	51.85
Mean	49.98	52.75	64.89	57.83	49.44	50.12	50.73	50.24	**53.25**

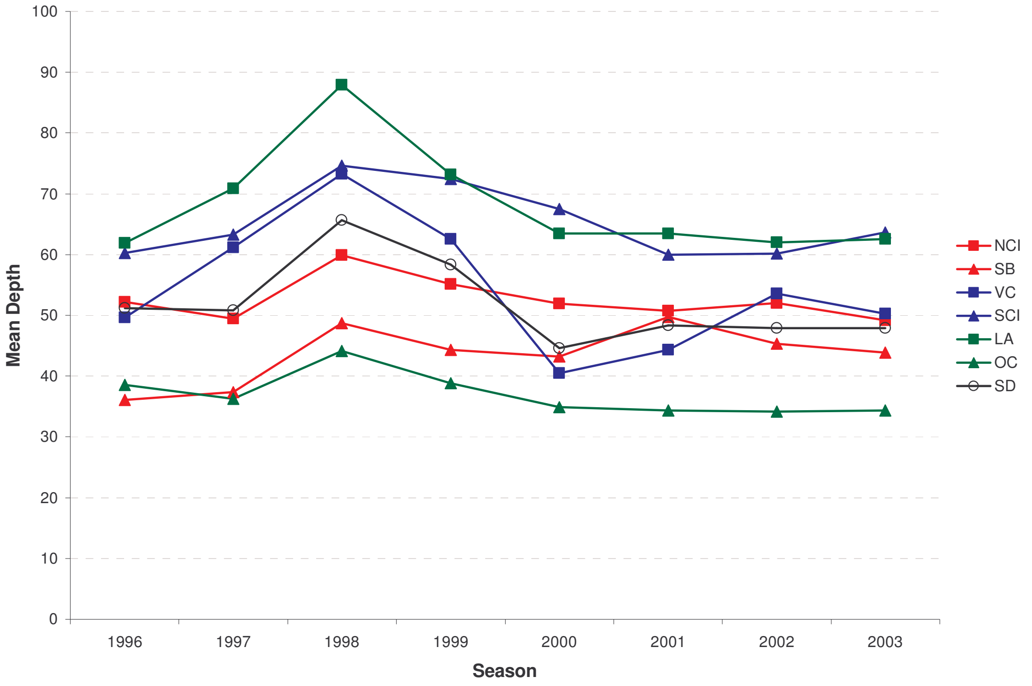


Figure 35: Mean Depth By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Table 32: Mean Nights Soaked By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Fishing Area	1996	1997	1998	1999	2000	2001	2002	2003	Mean
NCI	4.09	4.34	4.31	4.53	4.28	4.43	4.19	3.93	4.26
SB	3.12	3.41	3.61	3.59	3.33	3.54	3.16	3.22	3.37
VC	3.29	4.16	4.53	3.79	3.49	3.71	4.09	4.01	3.88
SCI	2.25	2.35	2.62	3.12	2.88	3.21	2.97	2.88	2.79
LA	2.44	2.36	2.35	2.58	2.65	2.86	2.86	2.81	2.61
OC	2.64	2.60	2.51	2.67	2.68	2.74	2.77	2.71	2.66
SD	2.41	2.74	2.79	2.98	2.96	3.01	2.99	3.01	2.86
Mean	2.89	3.14	3.25	3.32	3.18	3.36	3.29	3.22	**3.21**

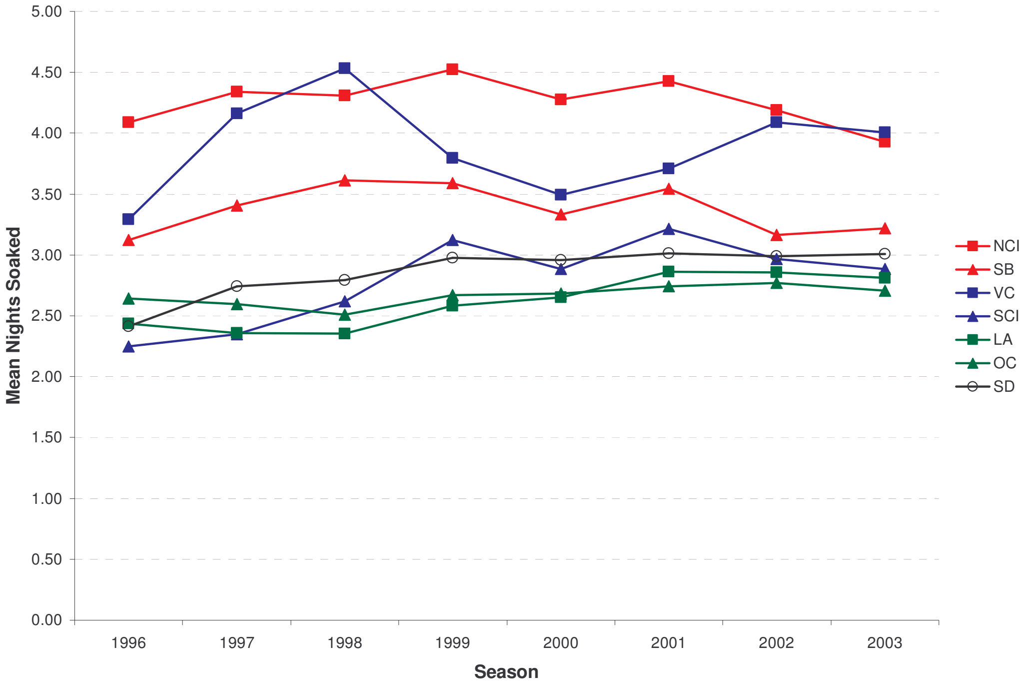


Figure 36: Mean Nights Soaked By Fishing Area, 1996 – 2003 Seasons. Source: (DFG, 2003d).

II. Historical Baseline Data by Block

A. Catch

Table 33: Catch For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Total
684	5,360	4,236	7,147	6,799	5,668	6,292	10,286	11,080	56,868
685	4,649	5,966	9,868	5,769	3,775	3,457	5,748	9,114	48,346
686	2,221	1,174	3,576	1,794	1,552	1,971	3,235	4,323	19,846
687	1,445	1,234	6,945	3,654	2,408	4,222	4,160	5,092	29,160
688	4,124	5,528	10,501	9,638	11,509	8,765	17,040	18,321	85,426
689	437	1,871	1,877	1,743	2,906	4,805	7,059	14,007	34,705
707	2,431	*	*	2,265	*	4,171	*	1,742	10,609
708	11,262	7,259	13,722	14,815	10,090	12,740	16,979	16,639	103,506
709	4,217	6,179	6,679	4,228	4,465	5,705	8,316	9,431	49,220
710	2,330	2,765	3,628	4,508	5,002	3,100	3,226	4,985	29,544
711	3,048	5,076	5,564	5,435	3,974	7,353	7,965	14,577	52,992
712	2,038	2,735	1,818	1,169	1,197	2,370	3,803	4,789	19,919
Total	43,562	44,023	71,325	61,817	52,546	64,951	87,817	114,100	**540,141**

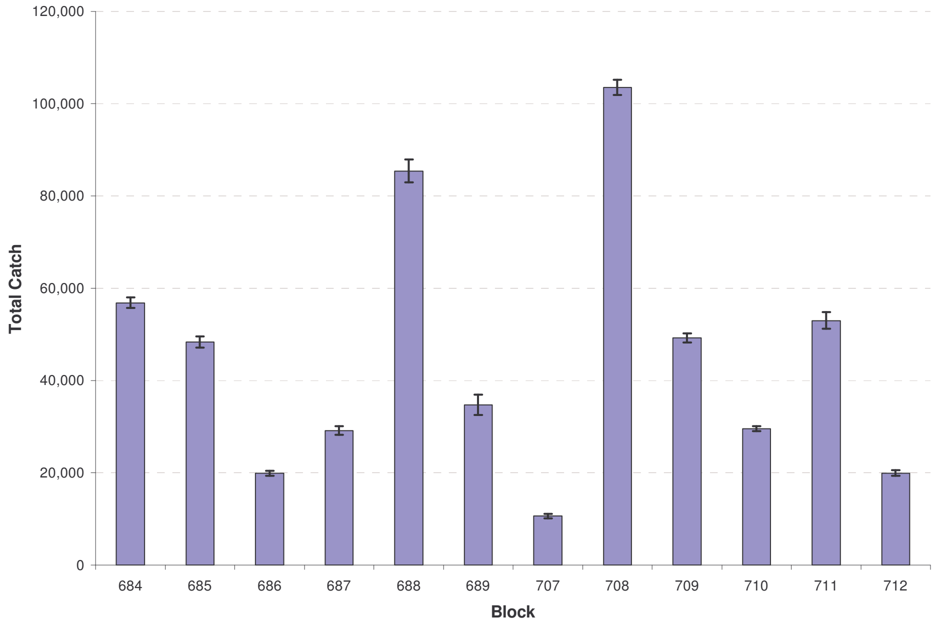


Figure 37: Total Catch For Study Area By Block Over 1996 - 2003 Seasons. Error bars represent the mean standard deviation. Source: (DFG, 2003d).

Table 34: Total Catch For Study Area By Block Over 1996 - 2003 Seasons, By Month. Source: (DFG, 2003d)

Block	Oct	Nov	Dec	Jan	Feb	Mar	Total
684	19,989	15,332	11,709	5,833	3,076	929	56,868
685	16,446	13,450	10,193	4,554	2,969	734	48,346
686	3,870	6,202	5,706	2,455	1,153	460	19,846
687	2,702	5,894	7,120	6,539	4,626	2,279	29,160
688	17,860	8,971	12,829	17,053	16,574	12,139	85,426
689	2,271	2,693	5,462	7,993	8,551	7,735	34,705
707	6,828	5,366	3,000	2,214	*	*	19,247
708	45,575	26,939	13,471	8,575	5,122	3,824	103,506
709	18,906	12,933	8,489	4,379	2,555	1,958	49,220
710	7,401	8,143	6,263	4,155	2,715	867	29,544
711	9,853	10,846	11,511	9,519	7,994	3,269	52,992
712	1,584	2,390	3,048	5,005	5,058	2,834	19,919
Total	153,285	119,159	98,801	78,274	60,393	37,028	**546,940**

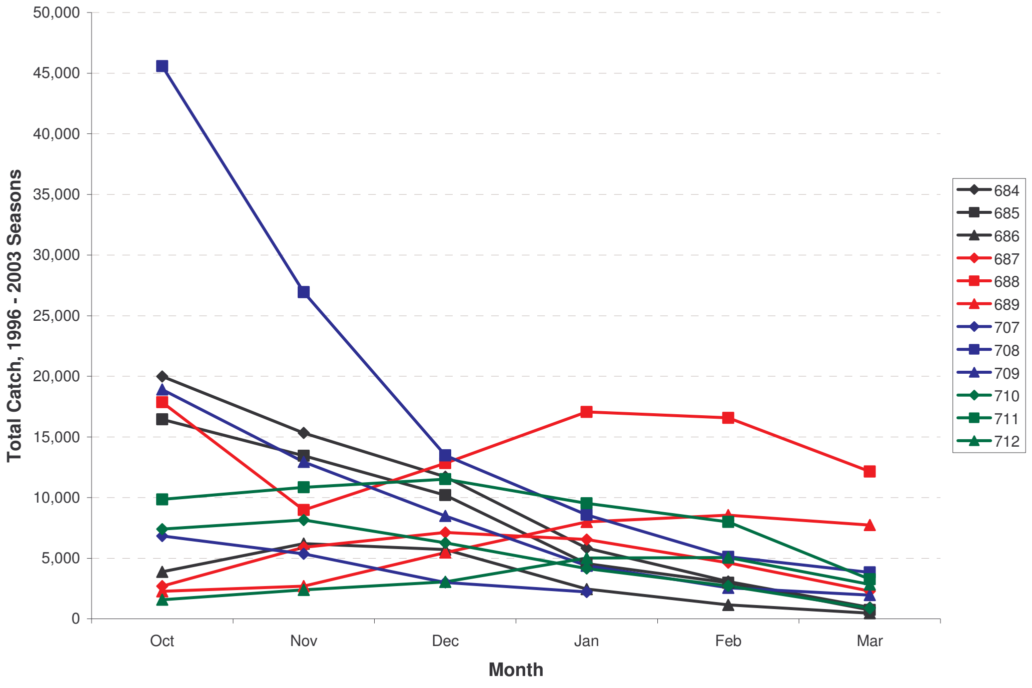


Figure 38: Total Catch For Study Area By Block Over 1996 - 2003 Seasons, By Month. Source: (DFG, 2003d).

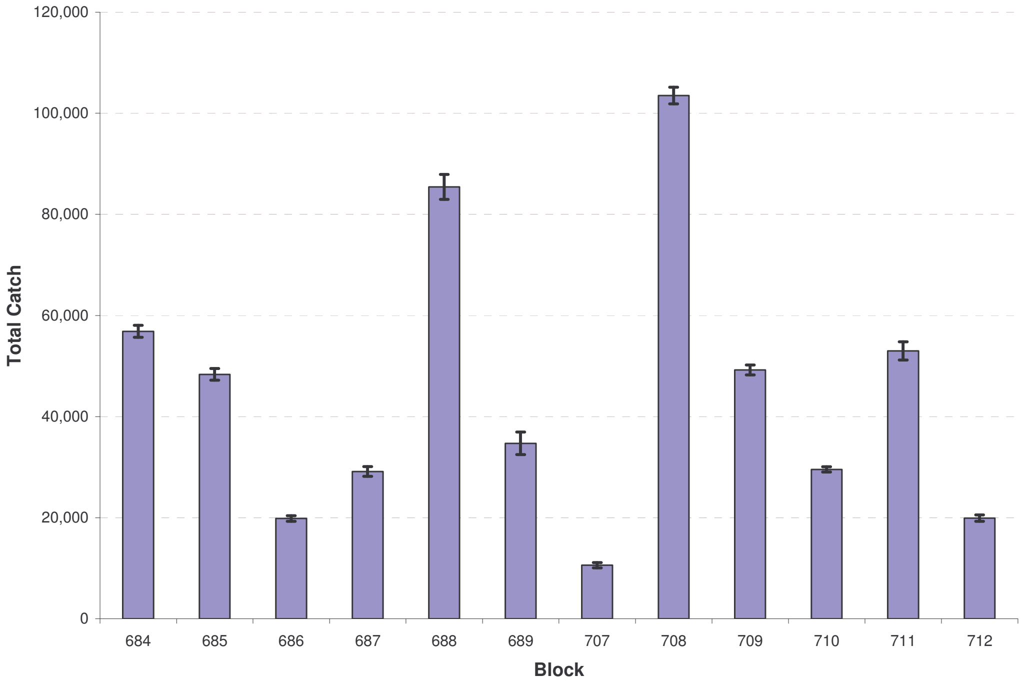


Figure 39: Mean Catch by Block, Seasons 1996 - 2003. Error bars represent the mean standard deviation. Source: (DFG, 2003d).

B. Catch Performance

Table 35: Mean Seasonal Catch Performance For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Mean
684	0.529	0.319	0.666	0.520	0.457	0.739	0.758	0.623	0.576
685	0.569	0.482	2.010	0.728	0.543	0.812	1.129	1.181	0.932
686	0.610	0.575	0.804	0.684	0.594	0.996	0.774	1.397	0.804
687	0.551	0.468	1.045	0.484	0.512	0.574	0.599	0.973	0.651
688	0.471	0.925	1.298	0.583	0.442	0.589	1.628	0.625	0.820
689	0.472	0.572	0.727	0.469	0.454	0.848	0.520	0.755	0.602
707	0.362	*	*	0.405	*	0.779	*	0.477	0.506
708	0.444	0.548	0.665	0.632	0.468	0.451	0.416	0.737	0.545
709	0.484	0.488	1.010	0.674	0.423	0.751	0.766	0.967	0.695
710	0.691	0.620	1.160	0.483	0.703	0.494	0.688	0.842	0.710
711	0.503	0.485	1.247	0.461	0.344	0.367	0.412	0.552	0.546
712	0.489	0.781	1.188	0.510	0.483	0.446	0.588	0.451	0.617
Mean	0.515	0.570	1.075	0.553	0.493	0.654	0.752	0.798	**0.674**

Table 36: Mean Catch Performance by Month and Block, 1996 - 2003 Seasons. Source: (DFG, 2003d).

Block	Oct	Nov	Dec	Jan	Feb	Mar	Mean
684	0.892	0.820	0.881	0.658	0.805	0.896	0.825
685	0.767	0.950	0.979	0.753	0.762	0.878	0.848
686	0.676	0.883	1.191	0.844	0.840	0.737	0.862
687	0.689	0.702	0.971	0.737	0.795	1.076	0.828
688	0.649	0.519	0.793	0.730	0.794	1.019	0.751
689	0.694	0.559	0.815	0.813	0.700	1.036	0.770
707	0.929	0.853	0.923	0.677	*	*	0.845
708	0.636	0.512	0.469	0.410	0.429	0.470	0.488
709	0.816	0.724	0.881	0.682	0.852	0.953	0.818
710	0.915	0.876	0.826	0.858	1.034	0.735	0.874
711	0.674	0.701	0.672	0.677	0.814	0.864	0.734
712	0.676	0.762	0.736	0.775	0.795	0.979	0.787
Mean	0.751	0.738	0.845	0.718	0.784	0.877	**0.784**

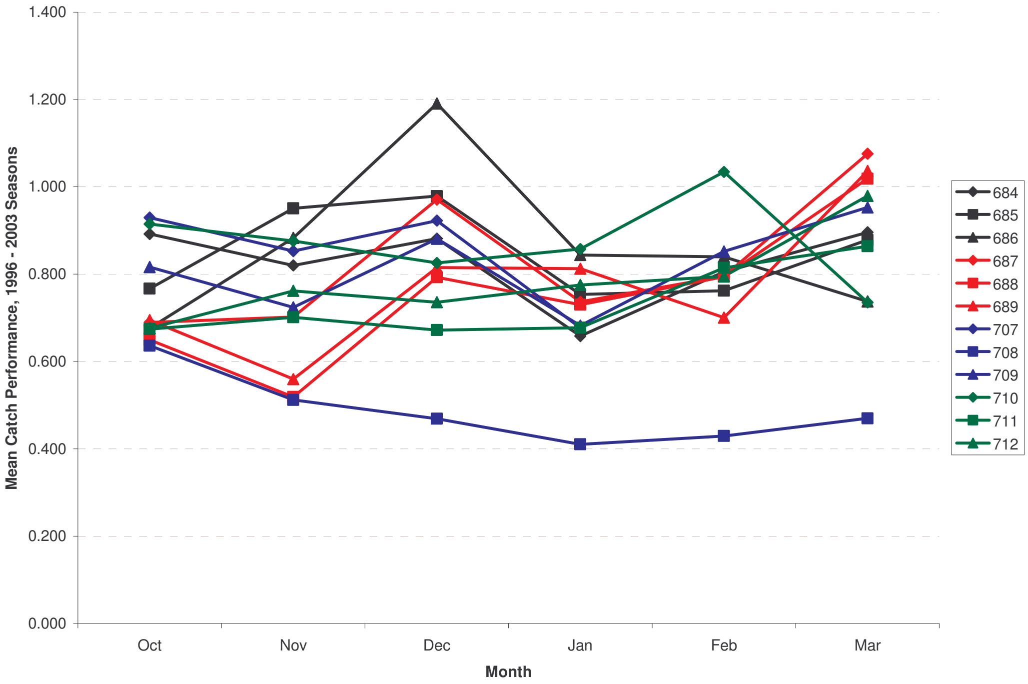


Figure 40: Mean Catch Performance by Block, 1996 - 2003 Seasons. Source: (DFG, 2003d).

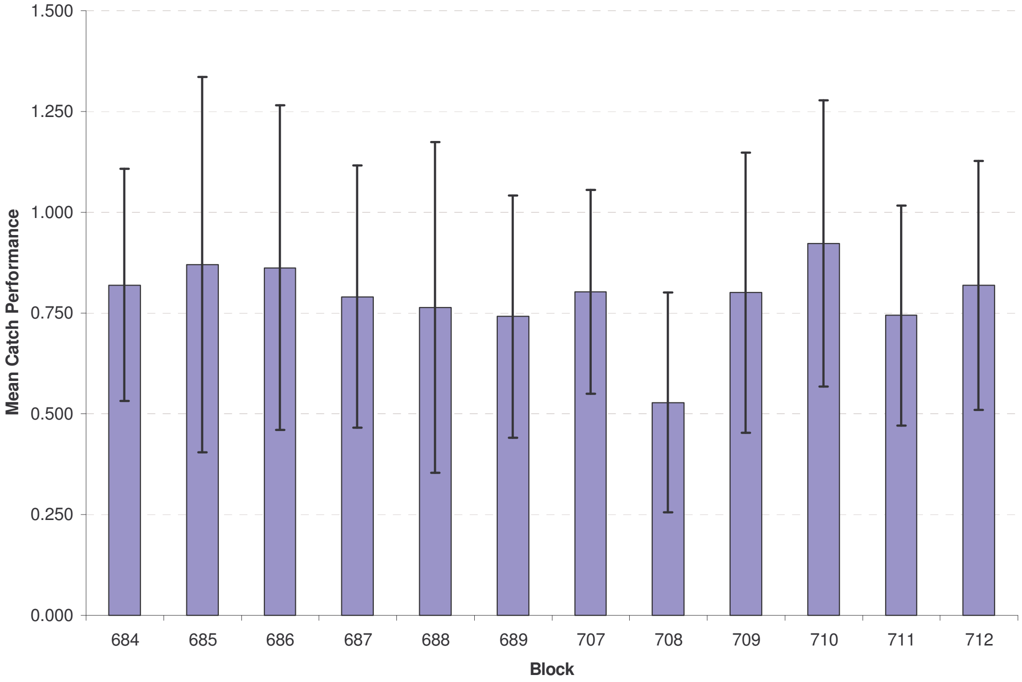


Figure 41: Mean Catch Performance For Study Area By Block Over 1996 - 2003 Seasons. Error bars represent the mean standard deviation. Source: (DFG, 2003d).

C. Traps Pulled

Table 37: Traps Pulled For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Total
684	9,162	6,295	8,285	8,749	8,410	7,672	9,119	14,687	72,379
685	9,371	11,309	12,245	9,543	7,994	5,424	5,663	9,733	71,282
686	2,965	1,602	4,637	3,252	2,864	3,484	4,501	4,164	27,469
687	2,335	2,088	5,481	6,808	4,065	6,324	5,058	6,282	38,441
688	6,166	6,290	13,670	16,065	24,158	16,137	24,334	23,886	130,706
689	1,486	1,814	1,923	3,297	5,255	6,594	8,197	18,428	46,994
707	3,251	*	*	3,185	*	4,990	*	2,977	14,403
708	25,400	19,367	22,911	35,310	29,838	27,724	35,378	39,601	235,529
709	7,659	9,842	6,609	7,255	7,805	7,950	10,506	13,818	71,444
710	3,041	3,882	2,728	6,442	7,496	4,858	3,475	4,913	36,835
711	4,637	7,439	5,483	10,360	10,710	13,594	11,339	18,053	81,615
712	3,097	2,621	1,445	2,005	2,319	3,604	4,560	5,357	25,008
Total	78,570	72,549	85,417	112,271	110,914	108,355	122,130	161,899	**852,105**

D. Shorts Released

Table 38: Shorts Released For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Total
684	1,875	1,500	1,445	1,571	1,423	1,410	2,522	3,113	14,859
685	3,046	2,527	2,954	3,249	2,210	1,252	1,721	3,542	20,501
686	676	257	1,222	979	538	948	1,139	1,790	7,549
687	628	557	2,052	1,528	1,006	2,417	1,791	2,931	12,910
688	863	1,372	2,058	2,550	4,247	5,827	8,323	8,648	33,888
689	179	648	292	403	1,481	4,430	2,374	6,157	15,964
707	378	*	*	466	*	864	*	160	1,868
708	12,225	6,504	8,471	16,230	12,580	16,081	15,243	15,968	103,302
709	3,702	4,455	3,331	2,843	2,595	3,679	4,404	5,680	30,689
710	1,278	1,208	1,294	2,284	2,307	1,838	1,303	2,541	14,053
711	326	708	839	1,309	1,359	2,885	2,923	4,790	15,139
712	475	465	351	304	412	2,895	1,353	2,313	8,568
Total	25,651	20,201	24,309	33,716	30,158	44,526	43,096	57,633	**279,290**

E. Depth

Table 39: Mean Depth For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Mean
684	65.15	60.94	62.55	65.03	60.95	67.69	65.78	63.73	63.98
685	54.50	51.74	62.71	57.84	56.34	65.85	67.26	55.29	58.94
686	62.13	56.82	59.87	65.49	66.54	55.71	65.58	54.08	60.78
687	64.33	66.20	70.11	64.71	63.16	60.23	64.30	67.80	65.10
688	54.81	60.79	59.47	61.42	54.89	54.77	55.51	53.13	56.85
689	71.92	51.03	80.98	79.43	63.73	57.91	51.00	56.30	64.04
707	42.51	*	*	29.91	*	57.84	*	40.55	42.70
708	42.56	45.93	54.26	44.93	37.92	36.32	34.60	32.26	41.10
709	47.96	40.49	55.67	50.56	47.13	46.16	50.82	43.43	47.78
710	43.12	38.82	51.14	41.27	44.32	35.10	45.34	40.95	42.51
711	52.02	49.29	56.82	55.98	47.18	44.16	47.88	46.46	49.97
712	62.69	52.00	82.07	82.41	64.23	52.79	44.92	48.81	61.24
Mean	55.31	52.19	63.24	58.25	55.13	52.88	53.91	50.23	**55.10**

F. Nights Soaked

Table 40: Mean Nights Soaked For Study Area By Block, 1996 – 2003 Seasons. Source: (DFG, 2003d).

Block	1996	1997	1998	1999	2000	2001	2002	2003	Mean
684	3.46	3.81	3.64	3.47	3.64	3.74	3.60	3.48	3.60
685	3.98	4.02	4.61	4.84	4.74	4.99	4.79	4.47	4.55
686	4.80	5.33	4.92	5.81	6.21	5.93	5.53	5.05	5.45
687	4.86	5.46	5.38	5.58	4.67	4.87	5.11	4.37	5.04
688	4.61	5.33	3.14	4.23	4.07	4.45	3.78	3.79	4.18
689	4.31	4.69	4.63	4.84	4.61	4.63	4.44	3.88	4.50
707	2.64	*	*	3.37	*	3.49	*	3.55	3.26
708	3.34	3.22	3.23	3.58	3.10	2.99	2.99	3.08	3.19
709	4.67	4.52	4.94	5.29	4.58	5.14	4.44	3.80	4.67
710	4.97	5.64	5.05	4.71	4.76	4.77	5.00	4.34	4.90
711	4.57	4.79	5.19	4.24	4.34	4.39	4.61	4.22	4.54
712	4.30	4.85	4.61	4.82	5.23	4.71	3.86	3.99	4.55
Mean	4.21	4.70	4.48	4.57	4.54	4.51	4.38	4.00	**4.42**

III. Historical Baseline Data by Landmark

In this section, we provide data that are key components of the historical baseline. Many of the figures in this section use a selection of "common landmarks" that we have identified for illustration purposes only; these common landmarks are *Albert Anchorage, Carrington Point, Chinese Harbor, Gull Island, Willows Anchorage,* and *Yellowbanks Anchorage.*

A. Catch

Table 41: Catch By Landmark, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Total
Albert Anchorage	1,028	1,055	1,531	2,031	3,270	8,915
Anacapa Island	8,954	4,463	10,360	12,654	12,813	49,244
Arch Rock	*	*	366	736	1,044	2,317
Bechers Bay	*	984	441	*	828	2,489
Bee Rock	567	1,024	1,366	1,736	1,420	6,113
Blue Banks Anchorage	180	*	*	*	*	379
Bowen Point	*	*	*	1,117	411	2,282
Brockway Point	■	*	2,321	3,081	2,753	9,493
Carrington Point	150	642	913	3,343	2,004	7,052
Cavern Point	491	1,163	917	915	949	4,435
Chinese Harbor	581	665	973	1,253	1,317	4,789
Christi Beach	13	*	*	*	*	31
Coche Point	506	*	*	747	*	3,281
Coches Prietos Anchorage	*	*	*	*	156	388
Cueva Valdez	315	*	*	*	1,207	1,871
Diablo Point	529	*	■	995	798	2,987
East Point	■	771	589	*	1,739	3,741
Ford Point	■	*	1,417	1,192	2,140	7,416
Forney Cove	1,183	717	1,124	*	■	5,682
Fraser Point	592	*	*	*	*	4,336
Frys Harbor	202	■	*	247	308	833
Gull Island	1,047	1,541	1,482	3,544	2,755	10,369
Kinton Point	1,142	757	641	1,606	1,561	5,707
Morse Point	*	606	474	*	*	2,397
Orizaba	*	*	*	*	152	345
Pelican Bay	*	326	254	*	382	1,279

Landmark	1999	2000	2001	2002	2003	Total
Posa Anchorage	274	*	*	*	*	1,011
Potato Harbor	183	*	*	*	*	827
Prisoners Harbor	122	*	*	*	1,958	2,344
Rodes Reef	816	*	■	1,232	2,619	5,957
San Pedro Point	*	671	*	*	*	2,169
Sandstone Point	347	600	*	*	2,207	5,621
Santa Cruz Island	2,327	2,246	■	*	4,683	13,896
Santa Rosa Island	10,515	5,681	10,645	16,860	25,452	69,153
Scorpion Anchorage	155	274	413	627	1,061	2,530
Smugglers Cove	355	*	2,103	■	1,023	3,838
South Point	*	*	264	*	*	1,043
Talcott Shoal	1,252	2,583	3,499	5,990	13,016	26,340
Valley Anchorage	487	868	1,142	2,602	2,395	7,494
West Point	167	777	1,030	1,362	1,565	4,901
Willows Anchorage	1,136	605	1,984	586	1,131	5,442
Yellow Bluff	35	*	*	*	794	1,096
Yellowbanks Anchorage	8,551	5,168	4,839	9,848	9,203	37,609
Total	47,804	39,674	58,134	82,952	110,878	**339,442**

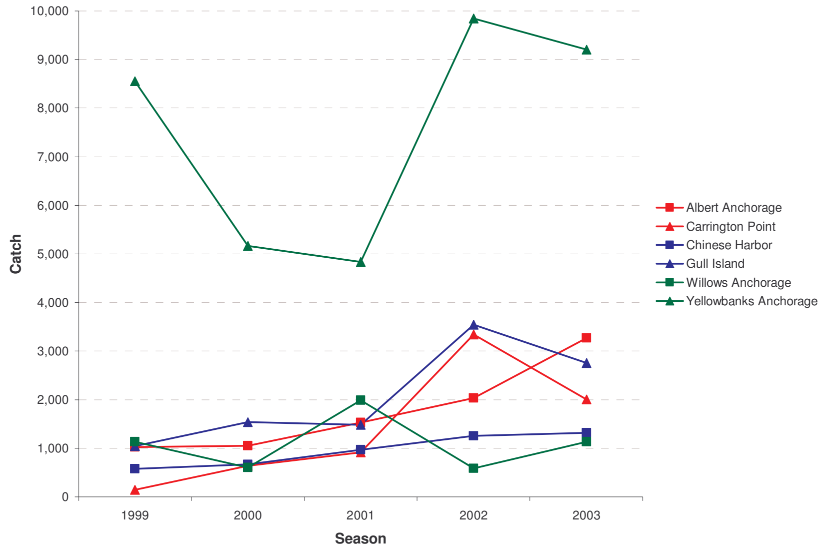
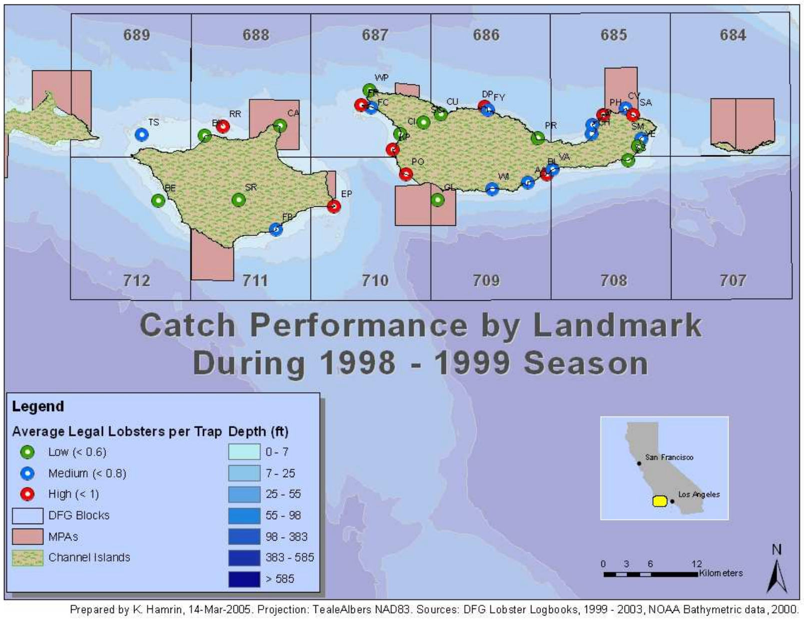
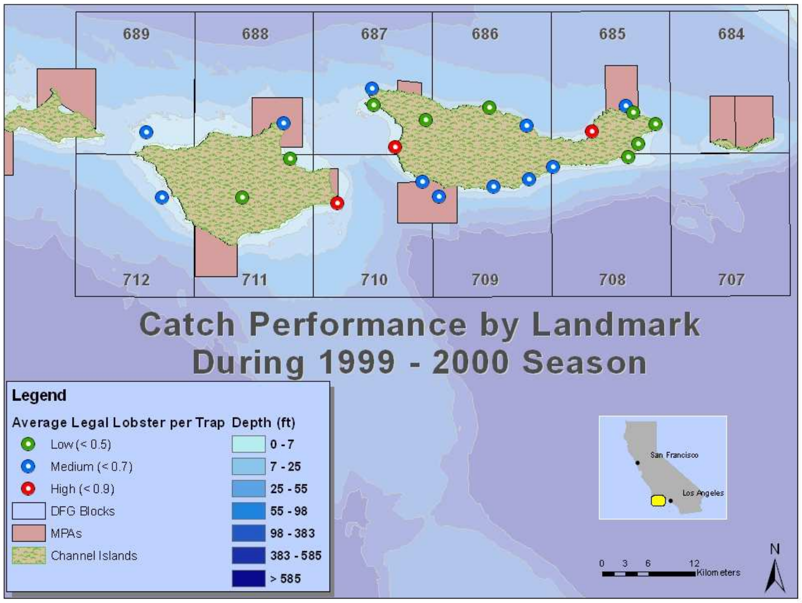


Figure 42: Catch For Common Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

B. Catch Performance

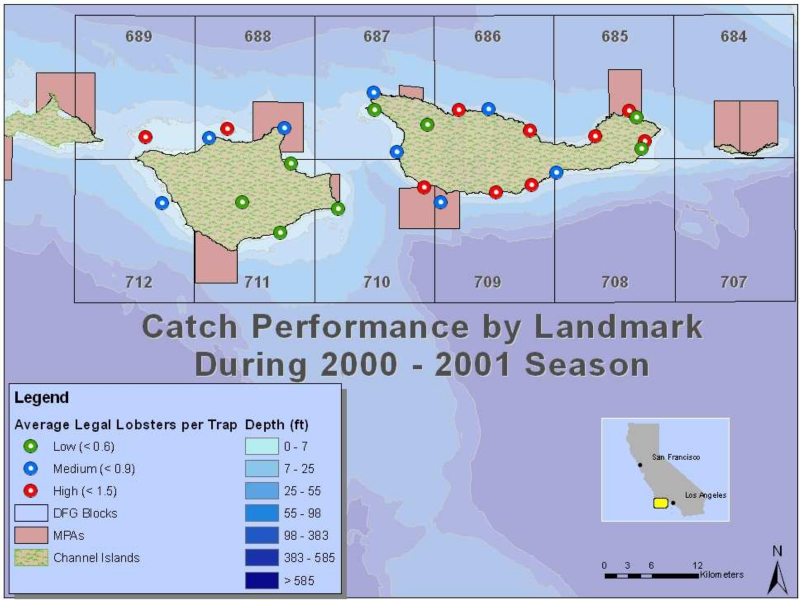


Map 9: Mean Catch Performance by Landmark for 1999 Season.



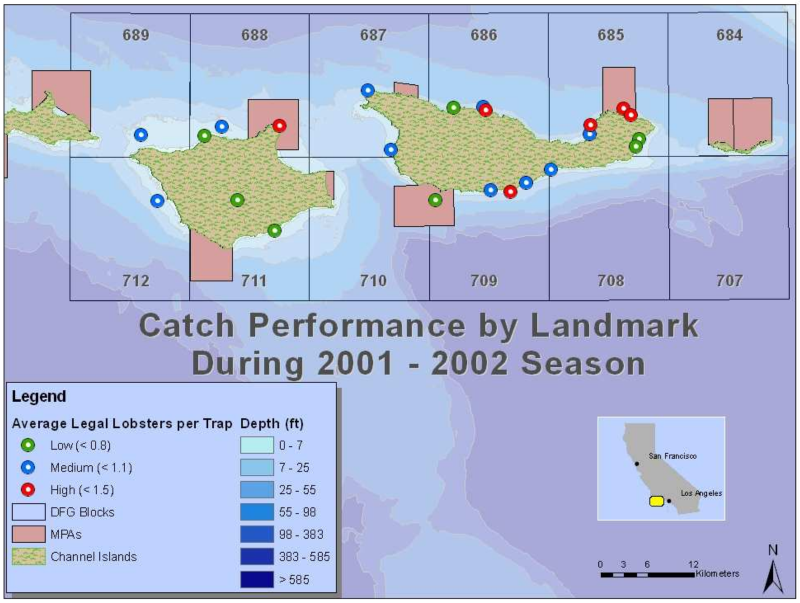
Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 10: Mean Catch Performance by Landmark for 2000 Season.



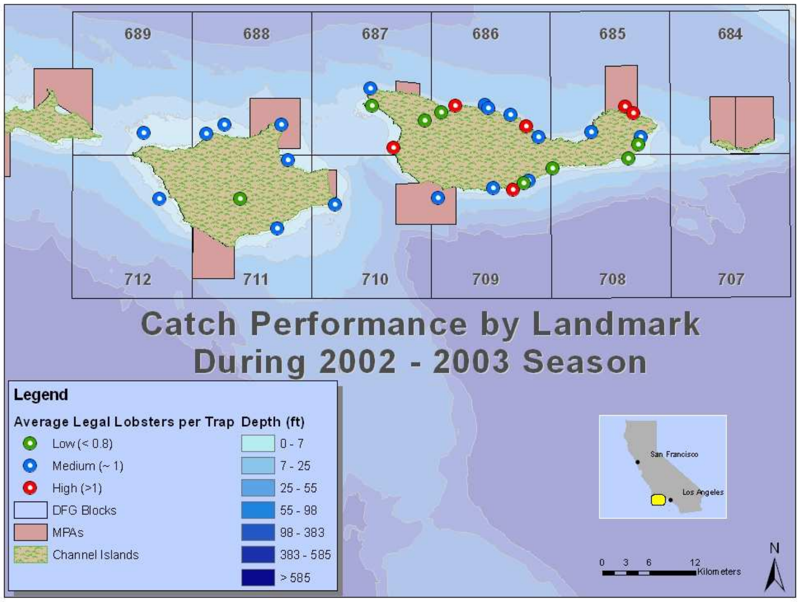
Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 11: Mean Catch Performance by Landmark for 2001 Season.



Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 12: Mean Catch Performance by Landmark for 2002 Season.



Prepared by K. Hamrin, 14-Mar-2005. Projection: TealeAlbers NAD83. Sources: DFG Lobster Logbooks, 1999 - 2003, NOAA Bathymetric data, 2000.

Map 13: Mean Catch Performance by Landmark for 2003 Season.

Table 42: Mean Catch Performance For Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Mean
Albert Anchorage	0.615	0.620	0.935	0.875	0.868	0.783
Anacapa Island	0.777	0.608	0.906	1.173	0.796	0.852
Arch Rock	*	*	0.918	0.829	1.574	0.941
Bechers Bay	*	0.427	0.434	*	0.982	0.568
Bee Rock	0.570	0.713	0.854	0.886	0.918	0.788
Blue Banks Anchorage	0.881	*	*	*	*	1.044
Bowen Point	*	*	*	1.263	1.779	1.042
Brockway Point	■	*	0.705	0.805	0.929	0.678
Carrington Point	0.515	0.532	0.763	1.330	1.191	0.866
Cavern Point	0.762	0.731	0.951	1.318	1.383	1.029
Chinese Harbor	0.765	0.879	0.937	1.146	0.937	0.933
Christi Beach	0.311	*	*	*	*	0.540
Coche Point	0.739	*	*	1.359	*	1.102
Coches Prietos Anchorage	*	*	*	*	0.555	0.923
Cueva Valdez	0.578	*	*	*	0.641	0.726
Diablo Point	1.014	*	■	1.061	0.943	0.942
East Point	■	0.892	0.508	*	1.022	0.805
Ford Point	■	*	0.472	0.792	1.054	0.711
Forney Cove	0.686	0.452	0.440	*	■	0.626
Fraser Point	0.918	*	*	*	*	1.243
Frys Harbor	0.613	■	*	1.376	0.868	0.805
Gull Island	0.540	0.639	0.750	0.793	0.830	0.710
Kinton Point	0.851	0.778	0.660	0.954	1.262	0.901
Morse Point	*	0.642	0.998	*	*	1.091
Orizaba	*	*	*	*	1.171	0.926
Pelican Bay	*	0.627	1.494	*	1.565	1.038
Posa Anchorage	1.058	*	*	*	*	1.427
Potato Harbor	0.965	*	*	*	*	1.052
Prisoners Harbor	0.338	*	*	*	1.062	0.541
Rodes Reef	0.860	*	■	0.975	1.077	0.923
San Pedro Point	*	0.367	*	*	*	0.657
Sandstone Point	0.445	0.417	*	*	0.726	0.684

Landmark	1999	2000	2001	2002	2003	Mean
Santa Cruz Island	0.562	0.414	■	*	0.572	0.491
Santa Rosa Island	0.557	0.409	0.496	0.700	0.804	0.593
Scorpion Anchorage	0.854	0.414	0.595	1.506	1.397	0.953
Smugglers Cove	0.685	*	0.993	■	0.985	0.760
South Point	*	*	0.819	*	*	0.755
Talcott Shoal	0.627	0.660	1.091	0.915	0.831	0.825
Valley Anchorage	0.785	0.589	0.719	1.072	0.789	0.791
West Point	0.477	0.556	0.806	1.026	0.979	0.769
Willows Anchorage	0.635	0.696	0.958	0.982	0.890	0.832
Yellow Bluff	0.526	*	*	*	0.537	0.629
Yellowbanks Anchorage	0.468	0.344	0.445	0.509	0.378	0.429
Mean	0.669	0.641	0.843	1.022	1.005	**0.834**

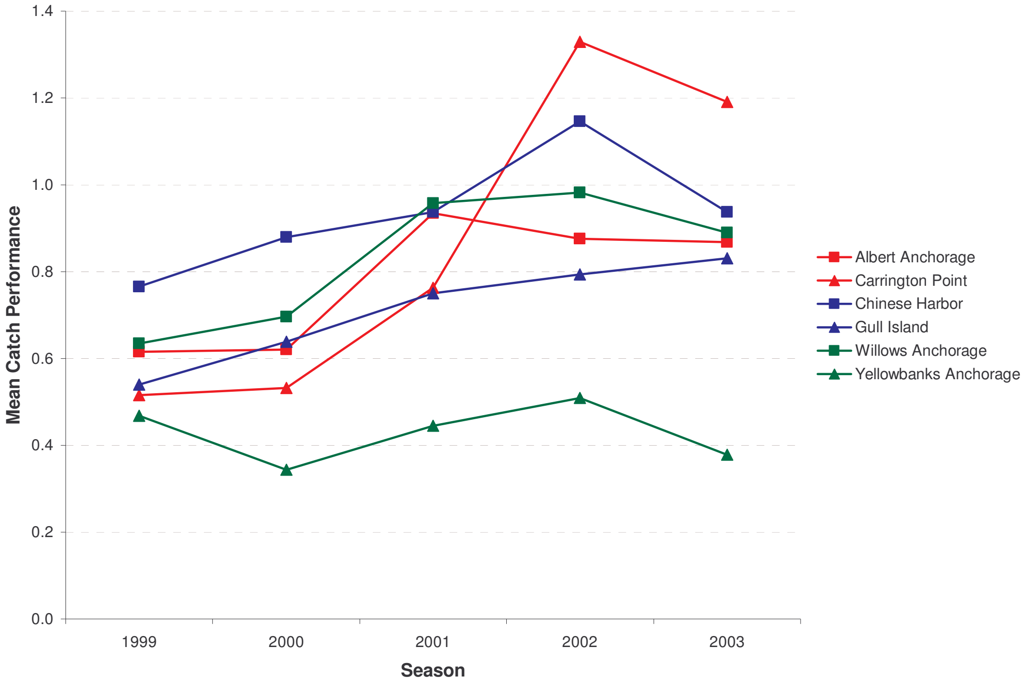


Figure 43: Mean Catch Performance For Common Landmarks, 1999 – 2003. Source: (DFG, 2003d).

C. Traps Pulled

Table 43: Traps Pulled For Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Total
Albert Anchorage	1,748	1,760	1,963	2,454	4,351	12,276
Anacapa Island	11,916	7,436	12,497	11,475	17,429	60,753
Arch Rock	*	*	493	911	722	2,304
Bechers Bay	*	2,096	863	*	815	4,227
Bee Rock	848	1,562	1,534	1,835	1,546	7,325
Blue Banks Anchorage	301	*	*	*	*	641
Bowen Point	*	*	*	1,164	330	2,605
Brockway Point	■	*	3,370	3,544	2,798	12,505
Carrington Point	291	1,101	1,120	3,302	1,883	7,697
Cavern Point	733	1,828	1,173	798	836	5,368
Chinese Harbor	843	855	929	1,247	1,595	5,469
Christi Beach	65	*	*	*	*	101
Coche Point	783	*	*	572	*	3,128
Coches Prietos Anchorage	*	*	*	*	231	591
Cueva Valdez	664	*	*	*	1,945	3,237
Diablo Point	662	*	■	1,033	1,558	4,089
East Point	■	717	960	*	1,677	4,275
Ford Point	■	*	3,057	1,685	1,809	11,056
Forney Cove	1,837	1,415	2,329	*	■	9,098
Fraser Point	581	*	*	*	*	3,506
Frys Harbor	379	■	*	249	377	1,135
Gull Island	1,926	2,608	2,193	4,760	3,522	15,009
Kinton Point	1,445	1,089	1,023	1,802	1,443	6,802
Morse Point	*	946	496	*	*	2,639
Orizaba	*	*	*	*	136	373
Pelican Bay	*	542	228	*	335	1,687
Posa Anchorage	246	*	*	*	*	832
Potato Harbor	217	*	*	*	*	851
Prisoners Harbor	359	*	*	*	2,040	3,363
Rodes Reef	902	*	■	1,295	2,507	6,224
San Pedro Point	*	1,993	*	*	*	4,092

Landmark	1999	2000	2001	2002	2003	Total
Sandstone Point	650	1,235	*	*	3,145	7,791
Santa Cruz Island	4,004	5,401	■	*	9,045	28,048
Santa Rosa Island	20,298	14,800	22,830	26,898	33,755	118,581
Scorpion Anchorage	247	617	1,182	521	1,076	3,643
Smugglers Cove	515	*	2,431	■	1,411	5,006
South Point	*	*	345	*	*	1,459
Talcott Shoal	2,122	3,731	3,793	6,380	18,548	34,574
Valley Anchorage	752	1,502	1,600	2,407	3,957	10,218
West Point	492	1,592	1,376	1,379	2,317	7,156
Willows Anchorage	2,050	901	2,600	661	1,593	7,805
Yellow Bluff	70	*	*	*	1,526	2,086
Yellowbanks Anchorage	24,081	20,071	14,090	23,574	26,308	108,124
Total	87,869	83,962	94,548	113,101	158,269	**537,749**

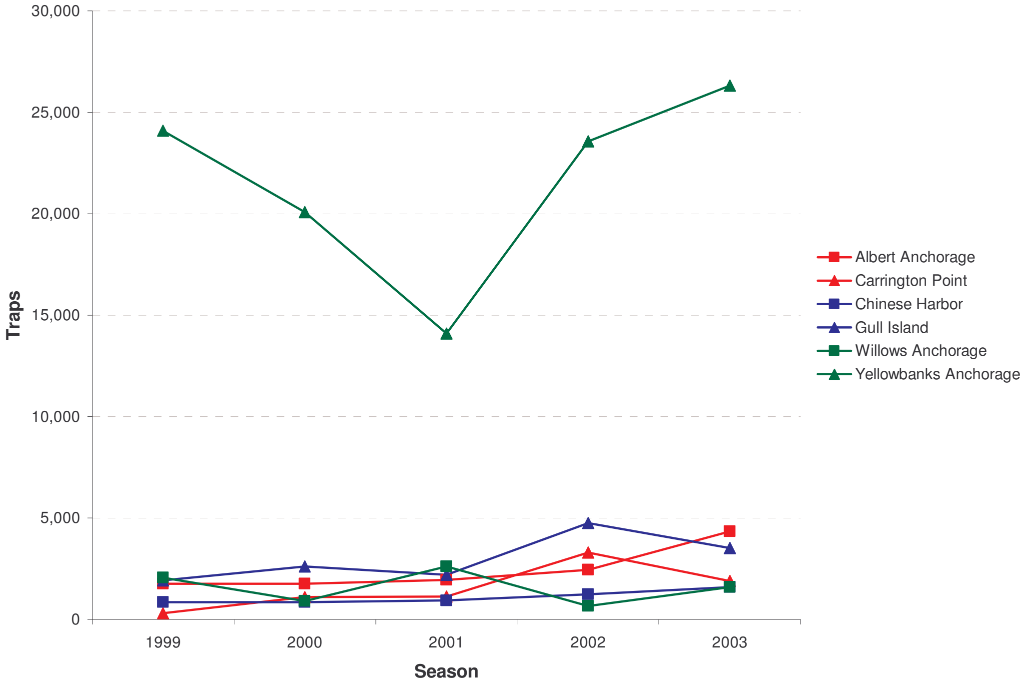


Figure 44: Traps Pulled For Common Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

D. Shorts Released

Table 44: Shorts Released For Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Total
Albert Anchorage	621	486	613	809	1,108	3,637
Anacapa Island	2,043	783	2,251	2,825	3,252	11,154
Arch Rock	*	*	363	231	367	1,096
Bechers Bay	*	527	81	*	311	959
Bee Rock	135	668	1,381	385	401	2,970
Blue Banks Anchorage	101	*	*	*	*	286
Bowen Point	*	*	*	375	158	948
Brockway Point	■	*	1,042	1,212	954	3,411
Carrington Point	127	202	1,039	1,287	1,060	3,715
Cavern Point	244	381	363	288	370	1,646
Chinese Harbor	332	333	233	445	512	1,855
Christi Beach	13	*	*	*	*	19
Coche Point	222	*	*	337	*	1,340
Coches Prietos Anchorage	*	*	*	*	137	343
Cueva Valdez	233	*	*	*	437	761
Diablo Point	204	*	■	327	592	1,360
East Point	■	233	239	*	804	1,494
Ford Point	■	*	982	407	825	3,577
Forney Cove	615	326	405	*	■	2,109
Fraser Point	221	*	*	*	*	1,701
Frys Harbor	164	■	*	95	268	583
Gull Island	475	732	1,883	1,561	1,302	5,953
Kinton Point	659	428	609	791	978	3,465
Morse Point	*	244	215	*	*	1,824
Orizaba	*	*	*	*	98	264
Pelican Bay	*	124	77	*	139	498
Posa Anchorage	200	*	*	*	*	651
Potato Harbor	117	*	*	*	*	464
Prisoners Harbor	61	*	*	*	518	704
Rodes Reef	217	*	■	482	914	2,290
San Pedro Point	*	554	*	*	*	1,266

Landmark	1999	2000	2001	2002	2003	Total
Sandstone Point	262	860	*	*	1,877	4,585
Santa Cruz Island	1,547	1,864	■	*	5,845	12,609
Santa Rosa Island	3,029	2,517	7,682	8,949	11,914	34,091
Scorpion Anchorage	79	60	92	169	312	712
Smugglers Cove	337	*	5,132	■	1,085	6,789
South Point	*	*	184	*	*	377
Talcott Shoal	315	1,249	3,000	1,474	4,850	10,888
Valley Anchorage	393	568	617	1,806	1,924	5,308
West Point	45	580	1,257	748	1,481	4,111
Willows Anchorage	696	224	745	259	580	2,504
Yellow Bluff	11	*	*	*	1,005	1,299
Yellowbanks Anchorage	8,190	7,316	6,131	10,448	7,811	39,896
Total	23,172	24,160	40,983	40,941	56,256	**185,512**

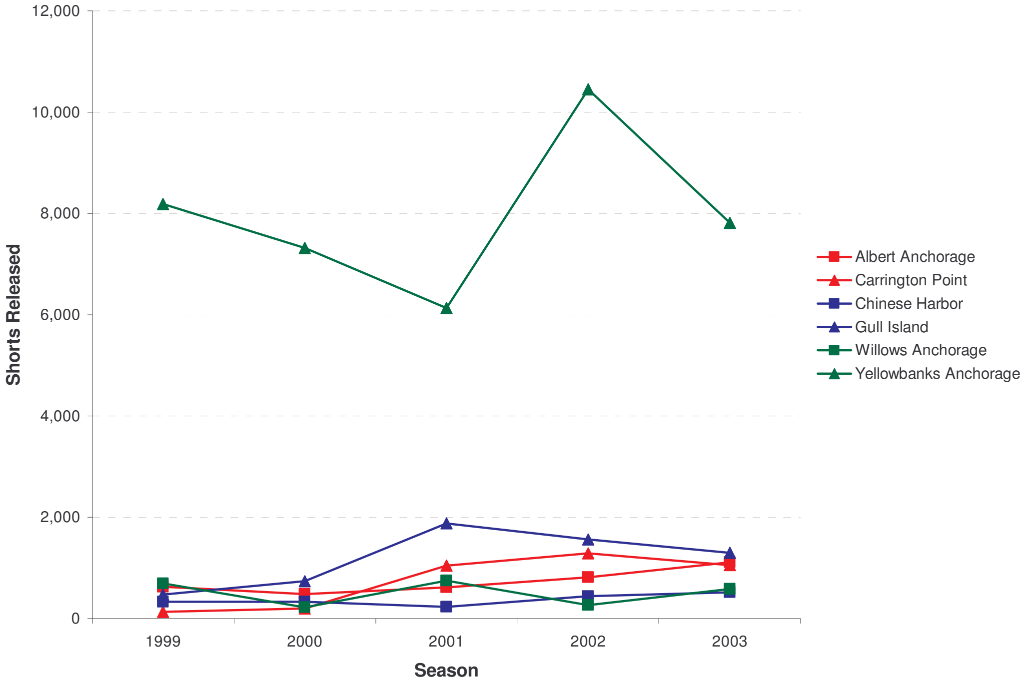


Figure 45: Shorts Released For Common Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

E. Depth

Table 45: Mean Depth Fished For Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Mean
Albert Anchorage	49.49	51.42	53.00	60.69	45.69	52.06
Anacapa Island	54.80	37.36	64.31	59.14	58.92	54.91
Arch Rock	*	*	53.33	49.17	60.17	59.87
Bechers Bay	*	36.53	25.19	*	34.89	37.61
Bee Rock	77.95	49.48	60.66	52.56	50.49	58.23
Blue Banks Anchorage	55.00	*	*	*	*	42.67
Bowen Point	*	*	*	57.67	58.42	62.94
Brockway Point	■	*	63.83	50.00	37.04	56.97
Carrington Point	65.54	65.44	56.79	62.01	52.30	60.42
Cavern Point	60.71	56.04	66.36	62.90	59.03	61.01
Chinese Harbor	49.85	61.77	58.14	57.66	44.54	54.39
Christi Beach	53.33	*	*	*	*	45.11
Coche Point	65.00	*	*	70.28	*	72.22
Coches Prietos Anchorage	*	*	*	*	49.17	67.92
Cueva Valdez	63.67	*	*	*	61.69	84.40
Diablo Point	75.83	*	■	73.20	80.63	76.89
East Point	■	49.04	40.22	*	45.27	55.75
Ford Point	■	*	33.04	52.78	42.92	47.12
Forney Cove	65.00	52.00	48.70	*	■	58.65
Fraser Point	63.20	*	*	*	*	75.48
Frys Harbor	76.59	■	*	70.00	45.79	70.29
Gull Island	49.05	44.39	24.51	40.63	30.89	37.89
Kinton Point	41.07	35.14	31.05	35.94	33.63	35.37
Morse Point	*	35.00	29.32	*	*	33.92
Orizaba	*	*	*	*	51.36	63.73
Pelican Bay	*	60.50	47.27	*	58.35	56.05
Posa Anchorage	55.10	*	*	*	*	56.59
Potato Harbor	74.33	*	*	*	*	74.23
Prisoners Harbor	45.00	*	*	*	38.84	46.12
Rodes Reef	66.88	*	■	50.63	52.41	56.39
San Pedro Point	*	43.75	*	*	*	61.32

Landmark	1999	2000	2001	2002	2003	Mean
Sandstone Point	44.67	50.29	*	*	22.25	33.79
Santa Cruz Island	75.22	46.95	■	*	51.44	61.87
Santa Rosa Island	57.27	54.04	44.46	44.63	50.99	50.28
Scorpion Anchorage	69.32	53.57	60.43	62.88	52.96	59.83
Smugglers Cove	75.28	*	35.92	■	76.69	51.14
South Point	*	*	75.00	*	*	71.70
Talcott Shoal	82.36	65.77	69.20	58.82	58.99	67.03
Valley Anchorage	41.12	29.97	27.56	32.20	31.91	32.55
West Point	70.00	62.13	43.25	59.38	80.07	62.96
Willows Anchorage	46.19	58.65	45.43	56.83	47.83	50.99
Yellow Bluff	41.67	*	*	*	33.09	32.32
Yellowbanks Anchorage	47.47	38.77	31.14	34.28	29.08	36.15
Mean	61.14	58.34	52.74	54.94	50.76	**55.60**

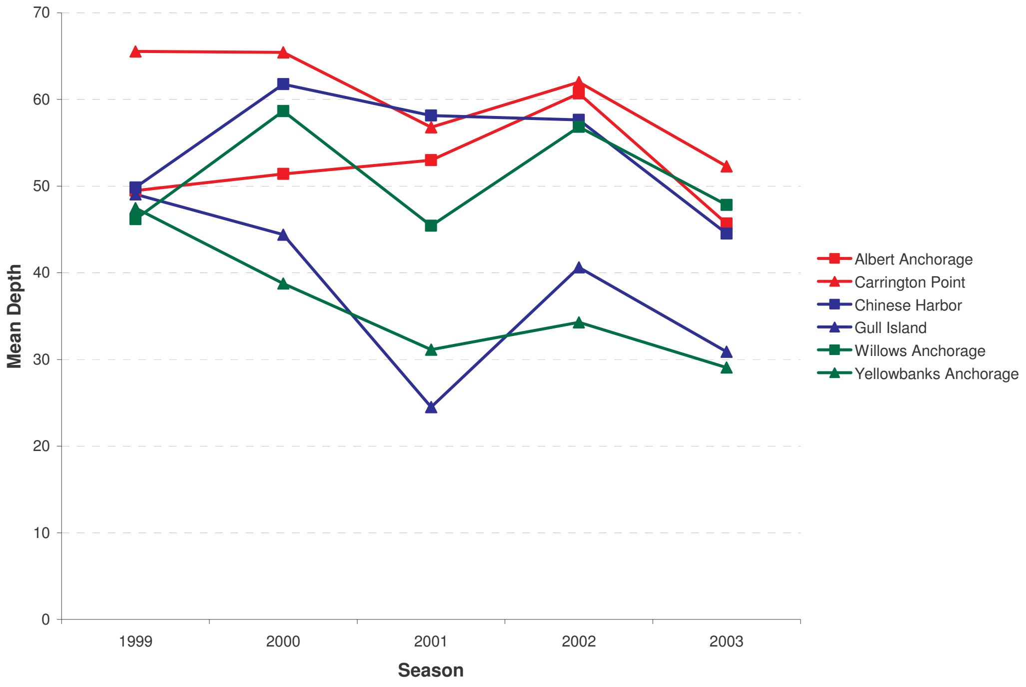


Figure 46: Mean Depth Fished For Common Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

F. Nights Soaked

Table 46: Mean Nights Soaked For Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	2003	Mean
Albert Anchorage	5.51	5.11	5.75	4.82	3.65	4.97
Anacapa Island	3.29	3.62	3.68	3.72	3.49	3.56
Arch Rock	*	*	5.67	4.33	5.21	5.66
Bechers Bay	*	3.84	3.11	*	5.17	4.11
Bee Rock	4.64	4.52	5.63	4.49	5.05	4.86
Blue Banks Anchorage	5.29	*	*	*	*	4.72
Bowen Point	*	*	*	5.23	5.68	5.94
Brockway Point	■	*	4.72	3.76	3.57	4.18
Carrington Point	4.15	5.47	4.97	4.69	4.34	4.72
Cavern Point	5.00	5.00	5.58	3.94	4.19	4.74
Chinese Harbor	5.50	5.32	4.79	4.49	4.25	4.87
Christi Beach	6.67	*	*	*	*	7.89
Coche Point	5.38	*	*	4.69	*	5.30
Coches Prietos Anchorage	*	*	*	*	5.83	7.06
Cueva Valdez	5.67	*	*	*	4.88	5.74
Diablo Point	5.46	*	■	5.68	4.28	5.83
East Point	■	4.65	4.07	*	5.45	5.19
Ford Point	■	*	3.79	5.44	5.56	4.87
Forney Cove	5.74	4.66	4.25	*	■	4.78
Fraser Point	7.44	*	*	*	*	6.00
Frys Harbor	5.86	■	*	6.08	5.37	6.77
Gull Island	5.39	4.67	3.18	3.51	2.83	3.92
Kinton Point	5.64	4.86	4.91	4.66	4.06	4.83
Morse Point	*	5.26	4.73	*	*	5.01
Orizaba	*	*	*	*	4.64	7.00
Pelican Bay	*	6.05	6.27	*	5.55	5.77
Posa Anchorage	5.52	*	*	*	*	6.89
Potato Harbor	5.80	*	*	*	*	6.22
Prisoners Harbor	5.91	*	*	*	4.76	4.46
Rodes Reef	5.19	*	■	3.72	4.66	4.82
San Pedro Point	*	3.57	*	*	*	5.78

Landmark	1999	2000	2001	2002	2003	Mean
Sandstone Point	5.40	4.11	*	*	2.10	3.31
Santa Cruz Island	3.87	3.91	■	*	3.95	3.85
Santa Rosa Island	3.97	4.10	3.63	3.28	3.24	3.64
Scorpion Anchorage	5.74	4.30	3.43	5.72	4.67	4.77
Smugglers Cove	4.56	*	3.20	■	5.08	3.67
South Point	*	*	6.43	*	*	5.51
Talcott Shoal	4.49	4.68	4.97	4.78	3.86	4.55
Valley Anchorage	5.88	3.07	3.88	3.06	4.34	4.05
West Point	5.50	4.75	3.97	4.79	4.33	4.67
Willows Anchorage	5.38	4.78	5.42	5.47	4.50	5.11
Yellow Bluff	3.00	*	*	*	2.58	3.02
Yellowbanks Anchorage	3.48	2.92	2.85	2.68	2.69	2.92
Mean	5.20	5.13	5.29	4.87	4.39	**4.98**

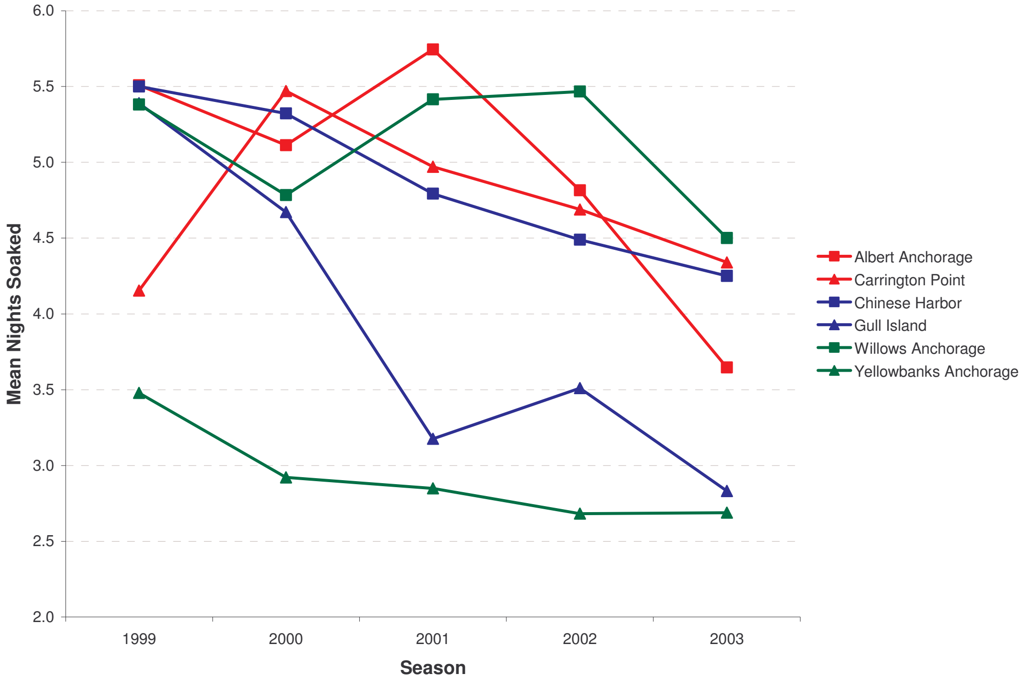


Figure 47: Mean Nights Soaked For Common Landmarks, 1999 – 2003 Seasons. Source: (DFG, 2003d).

Table 47: Number of Trapping Events for Landmarks, 1999 - 2003 Seasons. Source: (DFG, 2003d).

Landmark	1999	2000	2001	2002	20403	Total
Albert Anchorage	57	53	51	65	119	345
Anacapa Island	156	101	173	183	235	848
Arch Rock	*	*	24	24	29	92
Bechers Bay	*	49	27	*	35	127
Bee Rock	22	33	35	41	41	172
Blue Banks Anchorage	7	*	*	*	*	15
Bowen Point	*	*	*	30	19	83
Brockway Point	■	*	60	54	49	224
Carrington Point	13	34	34	87	50	218
Cavern Point	31	47	33	31	31	173
Chinese Harbor	34	31	29	47	56	197
Christi Beach	3	*	*	*	*	5
Coche Point	32	*	*	36	*	148
Coches Prietos Anchorage	*	*	*	*	12	29
Cueva Valdez	30	*	*	*	51	94
Diablo Point	24	*	■	25	32	120
East Point	■	26	41	*	49	142
Ford Point	■	*	52	36	36	201
Forney Cove	34	32	44	*	■	172
Fraser Point	25	*	*	*	*	104
Frys Harbor	22	■	*	13	19	66
Gull Island	59	64	51	94	95	363
Kinton Point	42	36	43	53	51	225
Morse Point	*	35	22	*	*	113
Orizaba	*	*	*	*	11	31
Pelican Bay	*	20	11	*	20	80
Posa Anchorage	21	*	*	*	*	68
Potato Harbor	15	*	*	*	*	55
Prisoners Harbor	11	*	*	*	55	82
Rodes Reef	26	*	■	32	56	162
San Pedro Point	*	44	*	*	*	94
Sandstone Point	30	45	*	*	40	156

Landmark	1999	2000	2001	2002	20403	Total
Santa Cruz Island	69	95	■	*	154	421
Santa Rosa Island	179	204	253	283	347	1,266
Scorpion Anchorage	19	23	23	25	45	135
Smugglers Cove	18	*	25	■	26	81
South Point	*	*	14	*	*	61
Talcott Shoal	39	62	69	108	190	468
Valley Anchorage	33	29	25	50	82	219
West Point	18	40	32	48	67	205
Willows Anchorage	63	37	65	30	60	255
Yellow Bluff	3	*	*	*	33	47
Yellowbanks Anchorage	234	179	132	211	247	1,003
Total	1,543	1,554	1,584	1,867	2,617	**9,165**

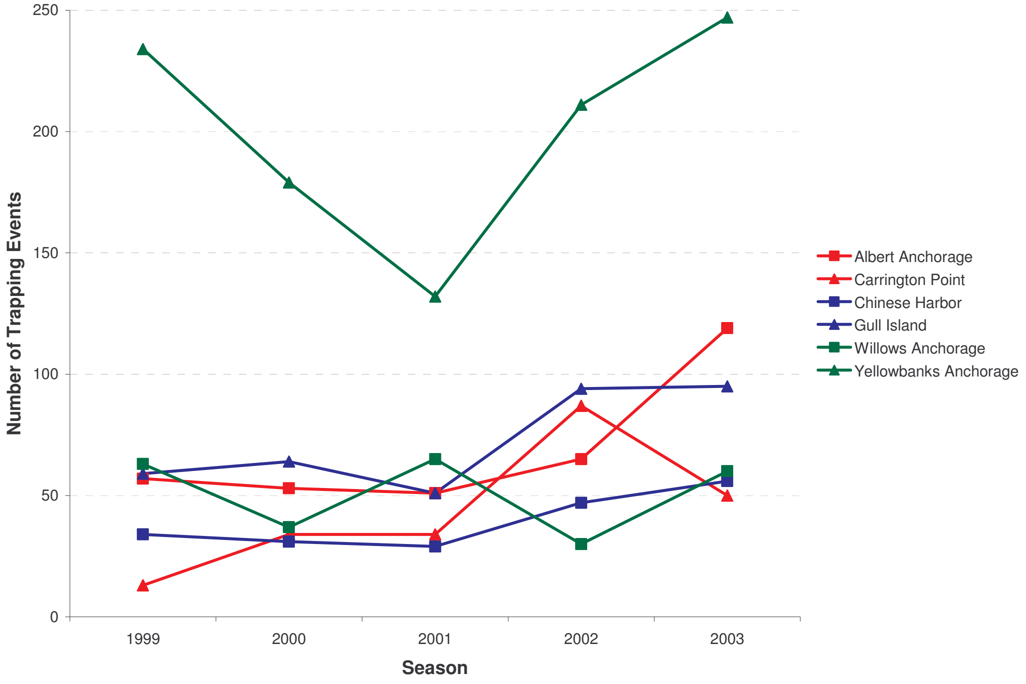


Figure 48: Number of Trapping Events For Common Landmarks, 1999 - 2003 Seasons.
Source: (DFG, 2003d).

IV. Mean lobster weight

Through cross-referencing the logbook and landing receipts, we can obtain both the weight and number of lobsters landed. Thus, we did an analysis to determine the mean weight of the spiny lobster in California.

The mean weight of a lobster is 1.40 lbs (σ=0.10) based on the data from Figure 49 which covers the 1998 – 2003 seasons. However, if you take into account the DFG compliance statistics, the mean weight is 1.48 lbs (σ=0.12). Figure 49 shows regressions for both the base data and the compliance data. The predicted mean weight is 1.47 lbs (adjusted R^2 = 0.795) for the base data, and 1.38 lbs (adjusted R^2 = 0.796) for the compliance data.

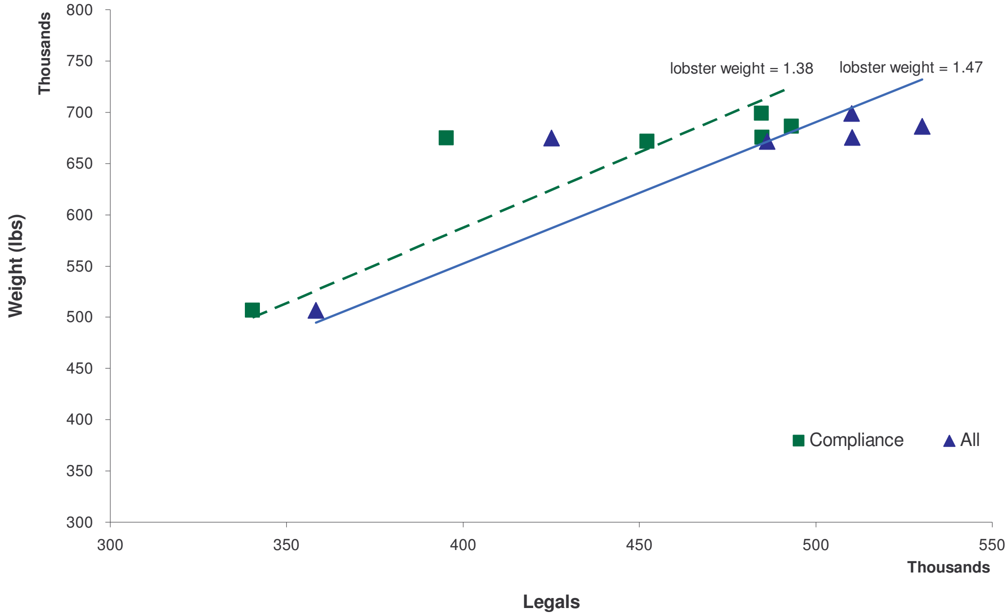


Figure 49: Mean Lobster Weight, 1999 – 2003 Seasons. Based on logbook and landing receipt cross-referencing. Source: (DFG, 2003d; Ramsay, 2003).

V. Logbook comments

Each logbook section has an optional comment section (Chapter 4). In our database, we entered 1,051 comments for 626 logbooks with an average of 1.68 comments per logbook (σ=0.81). Figure 50 shows the categorization of the content of these comments based on a 10% random sampling and 11 categorizations (Table 48).

Table 48: Logbook Comment Categories. Source: (DFG, 2003d).

- Catch Notes
- Date / Time Notes
- Fishing Comments
- Observers / Crew
- Other Notes
- Other Vessel / Pollution Observations
- Phone Numbers
- Poaching
- Sale Notes
- Vessel Problems
- Weather

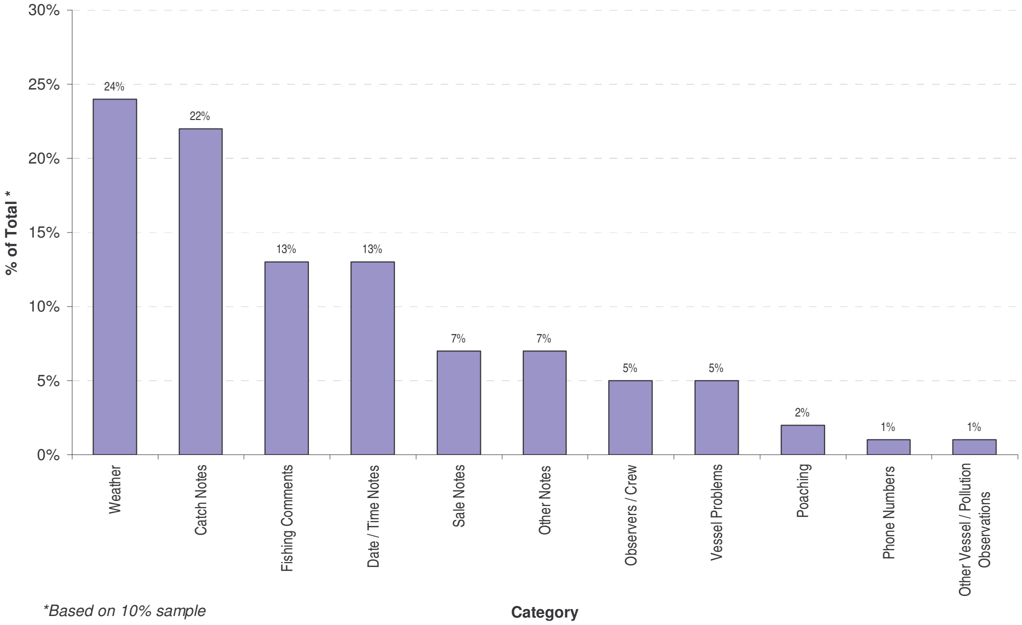


Figure 50: Logbook comment categories sorted by frequency, based on 10% sampling of over 1,000 comments from 1999 - 2003 seasons. Source: (DFG, 2003d).

VI. Pairwise comparisons between landmarks

In this section, we provide data of pairwise landmark comparisons using a set of five landmarks inside MPAs as our basis:

Inside Landmark	*MPA*
Carrington Point	Carrington Point SMR
Cavern Point	Scorpion SMR
Gull Island	Gull Island SMR
Morse Point	Gull Island SMR
Scorpion Anchorage	Scorpion SMR

This set of landmarks is our *Inside Landmarks*. In each of the following five tables, we compare the historical baseline data for the Inside Landmark to that of all of the *Outside Landmarks*. That is, an Outside Landmark is a landmark that is located anywhere except within the MPA in which the Inside Landmark resides; distance does not matter.

The data in the following tables represent the percent change between the Inside Landmark and the Outside Landmark. For example, below is a sample equation for how the percentage formula and a table describing all of the variables.

$$Catch = \frac{(Catch_{OUTSIDE} - Catch_{INSIDE})}{Catch_{INSIDE}}$$

These data are available at http://www.bren.ucsb.edu/~lobster, and the electronic version includes the values for the variables compared.

Table 49: Description Of Variables For Pairwise Landmark Comparison Tables.

Variable	Description
Outside	The Outside Landmark – the inside landmark is the same for the entire table
km	The straight line distance between the Inside and Outside landmarks (kilometers) calculated using "Great Circle" algorithm (Weisstein, 2005).
Year	The season year
Catch	% change of the number of legal lobsters retained between landmarks
CP	% change of the catch performance between landmarks
Traps	% change in the number of traps pulled between landmarks
Events	% change in the number of trapping events between landmarks

Table 50: Pairwise Comparisons Between Carrington Point And Its Outside Landmarks. Data are in terms of percent change between Inside versus Outside. Source: (DFG, 2003d).

Outside	km	Year	Catch	CP	Traps	Events
Albert Anchorage	32.60	1999	585%	19%	501%	338%
		2000	64%	17%	60%	56%
		2001	68%	23%	75%	50%
		2002	-39%	-34%	-26%	-25%
		2003	63%	-27%	131%	138%
Anacapa Island	59.49	1999	5869%	51%	3995%	1100%
		2000	595%	14%	575%	197%
		2001	1035%	19%	1016%	409%
		2002	279%	-12%	248%	110%
		2003	539%	-33%	826%	370%
Arch Rock	22.54	2001	-60%	20%	-56%	-29%
		2002	-78%	-38%	-72%	-72%
		2003	-48%	32%	-62%	-42%
Bechers Bay	4.66	2000	53%	-20%	90%	44%
		2001	-52%	-43%	-23%	-21%
		2003	-59%	-17%	-57%	-30%
Bee Rock	18.40	1999	278%	11%	191%	69%
		2000	60%	34%	42%	-3%
		2001	50%	12%	37%	3%
		2002	-48%	-33%	-44%	-53%
		2003	-29%	-23%	-18%	-18%
Blue Banks Anchorage	34.79	1999	20%	71%	3%	-46%
Bowen Point	30.93	2002	-67%	-5%	-65%	-66%
		2003	-79%	49%	-82%	-62%
Brockway Point	9.72	1999	581%	8%	584%	185%
		2001	154%	-7%	201%	76%
		2002	-8%	-39%	7%	-38%
		2003	37%	-22%	49%	-2%
Cavern Point	44.30	1999	227%	48%	152%	138%
		2000	81%	38%	66%	38%
		2001	0%	25%	5%	-3%
		2002	-73%	-1%	-76%	-64%
		2003	-53%	16%	-56%	-38%
Chinese Harbor	39.91	1999	287%	48%	190%	162%

Outside	km	Year	Catch	CP	Traps	Events
		2000	4%	65%	-22%	-9%
		2001	7%	23%	-17%	-15%
		2002	-63%	-14%	-62%	-46%
		2003	-34%	-21%	-15%	12%
Christi Beach	15.46	1999	-91%	-40%	-78%	-77%
Coche Point	40.05	1999	237%	43%	169%	146%
		2002	-78%	2%	-83%	-59%
Coches Prietos Anchorage	32.12	2003	-92%	-53%	-88%	-76%
Cueva Valdez	20.59	1999	110%	12%	128%	131%
		2003	-40%	-46%	3%	2%
Diablo Point	26.30	1999	253%	97%	127%	85%
		2001	-89%	7%	-89%	-71%
		2002	-70%	-20%	-69%	-71%
		2003	-60%	-21%	-17%	-36%
East Point	12.48	1999	115%	71%	40%	31%
		2000	20%	68%	-35%	-24%
		2001	-35%	-33%	-14%	21%
		2003	-13%	-14%	-11%	-2%
Ford Point	13.46	1999	525%	32%	370%	100%
		2001	55%	-38%	173%	53%
		2002	-64%	-40%	-49%	-59%
		2003	7%	-11%	-4%	-28%
Forney Cove	11.88	1999	689%	33%	531%	162%
		2000	12%	-15%	29%	-6%
		2001	23%	-42%	108%	29%
		2003	-19%	-34%	1%	-36%
Fraser Point	10.76	1999	295%	78%	100%	92%
Frys Harbor	26.68	1999	35%	19%	30%	69%
		2000	-89%	-12%	-89%	-68%
		2002	-93%	3%	-92%	-85%
		2003	-85%	-27%	-80%	-62%
Gull Island	22.24	1999	598%	5%	562%	354%
		2000	140%	20%	137%	88%
		2001	62%	-2%	96%	50%
		2002	6%	-40%	44%	8%
		2003	37%	-30%	87%	90%

Outside	km	Year	Catch	CP	Traps	Events
Kinton Point	14.72	1999	661%	65%	397%	223%
		2000	18%	46%	-1%	6%
		2001	-30%	-13%	-9%	26%
		2002	-52%	-28%	-45%	-39%
		2003	-22%	6%	-23%	2%
Morse Point	19.51	2000	-6%	21%	-14%	3%
		2001	-48%	31%	-56%	-35%
Orizaba	29.47	2003	-92%	-2%	-93%	-78%
Pelican Bay	31.47	2000	-49%	18%	-51%	-41%
		2001	-72%	96%	-80%	-68%
		2003	-81%	31%	-82%	-60%
Posa Anchorage	17.25	1999	83%	105%	-15%	62%
Potato Harbor	41.43	1999	22%	87%	-25%	15%
Prisoners Harbor	33.10	1999	-19%	-34%	23%	-15%
		2003	-2%	-11%	8%	10%
Rodes Reef	7.33	1999	444%	67%	210%	100%
		2001	-34%	22%	-45%	-32%
		2002	-63%	-27%	-61%	-63%
		2003	31%	-10%	33%	12%
San Pedro Point	48.12	2000	5%	-31%	81%	29%
Sandstone Point	44.82	1999	131%	-14%	123%	131%
		2000	-7%	-22%	12%	32%
		2003	10%	-39%	67%	-20%
Santa Cruz Island	18.40	1999	1451%	9%	1276%	431%
		2000	250%	-22%	391%	179%
		2001	129%	-41%	279%	38%
		2003	134%	-52%	380%	208%
Santa Rosa Island	10.97	1999	6910%	8%	6875%	1277%
		2000	785%	-23%	1244%	500%
		2001	1066%	-35%	1938%	644%
		2002	404%	-47%	715%	225%
		2003	1170%	-32%	1693%	594%
Scorpion Anchorage	45.24	1999	3%	66%	-15%	46%
		2000	-57%	-22%	-44%	-32%
		2001	-55%	-22%	6%	-32%
		2002	-81%	13%	-84%	-71%

Outside	km	Year	Catch	CP	Traps	Events
		2003	-47%	17%	-43%	-10%
Smugglers Cove	46.27	1999	137%	33%	77%	38%
		2001	130%	30%	117%	-26%
		2002	-90%	-40%	-82%	-89%
		2003	-49%	-17%	-25%	-48%
South Point	17.11	2001	-71%	7%	-69%	-59%
Talcott Shoal	17.79	1999	735%	22%	629%	200%
		2000	302%	24%	239%	82%
		2001	283%	43%	239%	103%
		2002	79%	-31%	93%	24%
		2003	550%	-30%	885%	280%
Valley Anchorage	35.35	1999	225%	52%	158%	154%
		2000	35%	11%	36%	-15%
		2001	25%	-6%	43%	-26%
		2002	-22%	-19%	-27%	-43%
		2003	20%	-34%	110%	64%
West Point	12.32	1999	11%	-8%	69%	38%
		2000	21%	5%	45%	18%
		2001	13%	6%	23%	-6%
		2002	-59%	-23%	-58%	-45%
		2003	-22%	-18%	23%	34%
Willows Anchorage	28.42	1999	657%	23%	604%	385%
		2000	-6%	31%	-18%	9%
		2001	117%	26%	132%	91%
		2002	-82%	-26%	-80%	-66%
		2003	-44%	-25%	-15%	20%
Yellowbanks Anchorage	45.95	1999	5601%	-9%	8175%	1700%
		2000	705%	-35%	1723%	426%
		2001	430%	-42%	1158%	288%
		2002	195%	-62%	614%	143%
		2003	359%	-68%	1297%	394%

Table 51: Pairwise Comparisons Between Cavern Point And Its Outside Landmarks. Source: (DFG, 2003d).

Outside	km	Year	Catch	CP	Traps	Events
Albert Anchorage	15.70	1999	109%	-19%	138%	84%
		2000	-9%	-15%	-4%	13%
		2001	67%	-2%	67%	55%
		2002	122%	-34%	208%	110%
		2003	245%	-37%	420%	284%
Anacapa Island	16.16	1999	1724%	2%	1526%	403%
		2000	284%	-17%	307%	115%
		2001	1030%	-5%	965%	424%
		2002	1283%	-11%	1338%	490%
		2003	1250%	-42%	1985%	658%
Arch Rock	21.83	2001	-60%	-3%	-58%	-27%
		2002	-20%	-37%	14%	-23%
		2003	10%	14%	-14%	-6%
Bechers Bay	43.88	2000	-15%	-42%	15%	4%
		2001	-52%	-54%	-26%	-18%
		2003	-13%	-29%	-3%	13%
Bee Rock	61.09	1999	15%	-25%	16%	-29%
		2000	-12%	-3%	-15%	-30%
		2001	49%	-10%	31%	6%
		2002	90%	-33%	130%	32%
		2003	50%	-34%	85%	32%
Blue Banks Anchorage	13.12	1999	-63%	16%	-59%	-77%
Bowen Point	18.03	2002	22%	-4%	46%	-3%
		2003	-57%	29%	-61%	-39%
Brockway Point	54.00	1999	108%	-27%	171%	19%
		2001	153%	-26%	187%	82%
		2002	237%	-39%	344%	74%
		2003	190%	-33%	235%	58%
Carrington Point	44.30	1999	-69%	-32%	-60%	-58%
		2000	-45%	-27%	-40%	-28%
		2001	0%	-20%	-5%	3%
		2002	265%	1%	314%	181%
		2003	111%	-14%	125%	61%

Outside	km	Year	Catch	CP	Traps	Events
Chinese Harbor	5.43	1999	18%	0%	15%	10%
		2000	-43%	20%	-53%	-34%
		2001	6%	-1%	-21%	-12%
		2002	37%	-13%	56%	52%
		2003	39%	-32%	91%	81%
Christi Beach	29.00	1999	-97%	-59%	-91%	-90%
Coche Point	4.69	1999	3%	-3%	7%	3%
		2002	-18%	3%	-28%	16%
Coches Prietos Anchorage	16.34	2003	-84%	-60%	-72%	-61%
Cueva Valdez	23.72	1999	-36%	-24%	-9%	-3%
		2003	27%	-54%	133%	65%
Diablo Point	18.06	1999	8%	33%	-10%	-23%
		2001	-89%	-14%	-90%	-70%
		2002	9%	-20%	29%	-19%
		2003	-16%	-32%	86%	3%
East Point	39.40	1999	-34%	15%	-44%	-45%
		2000	-34%	22%	-61%	-45%
		2001	-36%	-47%	-18%	24%
		2003	83%	-26%	101%	58%
Ford Point	47.46	1999	91%	-11%	87%	-16%
		2001	55%	-50%	161%	58%
		2002	30%	-40%	111%	16%
		2003	126%	-24%	116%	16%
Forney Cove	32.61	1999	141%	-10%	151%	10%
		2000	-38%	-38%	-23%	-32%
		2001	23%	-54%	99%	33%
		2003	70%	-43%	126%	3%
Fraser Point	33.82	1999	21%	20%	-21%	-19%
Frys Harbor	17.65	1999	-59%	-20%	-48%	-29%
		2000	-94%	-36%	-93%	-77%
		2002	-73%	4%	-69%	-58%
		2003	-68%	-37%	-55%	-39%
Gull Island	26.85	1999	113%	-29%	163%	90%
		2000	33%	-13%	43%	36%
		2001	62%	-21%	87%	55%
		2002	287%	-40%	496%	203%

Outside	km	Year	Catch	CP	Traps	Events
		2003	190%	-40%	321%	206%
Kinton Point	30.30	1999	133%	12%	97%	35%
		2000	-35%	6%	-40%	-23%
		2001	-30%	-31%	-13%	30%
		2002	76%	-28%	126%	71%
		2003	64%	-9%	73%	65%
Morse Point	28.06	2000	-48%	-12%	-48%	-26%
		2001	-48%	5%	-58%	-33%
Orizaba	14.84	2003	-84%	-15%	-84%	-65%
Pelican Bay	13.02	2000	-72%	-14%	-70%	-57%
		2001	-72%	57%	-81%	-67%
		2003	-60%	13%	-60%	-35%
Posa Anchorage	29.43	1999	-44%	39%	-66%	-32%
Potato Harbor	2.96	1999	-63%	27%	-70%	-52%
Prisoners Harbor	11.83	1999	-75%	-56%	-51%	-65%
		2003	106%	-23%	144%	77%
Rodes Reef	51.62	1999	66%	13%	23%	-16%
		2001	-34%	-2%	-47%	-30%
		2002	35%	-26%	62%	3%
		2003	176%	-22%	200%	81%
San Pedro Point	4.54	2000	-42%	-50%	9%	-6%
Sandstone Point	6.66	1999	-29%	-42%	-11%	-3%
		2000	-48%	-43%	-32%	-4%
		2003	133%	-48%	276%	29%
Santa Cruz Island	25.91	1999	374%	-26%	446%	123%
		2000	93%	-43%	195%	102%
		2001	128%	-53%	262%	42%
		2003	393%	-59%	982%	397%
Santa Rosa Island	50.98	1999	2042%	-27%	2669%	477%
		2000	388%	-44%	710%	334%
		2001	1061%	-48%	1846%	667%
		2002	1743%	-47%	3271%	813%
		2003	2582%	-42%	3938%	1019%
Scorpion Anchorage	1.28	1999	-68%	12%	-66%	-39%
		2000	-76%	-43%	-66%	-51%
		2001	-55%	-37%	1%	-30%

Outside	km	Year	Catch	CP	Traps	Events
		2002	-31%	14%	-35%	-19%
		2003	12%	1%	29%	45%
Smugglers Cove	4.42	1999	-28%	-10%	-30%	-42%
		2001	129%	4%	107%	-24%
		2002	-63%	-39%	-27%	-68%
		2003	8%	-29%	69%	-16%
South Point	53.99	2001	-71%	-14%	-71%	-58%
Talcott Shoal	62.09	1999	155%	-18%	189%	26%
		2000	122%	-10%	104%	32%
		2001	282%	15%	223%	109%
		2002	555%	-31%	699%	248%
		2003	1272%	-40%	2119%	513%
Valley Anchorage	12.25	1999	-1%	3%	3%	6%
		2000	-25%	-19%	-18%	-38%
		2001	25%	-24%	36%	-24%
		2002	184%	-19%	202%	61%
		2003	152%	-43%	373%	165%
West Point	32.90	1999	-66%	-37%	-33%	-42%
		2000	-33%	-24%	-13%	-15%
		2001	12%	-15%	17%	-3%
		2002	49%	-22%	73%	55%
		2003	65%	-29%	177%	116%
Willows Anchorage	20.00	1999	131%	-17%	180%	103%
		2000	-48%	-5%	-51%	-21%
		2001	116%	1%	122%	97%
		2002	-36%	-26%	-17%	-3%
		2003	19%	-36%	91%	94%
Yellowbanks Anchorage	5.12	1999	1642%	-39%	3185%	655%
		2000	344%	-53%	998%	281%
		2001	428%	-53%	1101%	300%
		2002	976%	-61%	2854%	581%
		2003	870%	-73%	3047%	697%

Table 52: Pairwise Comparisons Between Gull Island And Its Outside Landmarks. Source: (DFG, 2003d).

Outside	km	Year	Catch	CP	Traps	Events
Albert Anchorage	11.87	1999	-2%	14%	-9%	-3%
		2000	-32%	-3%	-33%	-17%
		2001	3%	25%	-10%	0%
		2002	-43%	10%	-48%	-31%
		2003	19%	5%	24%	25%
Anacapa Island	39.76	1999	755%	44%	519%	164%
		2000	190%	-5%	185%	58%
		2001	599%	21%	470%	239%
		2002	257%	48%	141%	95%
		2003	365%	-4%	395%	147%
Arch Rock	12.13	2001	-75%	22%	-78%	-53%
		2002	-79%	5%	-81%	-74%
		2003	-62%	90%	-80%	-69%
Bechers Bay	19.83	2000	-36%	-33%	-20%	-23%
		2001	-70%	-42%	-61%	-47%
		2003	-70%	18%	-77%	-63%
Bee Rock	35.78	1999	-46%	6%	-56%	-63%
		2000	-34%	12%	-40%	-48%
		2001	-8%	14%	-30%	-31%
		2002	-51%	12%	-61%	-56%
		2003	-48%	11%	-56%	-57%
Blue Banks Anchorage	14.50	1999	-83%	63%	-84%	-88%
Bowen Point	9.70	2002	-68%	59%	-76%	-68%
		2003	-85%	114%	-91%	-80%
Brockway Point	30.87	1999	-2%	3%	3%	-37%
		2001	57%	-6%	54%	18%
		2002	-13%	1%	-26%	-43%
		2003	0%	12%	-21%	-48%
Carrington Point	22.24	1999	-86%	-5%	-85%	-78%
		2000	-58%	-17%	-58%	-47%
		2001	-38%	2%	-49%	-33%
		2002	-6%	68%	-31%	-7%
		2003	-27%	43%	-47%	-47%

Outside	km	Year	Catch	CP	Traps	Events
Cavern Point	26.85	1999	-53%	41%	-62%	-47%
		2000	-25%	14%	-30%	-27%
		2001	-38%	27%	-47%	-35%
		2002	-74%	66%	-83%	-67%
		2003	-66%	67%	-76%	-67%
Chinese Harbor	21.54	1999	-45%	42%	-56%	-42%
		2000	-57%	38%	-67%	-52%
		2001	-34%	25%	-58%	-43%
		2002	-65%	44%	-74%	-50%
		2003	-52%	13%	-55%	-41%
Christi Beach	9.67	1999	-99%	-42%	-97%	-95%
Coche Point	22.17	1999	-52%	37%	-59%	-46%
		2002	-79%	71%	-88%	-62%
Coches Prietos Anchorage	11.26	2003	-94%	-33%	-93%	-87%
Cueva Valdez	11.08	1999	-70%	7%	-66%	-49%
		2003	-56%	-23%	-45%	-46%
Diablo Point	13.49	1999	-49%	88%	-66%	-59%
		2001	-93%	9%	-94%	-80%
		2002	-72%	34%	-78%	-73%
		2003	-71%	14%	-56%	-66%
East Point	13.21	1999	-69%	63%	-79%	-71%
		2000	-50%	40%	-73%	-59%
		2001	-60%	-32%	-56%	-20%
		2003	-37%	23%	-52%	-48%
Ford Point	21.02	1999	-11%	26%	-29%	-56%
		2001	-4%	-37%	39%	2%
		2002	-66%	0%	-65%	-62%
		2003	-22%	27%	-49%	-62%
Forney Cove	14.63	1999	13%	27%	-5%	-42%
		2000	-53%	-29%	-46%	-50%
		2001	-24%	-41%	6%	-14%
		2003	-41%	-5%	-46%	-66%
Fraser Point	15.55	1999	-43%	70%	-70%	-58%
Frys Harbor	13.30	1999	-81%	14%	-80%	-63%
		2000	-96%	-27%	-95%	-83%
		2002	-93%	73%	-95%	-86%

Outside	km	Year	Catch	CP	Traps	Events
		2003	-89%	5%	-89%	-80%
Kinton Point	8.64	1999	9%	58%	-25%	-29%
		2000	-51%	22%	-58%	-44%
		2001	-57%	-12%	-53%	-16%
		2002	-55%	20%	-62%	-44%
		2003	-43%	52%	-59%	-46%
Morse Point	2.86	2000	-61%	1%	-64%	-45%
		2001	-68%	33%	-77%	-57%
Orizaba	14.22	2003	-94%	41%	-96%	-88%
Pelican Bay	14.66	2000	-79%	-2%	-79%	-69%
		2001	-83%	99%	-90%	-78%
		2003	-86%	89%	-90%	-79%
Posa Anchorage	5.17	1999	-74%	96%	-87%	-64%
Potato Harbor	23.95	1999	-83%	79%	-89%	-75%
Prisoners Harbor	15.18	1999	-88%	-37%	-81%	-81%
		2003	-29%	28%	-42%	-42%
Rodes Reef	29.02	1999	-22%	59%	-53%	-56%
		2001	-59%	24%	-72%	-55%
		2002	-65%	23%	-73%	-66%
		2003	-5%	30%	-29%	-41%
San Pedro Point	29.55	2000	-56%	-43%	-24%	-31%
Sandstone Point	25.03	1999	-67%	-18%	-66%	-49%
		2000	-61%	-35%	-53%	-30%
		2003	-20%	-13%	-11%	-58%
Santa Cruz Island	10.13	1999	122%	4%	108%	17%
		2000	46%	-35%	107%	48%
		2001	41%	-40%	93%	-8%
		2003	70%	-31%	157%	62%
Santa Rosa Island	25.45	1999	904%	3%	954%	203%
		2000	269%	-36%	467%	219%
		2001	618%	-34%	941%	396%
		2002	376%	-12%	465%	201%
		2003	824%	-3%	858%	265%
Scorpion Anchorage	27.39	1999	-85%	58%	-87%	-68%
		2000	-82%	-35%	-76%	-64%
		2001	-72%	-21%	-46%	-55%

Outside	km	Year	Catch	CP	Traps	Events
		2002	-82%	90%	-89%	-73%
		2003	-61%	68%	-69%	-53%
Smugglers Cove	27.27	1999	-66%	27%	-73%	-69%
		2001	42%	32%	11%	-51%
		2002	-91%	1%	-88%	-89%
		2003	-63%	19%	-60%	-73%
South Point	27.48	2001	-82%	9%	-84%	-73%
Talcott Shoal	38.78	1999	20%	16%	10%	-34%
		2000	68%	3%	43%	-3%
		2001	136%	45%	73%	35%
		2002	69%	15%	34%	15%
		2003	372%	0%	427%	100%
Valley Anchorage	15.28	1999	-53%	45%	-61%	-44%
		2000	-44%	-8%	-42%	-55%
		2001	-23%	-4%	-27%	-51%
		2002	-27%	35%	-49%	-47%
		2003	-13%	-5%	12%	-14%
West Point	16.58	1999	-84%	-12%	-74%	-69%
		2000	-50%	-13%	-39%	-38%
		2001	-30%	7%	-37%	-37%
		2002	-62%	29%	-71%	-49%
		2003	-43%	18%	-34%	-29%
Willows Anchorage	7.22	1999	9%	18%	6%	7%
		2000	-61%	9%	-65%	-42%
		2001	34%	28%	19%	27%
		2002	-83%	24%	-86%	-68%
		2003	-59%	7%	-55%	-37%
Yellowbanks Anchorage	26.68	1999	717%	-13%	1150%	297%
		2000	235%	-46%	670%	180%
		2001	227%	-41%	542%	159%
		2002	178%	-36%	395%	124%
		2003	234%	-54%	647%	160%

Table 53: Pairwise Comparisons Between Morse Point And Its Outside Landmarks. Source: (DFG, 2003d).

Outside	km	Year	Catch	CP	Traps	Events
Albert Anchorage	13.80	2000	74%	-3%	86%	51%
		2001	223%	-6%	296%	132%
Anacapa Island	41.63	2000	636%	-5%	686%	189%
		2001	2086%	-9%	2420%	686%
Arch Rock	10.94	2001	-23%	-8%	-1%	9%
Bechers Bay	17.34	2000	62%	-33%	122%	40%
		2001	-7%	-57%	74%	23%
Bee Rock	33.71	2000	69%	11%	65%	-6%
		2001	188%	-14%	209%	59%
Brockway Point	28.33	2001	390%	-29%	579%	173%
Carrington Point	19.51	2000	6%	-17%	16%	-3%
		2001	93%	-24%	126%	55%
Cavern Point	28.06	2000	92%	14%	93%	34%
		2001	93%	-5%	136%	50%
Chinese Harbor	22.89	2000	10%	37%	-10%	-11%
		2001	105%	-6%	87%	32%
Diablo Point	13.04	2001	-78%	-18%	-75%	-55%
East Point	11.40	2000	27%	39%	-24%	-26%
		2001	24%	-49%	94%	86%
Ford Point	19.42	2001	199%	-53%	516%	136%
Forney Cove	11.85	2000	18%	-30%	50%	-9%
		2001	137%	-56%	370%	100%
Frys Harbor	12.97	2000	-89%	-27%	-87%	-69%
Gull Island	2.86	2000	154%	-1%	176%	83%
		2001	213%	-25%	342%	132%
Kinton Point	5.80	2000	25%	21%	15%	3%
		2001	35%	-34%	106%	95%
Pelican Bay	15.37	2000	-46%	-2%	-43%	-43%
		2001	-46%	50%	-54%	-50%
Rodes Reef	26.40	2001	27%	-7%	25%	5%
San Pedro Point	31.06	2000	11%	-43%	111%	26%
Sandstone Point	26.82	2000	-1%	-35%	31%	29%
Santa Cruz Island	8.08	2000	271%	-35%	471%	171%
		2001	341%	-55%	755%	114%

Outside	km	Year	Catch	CP	Traps	Events
Santa Rosa Island	23.40	2000	837%	-36%	1464%	483%
		2001	2146%	-50%	4503%	1050%
Scorpion Anchorage	28.70	2000	-55%	-36%	-35%	-34%
		2001	-13%	-40%	138%	5%
Smugglers Cove	28.87	2001	344%	-1%	390%	14%
South Point	25.95	2001	-44%	-18%	-30%	-36%
Talcott Shoal	36.31	2000	326%	3%	294%	77%
		2001	638%	9%	665%	214%
Valley Anchorage	17.03	2000	43%	-8%	59%	-17%
		2001	141%	-28%	223%	14%
West Point	13.85	2000	28%	-13%	68%	14%
		2001	117%	-19%	177%	45%
Willows Anchorage	9.26	2000	0%	8%	-5%	6%
		2001	319%	-4%	424%	195%
Yellowbanks Anchorage	28.35	2000	753%	-46%	2022%	411%
		2001	921%	-55%	2741%	500%

Table 54: Pairwise Comparisons Between Scorpion Anchorage And Its Outside Landmarks.
Source: (DFG, 2003d).

Outside	km	Year	Catch	CP	Traps	Events
Albert Anchorage	16.02	1999	563%	-28%	608%	200%
		2000	285%	50%	185%	130%
		2001	271%	57%	66%	122%
		2002	224%	-42%	371%	160%
		2003	208%	-38%	304%	164%
Anacapa Island	14.96	1999	5677%	-9%	4724%	721%
		2000	1529%	47%	1105%	339%
		2001	2408%	52%	957%	652%
		2002	1918%	-22%	2102%	632%
		2003	1108%	-43%	1520%	422%
Arch Rock	22.83	2001	-11%	54%	-58%	4%
		2002	17%	-45%	75%	-4%
		2003	-2%	13%	-33%	-36%
Bechers Bay	44.73	2000	259%	3%	240%	113%
		2001	7%	-27%	-27%	17%
		2003	-22%	-30%	-24%	-22%
Bee Rock	61.89	1999	266%	-33%	243%	16%
		2000	274%	72%	153%	43%
		2001	231%	43%	30%	52%
		2002	177%	-41%	252%	64%
		2003	34%	-34%	44%	-9%
Blue Banks Anchorage	13.39	1999	16%	3%	22%	-63%
Bowen Point	18.36	2002	78%	-16%	123%	20%
		2003	-61%	27%	-69%	-58%
Brockway Point	54.92	1999	559%	-35%	706%	95%
		2001	462%	19%	185%	161%
		2002	391%	-47%	580%	116%
		2003	159%	-33%	160%	9%
Carrington Point	45.24	1999	-3%	-40%	18%	-32%
		2000	134%	28%	78%	48%
		2001	121%	28%	-5%	48%
		2002	433%	-12%	534%	248%
		2003	89%	-15%	75%	11%
Cavern Point	1.28	1999	217%	-11%	197%	63%

Outside	km	Year	Catch	CP	Traps	Events
		2000	324%	77%	196%	104%
		2001	122%	60%	-1%	43%
		2002	46%	-12%	53%	24%
		2003	-11%	-1%	-22%	-31%
Chinese Harbor	5.85	1999	275%	-10%	241%	79%
		2000	143%	112%	39%	35%
		2001	136%	57%	-21%	26%
		2002	100%	-24%	139%	88%
		2003	24%	-33%	48%	24%
Christi Beach	29.90	1999	-92%	-64%	-74%	-84%
Coche Point	5.32	1999	226%	-13%	217%	68%
		2002	19%	-10%	10%	44%
Coches Prietos Anchorage	16.67	2003	-85%	-60%	-79%	-73%
Cueva Valdez	24.69	1999	103%	-32%	169%	58%
		2003	14%	-54%	81%	13%
Diablo Point	19.07	1999	241%	19%	168%	26%
		2001	-75%	37%	-90%	-57%
		2002	59%	-30%	98%	0%
		2003	-25%	-32%	45%	-29%
East Point	40.08	1999	108%	3%	65%	-11%
		2000	181%	115%	16%	13%
		2001	43%	-15%	-19%	78%
		2003	64%	-27%	56%	9%
Ford Point	48.12	1999	505%	-21%	454%	37%
		2001	243%	-21%	159%	126%
		2002	90%	-47%	223%	44%
		2003	102%	-25%	68%	-20%
Forney Cove	33.60	1999	663%	-20%	644%	79%
		2000	162%	9%	129%	39%
		2001	172%	-26%	97%	91%
		2003	52%	-43%	76%	-29%
Fraser Point	34.82	1999	282%	7%	135%	32%
Frys Harbor	18.64	1999	30%	-28%	53%	16%
		2000	-75%	13%	-81%	-52%
		2002	-61%	-9%	-52%	-48%
		2003	-71%	-38%	-65%	-58%

Outside	km	Year	Catch	CP	Traps	Events
Gull Island	27.39	1999	575%	-37%	680%	211%
		2000	462%	54%	323%	178%
		2001	259%	26%	86%	122%
		2002	465%	-47%	814%	276%
		2003	160%	-41%	227%	111%
Kinton Point	31.14	1999	637%	0%	485%	121%
		2000	176%	88%	76%	57%
		2001	55%	11%	-13%	87%
		2002	156%	-37%	246%	112%
		2003	47%	-10%	34%	13%
Morse Point	28.70	2000	121%	55%	53%	52%
		2001	15%	68%	-58%	-4%
Orizaba	15.78	2003	-86%	-16%	-87%	-76%
Pelican Bay	13.85	2000	19%	52%	-12%	-13%
		2001	-38%	151%	-81%	-52%
		2003	-64%	12%	-69%	-56%
Posa Anchorage	30.15	1999	77%	24%	0%	11%
Potato Harbor	3.82	1999	18%	13%	-12%	-21%
Prisoners Harbor	12.53	1999	-21%	-60%	45%	-42%
		2003	85%	-24%	90%	22%
Rodes Reef	52.57	1999	426%	1%	265%	37%
		2001	46%	56%	-48%	0%
		2002	96%	-35%	149%	28%
		2003	147%	-23%	133%	24%
San Pedro Point	3.28	2000	145%	-11%	223%	91%
Sandstone Point	5.85	1999	124%	-48%	163%	58%
		2000	119%	1%	100%	96%
		2003	108%	-48%	192%	-11%
Santa Cruz Island	26.84	1999	1401%	-34%	1521%	263%
		2000	720%	0%	775%	313%
		2001	406%	-25%	259%	104%
		2003	341%	-59%	741%	242%
Santa Rosa Island	51.74	1999	6684%	-35%	8118%	842%
		2000	1973%	-1%	2299%	787%
		2001	2477%	-17%	1831%	1000%
		2002	2589%	-54%	5063%	1032%

Outside	km	Year	Catch	CP	Traps	Events
		2003	2299%	-42%	3037%	671%
Smugglers Cove	3.28	1999	129%	-20%	109%	-5%
		2001	409%	67%	106%	9%
		2002	-47%	-47%	12%	-60%
		2003	-4%	-30%	31%	-42%
South Point	54.65	2001	-36%	38%	-71%	-39%
Talcott Shoal	63.03	1999	708%	-27%	759%	105%
		2000	843%	59%	505%	170%
		2001	747%	83%	221%	200%
		2002	855%	-39%	1125%	332%
		2003	1127%	-40%	1624%	322%
Valley Anchorage	12.53	1999	214%	-8%	204%	74%
		2000	217%	42%	143%	26%
		2001	177%	21%	35%	9%
		2002	315%	-29%	362%	100%
		2003	126%	-43%	268%	82%
West Point	33.95	1999	8%	-44%	99%	-5%
		2000	184%	34%	158%	74%
		2001	149%	35%	16%	39%
		2002	117%	-32%	165%	92%
		2003	48%	-30%	115%	49%
Willows Anchorage	20.44	1999	633%	-26%	730%	232%
		2000	121%	68%	46%	61%
		2001	380%	61%	120%	183%
		2002	-7%	-35%	27%	20%
		2003	7%	-36%	48%	33%
Yellowbanks Anchorage	4.07	1999	5417%	-45%	9649%	1132%
		2000	1786%	-17%	3153%	678%
		2001	1072%	-25%	1092%	474%
		2002	1471%	-66%	4425%	744%
		2003	767%	-73%	2345%	449%

VII. Data integrity

Our error rates were in the 1 – 2% range for processing the DFG logbook data. Most of these errors were during the event conversion stage as the DFG logbook database storage the data as text fields and our validation processes would catch type mismatch errors (i.e., a block number that had the letter "L" rather than a one).

Among our worst error rates occurred processing the data for the last lines of the logbook form sections (Line #5, #10, and #15). And the reverse was true – our best error rates were from the first lines of the logbook form sections (Line #1, Line #6, and Line #11). In Figure 51 these are visible as the points with the most records (for the first lines) and the least records (for the last lines). Either the error rates improve with scale, or trappers make more errors in the latter portions of the sections. A linear regression on these data does not fit well with an adjusted R^2 of 0.383.

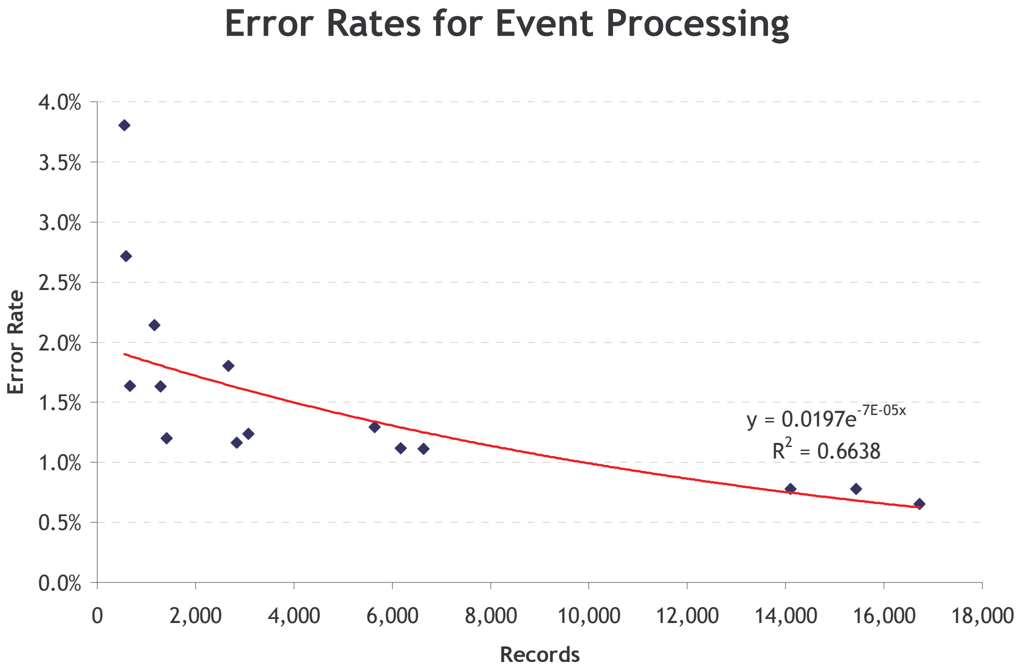


Figure 51: Error Rates in DFG Database Conversion. Source: (DFG, 2003d).

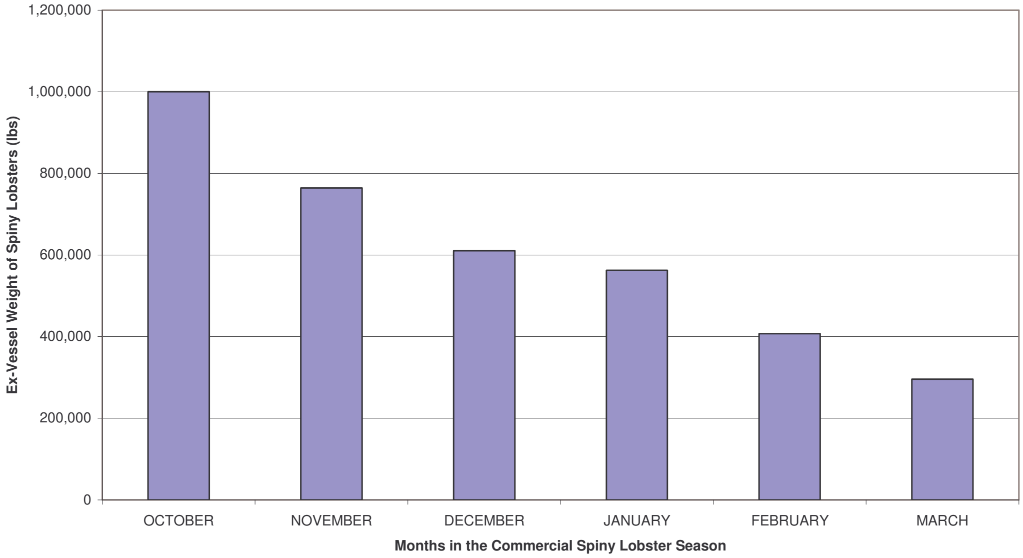
Appendix K: Economic Value of Lobster Catch

I. Ex-Vessel Weight and Value over Time

Using the California Commercial Landings database, we summarized the spiny lobster landings for the Santa Barbara fishing area, as well as for all areas of California from 1984 to 2003. This data is pertinent to our study because it provides tertiary information on the historical baseline catch information, specifically for temporal patterns. The spiny lobster commercial landings information provides a condensed and summarized representation of the spiny lobster commercial catch and effort over time, for various fishing areas in California. The spiny lobster commercial landings provide only summarized data for a historical baseline of lobster catch because lobsters are recorded by the pound (and not by count of individuals sold) and there is no spatial reference to the fishing location other than by fishing region. Therefore, the commercial landings data is useful to note the pattern of catch for fishing regions over time, but it does not have a fine-grain spatial representation. One useful aspect of the commercial landing data is that it can show trapping effort patterns within seasons. For example, Figure 52 shows the landings of spiny lobsters (by weight) for sale decreases throughout the commercial season.

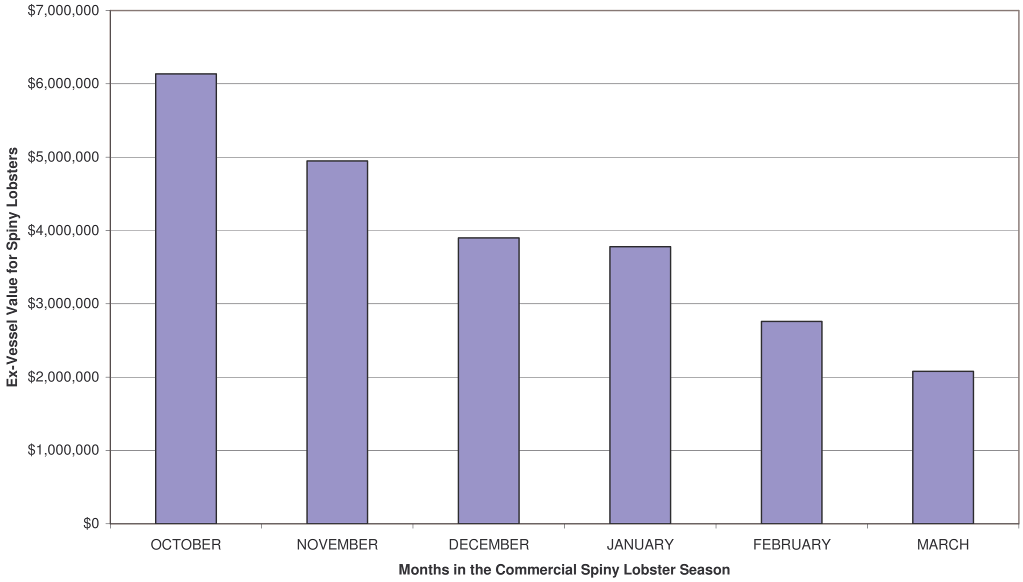
All data reported from the *California Commercial Landings* database (DFG, 2000, 2003c) is referred to as Ex-Vessel weight and value. The data is defined using the term "Ex-Vessel" because this means "off the boat." The commercial landings data does not reflect any market weight or value, only the weight and value of spiny lobsters sold directly from the fishing boats to commercial buyers. The commercial buyers may in turn, change the price of spiny lobster sold per pound, or discard some lobsters to not be sold due to appendages lost, or injuries sustained during transporting, to private buyers.

We also summarized the Ex-Vessel value for spiny lobsters throughout the commercial season. Here, the Ex-Vessel value is the price per pound sold times the weight of lobsters sold, totaled for all commercial seasons from 1984 to 2003. Figure 53 shows that the Ex-Vessel value for spiny lobster decreases throughout the commercial season.



Prepared by Sofia Hamrin, 01/20/2005, www.bren.ucsb.edu/~lobster. Sources: Source: CDFG. (2004). Final California Commercial Landings For 1984 - 2003. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).

Figure 52: Monthly Ex-Vessel Weight of Spiny Lobsters in Santa Barbara from 1984 – 2003.



Prepared by Sofia Hamrin, 01/20/2005, www.bren.ucsb.edu/~lobster. Sources: Source: CDFG. (2004). Final California Commercial Landings For 1984 - 2003. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).

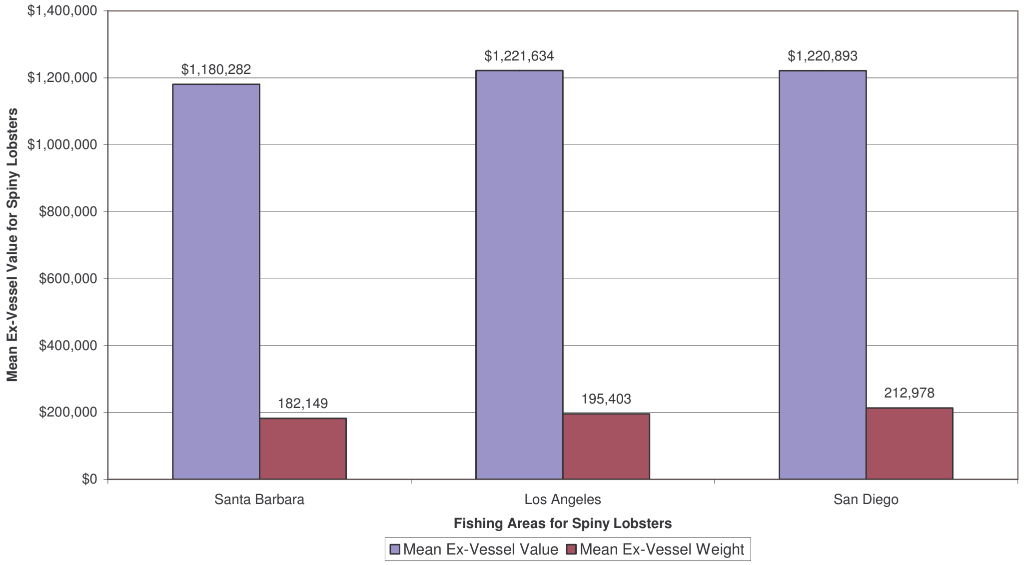
Figure 53: Monthly Ex-Vessel Value for Spiny Lobsters in Santa Barbara from 1984 – 2003.

II. Comparison of Ex-Vessel Weight and Value for Santa Barbara to other Fishing Areas

We believe it is important to report not only the catch and trapping effort patterns for Santa Barbara over time, but for all other fishing areas for spiny lobster as well. Comparison of the Santa Barbara fishing area to Los Angeles and San Diego fishing areas (Figure 54) reveal that Santa Barbara is an economically important fishing area. Although, Santa Barbara has the lowest mean Ex-vessel weight and value, it is not far apart from the more prominent areas of Los Angeles and San Diego. Figure 54 has the mean Ex-Vessel weight and value from 1984 to 2003 because the catch, effort, weight, and value fluctuate over time within each fishing area.

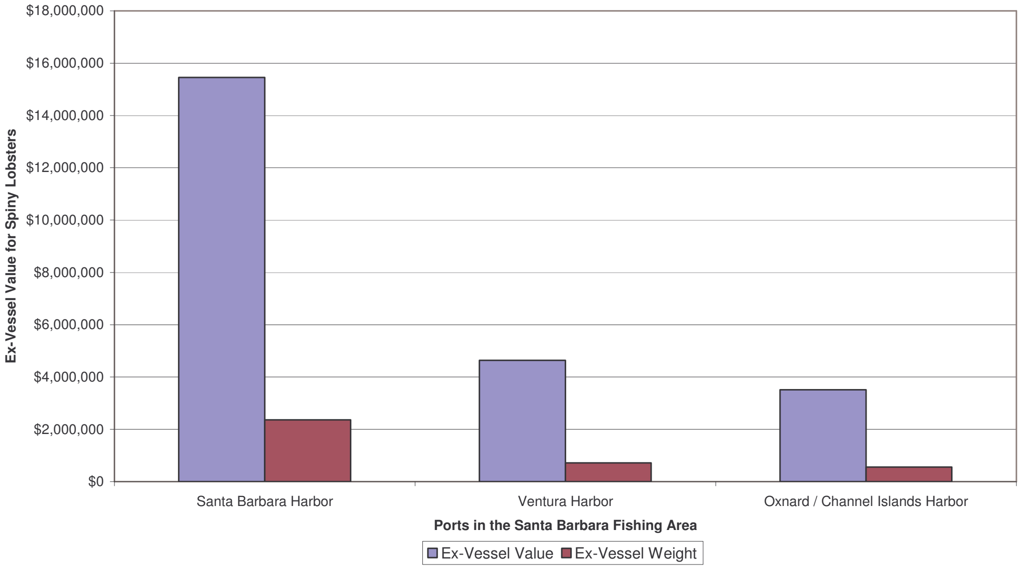
To further investigate the lobster catch and effort for the Santa Barbara fishing area, we summarized the Ex-Vessel weight and value per port. Shown in Figure 55, Santa Barbara Harbor has the highest Ex-Vessel weight and value. We believe the Ex-Vessel weight and value on a per port basis is another coarse-grain indicator of where commercial lobstermen fish. For example, a commercial landing of spiny lobster in the Oxnard/Channel Island Harbor could be from Santa Rosa Island, but it is most likely from closer fishing grounds. The logic for such reasoning is that the cost of fuel and time for boat travel would most likely not increase the economic rent to commercial trappers. The spatial representation of catch data from commercial landings categorized by port certainly cannot be depicted with higher resolution. However, certain patterns of port use, correlated with Ex-Vessel weight and value can point towards larger spatial areas that are more frequently fished, supporting a historical baseline of catch data for the Santa Barbara fishing area.

As previously shown, Santa Barbara Harbor has the highest Ex-Vessel weight and value. We summarized the number of times a port was recorded in the commercial landing records and also calculated the average price per pound of lobster from 1984 to 2003 in Figure 56. Santa Barbara harbor is used roughly 75% of the time for commercial landings, and also has the highest average price per pound of lobster.



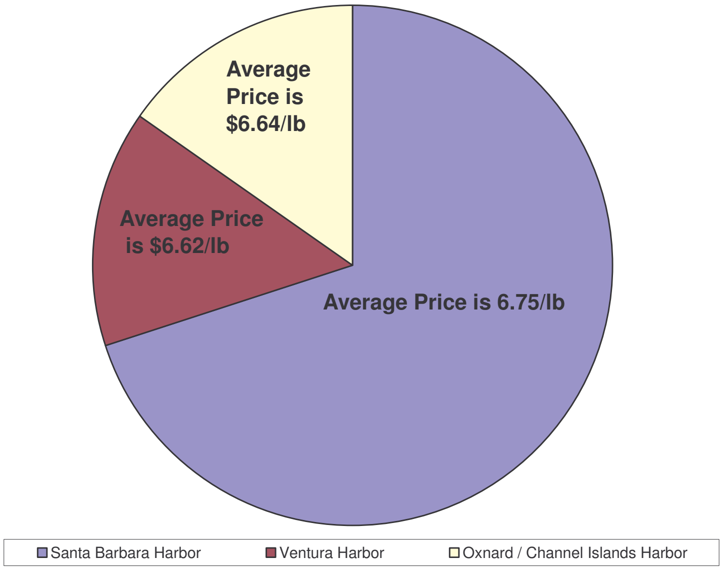
Prepared by Sofia Hamrin, 01/20/2005, www.bren.ucsb.edu/~lobster. Sources: Source: CDFG. (2004). Final California Commercial Landings For 1984 - 2003. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).
Morro Bay data was not used. It accounts for .1% of data. Due to data reporting errors, another .2% of data was not used as well.

Figure 54: Mean Ex-Vessel Value and Mean Ex-Vessel Weight for Spiny Lobsters from 1984 – 2003.



Prepared by Sofia Hamrin, 01/20/2005, www.bren.ucsb.edu/~lobster. Sources: Source: CDFG. (2004). Final California Commercial Landings For 1984 - 2003. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG).
Due to data privacy concerns .06% of data was not used for this chart.

Figure 55: Mean Ex-Vessel Value and Mean Ex-Vessel Weight of Spiny Lobsters from 1984 – 2003.



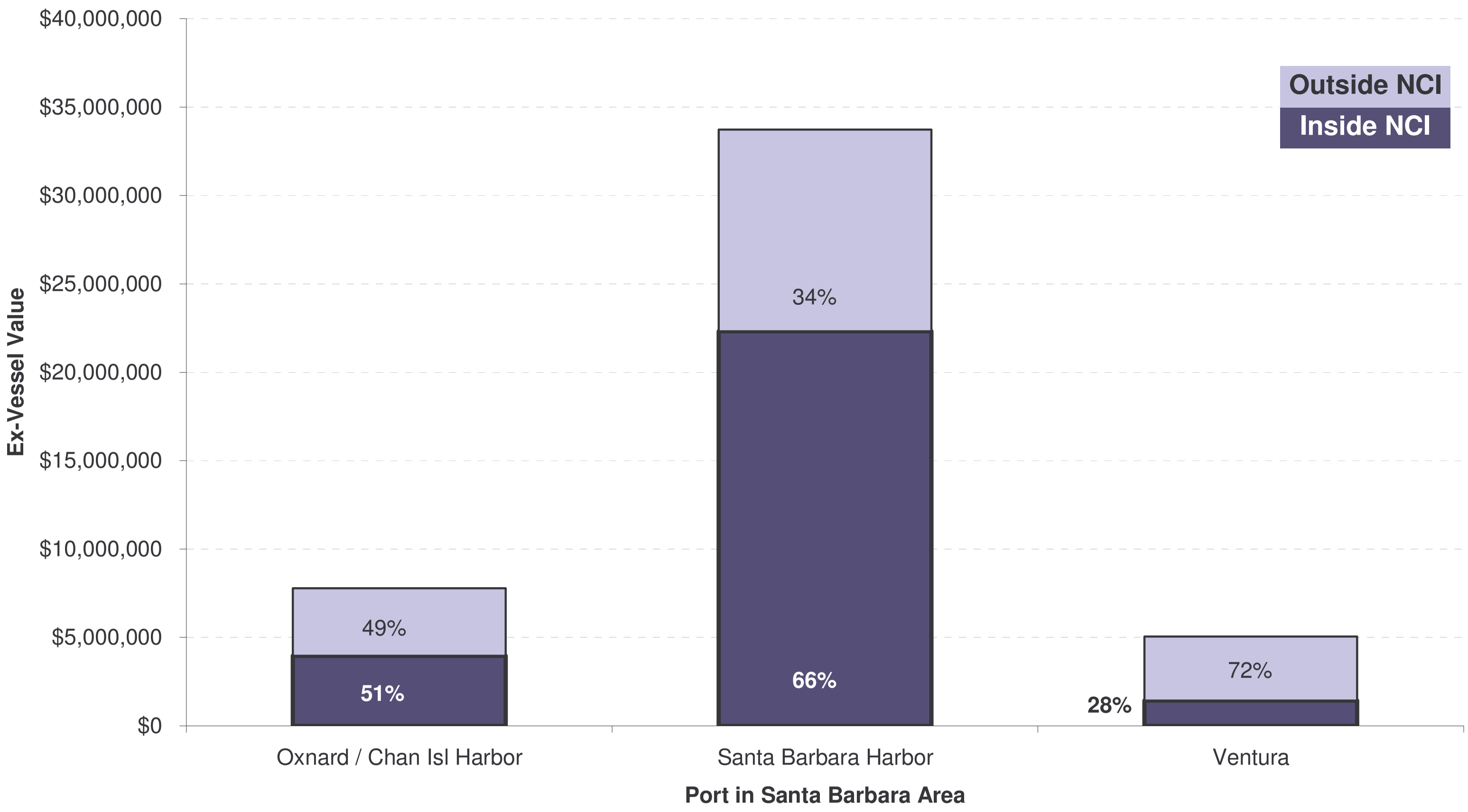
Prepared by Sofia Hamrin, 01/20/2005, www.bren.ucsb.edu/~lobster. Sources: Source: CDFG. (2004). Final California Commercial Landings For 1984 - 2003. Sacramento: State Of California, The Resources Agency, Department Of Fish And Game (CDFG). Due to data privacy concerns .06% of data was not used for this chart.

Figure 56: Usage of Ports in the Santa Barbara Fishing Area from 1984 – 2003.

III. Distribution of Economic Value over the Study Area

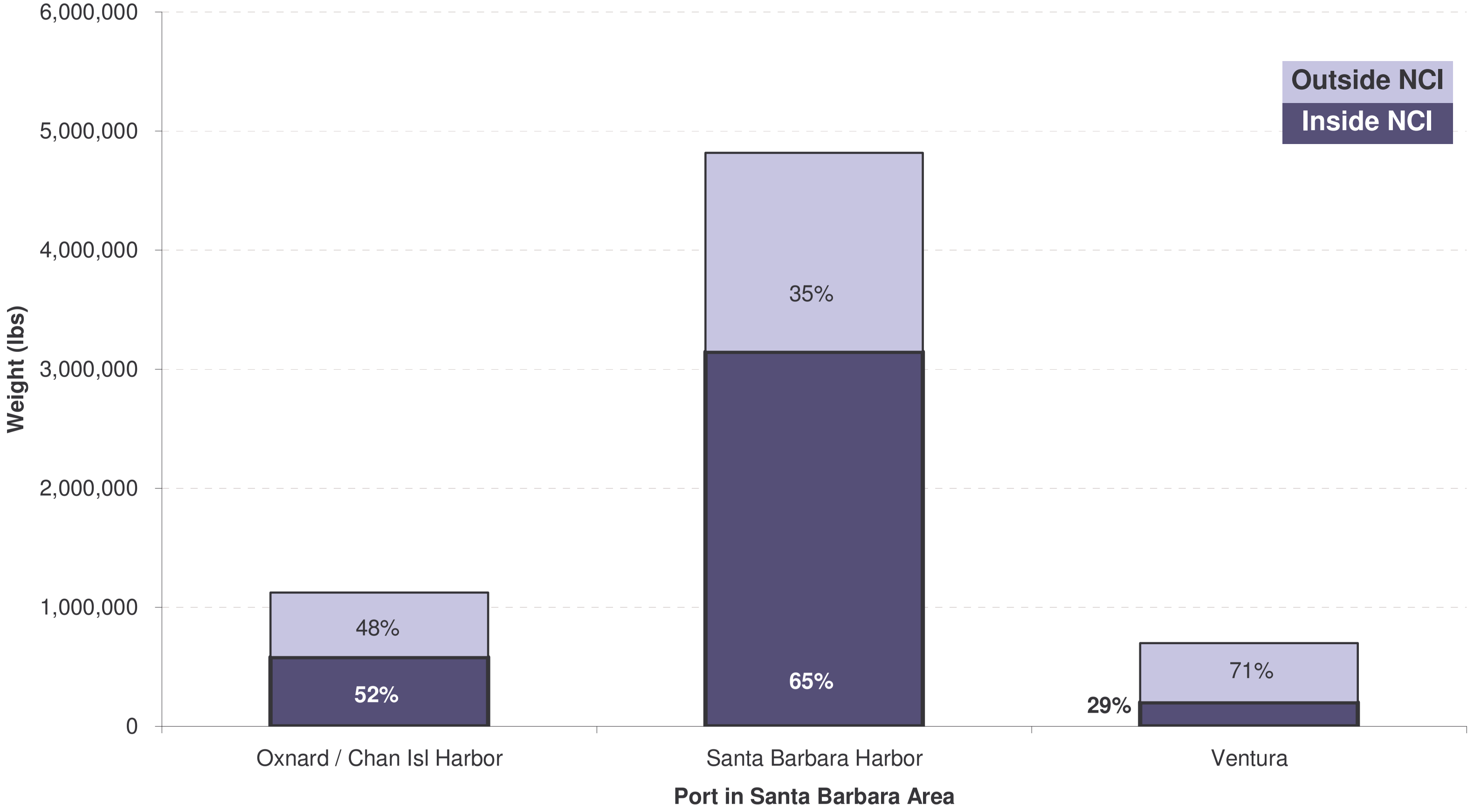
By cross-referencing the landmark receipt data in the logbooks with the California Landing Receipt database (DFG, 2003c), we analyze the distribution of economic value and other attributes over our study area. The lobster fishing grounds inside the northern Channel Islands (Chapter 4, Map 1) contribute the majority of the revenue for the Santa Barbara regional fishery as shown in Figure 57. Figure 58, Figure 59, and Figure 60 show each port's catch in weight, number of lobsters, and traps, respectively; indicating their contribution to the regional fishery. In all cases, Santa Barbara harbor derives the majority of its contribution from inside our study area in the northern Channel Islands. The exception is in traps pulled (Figure 60) where 47% of the traps pulled were from the northern Channel Islands.

Figure 61 shows the per season contributions from Figure 57. The majority of value from the lobster fishery in Ventura comes from outside the northern Channel Islands study area, whereas it is seasonally variable whether Oxnard's value comes from within our outside the study area. Santa Barbara demonstrated similar variability prior to 1999, but has since consistently drawn the majority of its value from inside the study area of the northern Channel Islands. Between the 1996 and 2003 seasons, the mean seasonal contribution has been 62.0% (σ=10.7) with an increasing trend and a mean growth rate of 3.8% ($R^2 = 0.74$).



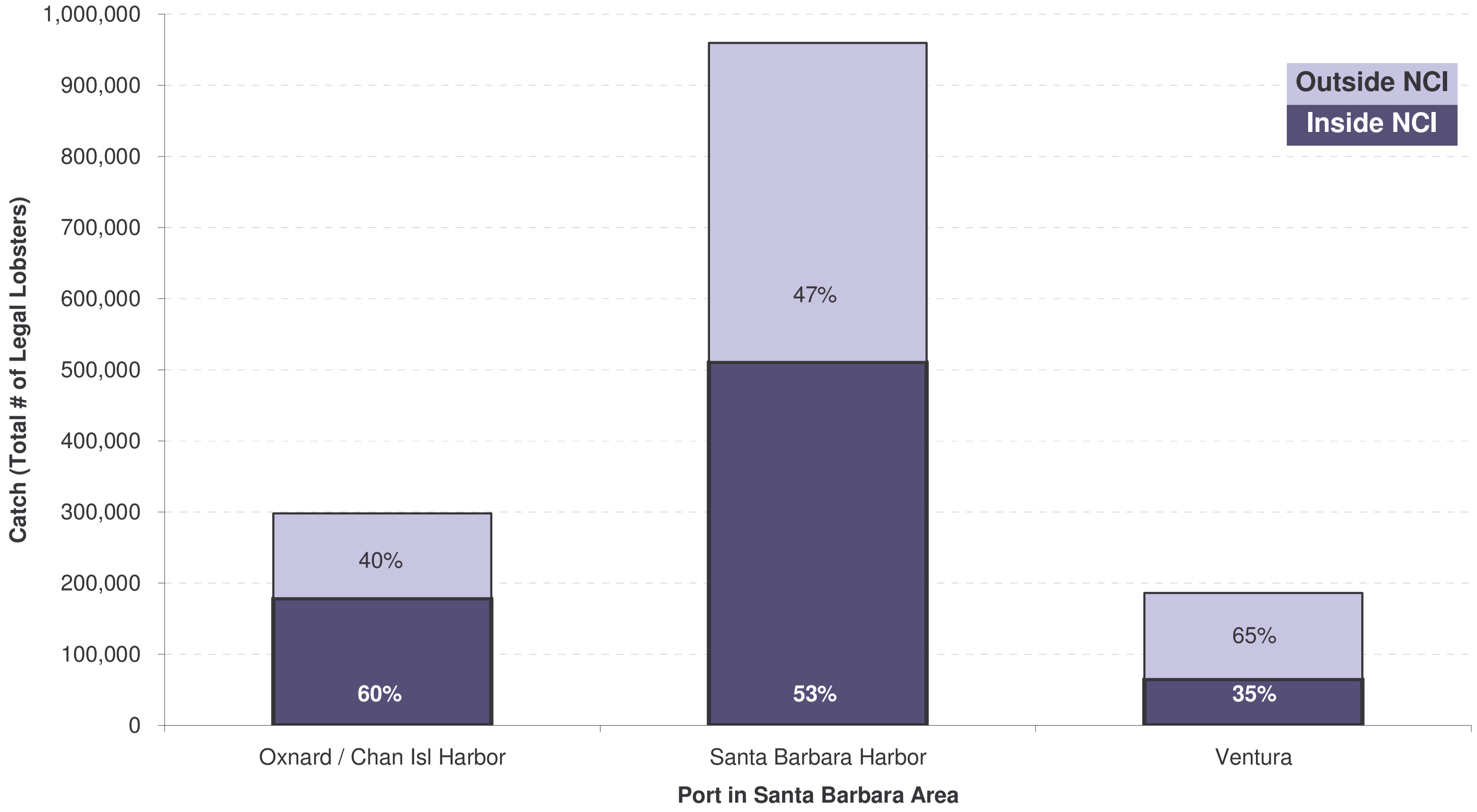
Sources: CDFG (2004). Lobster Logbooks For 1996 - 2003 and CDFG (2003). Final California Commercial Landings For 1984 - 2003.
Both from

Figure 57: Total Economic Value Of The Santa Barbara Region By Port And The Proportion From The Study Area Of The Northern Channel Islands, 1996 - 2003 Seasons. Source: (DFG, 2003c, 2003d).



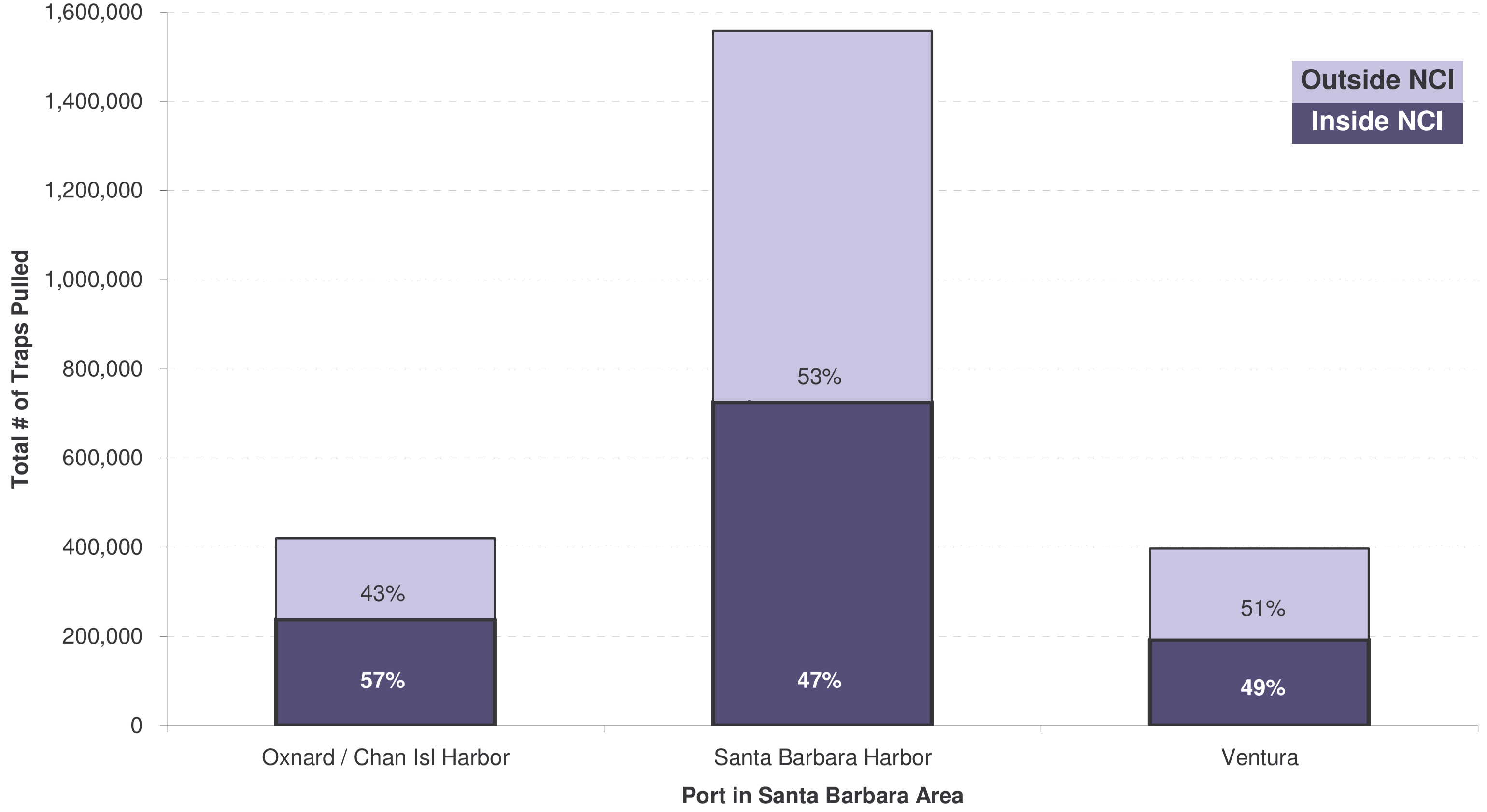
Sources: CDFG (2004). Lobster Logbooks For 1996 - 2003 and CDFG (2003). Final California Commercial Landings For 1984 - 2003. Both from

Figure 58: Total Lobsters Landed (In Weight) In The Santa Barbara Region By Port And The Proportion From The Study Area Of The Northern Channel Islands, 1996 - 2003 Seasons. Source: (DFG, 2003c, 2003d).



Sources: CDFG (2004). Lobster Logbooks For 1996 - 2003 and CDFG (2003). Final California Commercial Landings For 1984 - 2003.
Both from

Figure 59: Total Lobsters Landed (In Numbers) In The Santa Barbara Region By Port And The Proportion From The Study Area Of The Northern Channel Islands, 1996 - 2003 Seasons. Source: (DFG, 2003c, 2003d).



Sources: CDFG (2004). Lobster Logbooks For 1996 - 2003 and CDFG (2003). Final California Commercial Landings For 1984 - 2003.
Both from

Figure 60: Total Traps Pulled (Proxy For Effort) In The Santa Barbara Region By Port And The Proportion From The Study Area Of The Northern Channel Islands, 1996 - 2003 Seasons. Note that a lower percentage may indicate better catch performance as traps pulled is inversely proportional to catch performance. Source: (DFG, 2003c, 2003d).

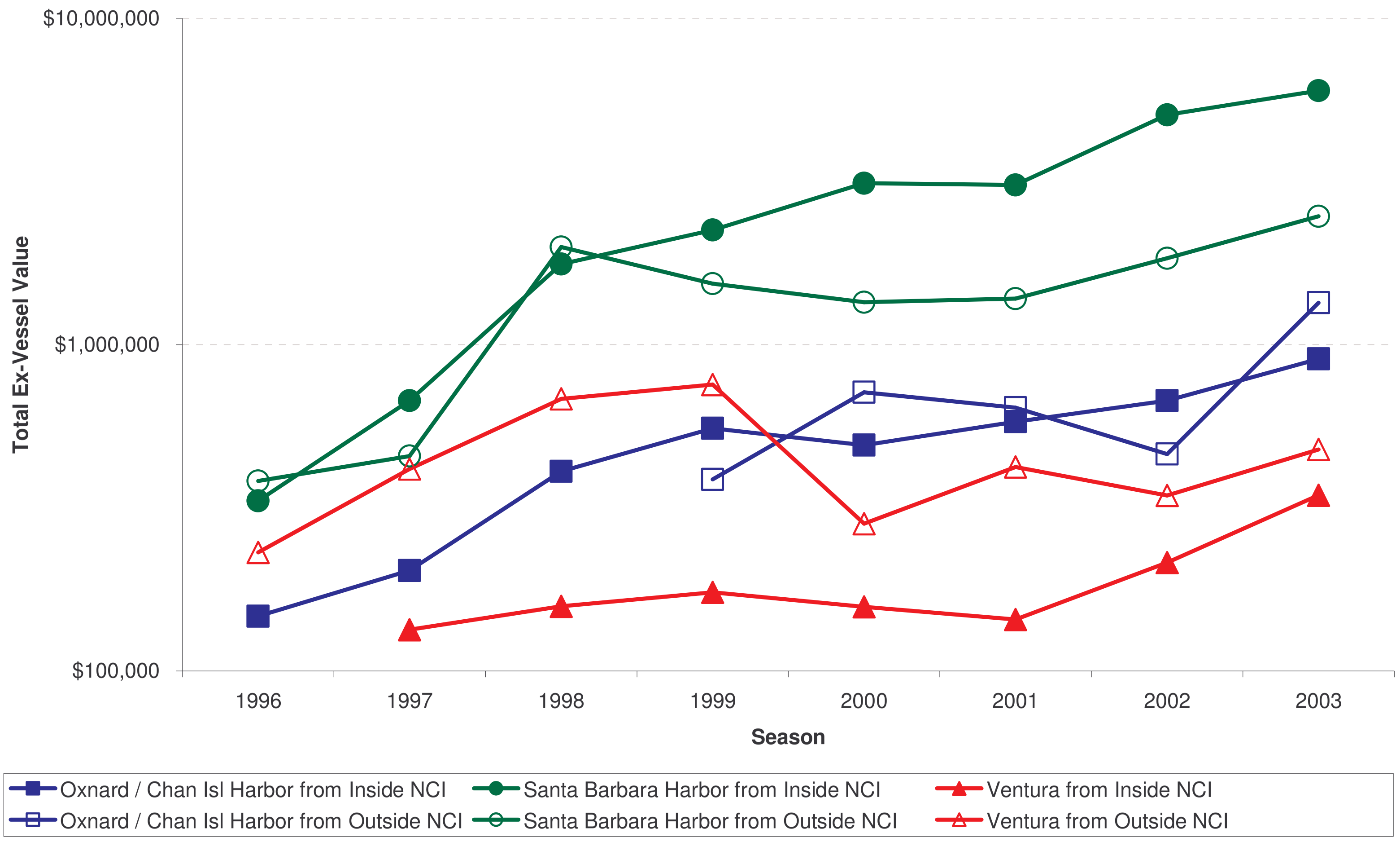


Figure 61: Seasonal Economic Value Of The Santa Barbara Region By Port And The Proportion From The Study Area Of The Northern Channel Islands, 1996 - 2003 Seasons. Source: (DFG, 2003c, 2003d).

IV. Distribution of Economic Value over the Landmarks

By cross-referencing the landmark receipt data in the logbooks with the *California Landing Receipts* database (DFG, 2000, 2003c) and our historical baseline, we analyze the distribution of economic value and other attributes over the landmarks in our study area. Table 55 ranks the landmarks by economic value. Talcott Shoal, Gull Island, Albert Anchorage, Carrington Point, and Bee Rock rank as the most valuable landmarks overall. Santa Rosa Island and Anacapa Island rank higher, but they are not preferred landmarks due to their non-specific nature (Appendix I). Landmarks that show up multiple times, such as Yellowbanks Anchorage, contribute economic value to multiple ports. From a port perspective, Oxnard's most valuable landmark is Yellowbanks Anchorage (or Anacapa Island, if including non-specific landmarks), Santa Barbara Harbor's is Talcott Shoal (or Santa Rosa Island, if including non-specific landmarks), and Ventura's is Yellowbanks Anchorage. Furthermore, for comparison purposes, Table 56 includes price, catch, and traps data. As an example, Ventura's trapping effort at Yellowbanks (103,240 traps) is 193% higher than Santa Barbara's trapping effort at Yellowbanks (35,144 traps), yet Ventura's catch (26,113 lobsters) is only 44% better than Santa Barbara's (18,154 lobsters). As a reporting tool, the improved spatial resolution of the historical baseline enables these types of detailed analyses. Table 57 ranks the landmarks by total catch (number of lobsters and weight) for the entire Santa Barbara region. Table 58 ranks the landmarks by mean seasonal catch performance. The original numerical rank from Table 56 is retained as a reference point in and in the second column so that the reader may compare how the most economically valuable landmarks perform on these metrics.

Figure 62 shows that catch as weight is near identical ($R^2 = 0.99$) to the original rankings from Table 56, as expected since price changes would be the only variability in the rankings. Figure 63 shows that *catch* correlates well (R2 = 0.93) with the original rankings demonstrating that it's a good proxy to value. However, Figure 64 shows that *catch performance* correlates extremely poor ($R^2 = 0.00005$) with the original rankings. For example, the 4th ranked Yellowbanks Anchorage in economic value ranks last in catch performance, and the top-ranked Santa Rosa Island in economic value ranks 28th out of 34 in catch performance. This poor correlation suggests that trappers are focusing more effort on these high value landmarks than lobster catch can support. Only a few landmarks seem to be correlated with economic value and catch performance such as Bee Rock, Kinton Point, Scorpion Anchorage, Smugglers Cove, and San Pedro Point.

Table 55: Landmarks Ranked By Total Ex-Vessel Value And Port At Which Those Landings Were Received, 1999 – 2003 Seasons. Ex-Vessel price, catch, and traps pulled data also included. (SBH) is Santa Barbara Harbor, (OXH) is Oxnard / Channel Islands Harbor, and (VNH) is Ventura Harbor. Sources: (DFG, 2003c, 2003d).

Rank	Port	Landmark	Ex-Vessel Value			Ex-Vessel Price		Catch			Traps Pulled		
			Total	Mean	StDev	Mean	StDev	Total	Mean	StDev	Total	Mean	StDev
1	SBH	Santa Rosa Island	$3,391,432	$1,801.08	$1,423.25	$7.14	$0.88	109,154	57.66	49.02	174,797	92.34	59.32
2	OXH	Anacapa Island	$2,570,776	$1,469.01	$1,046.45	$6.78	$0.79	115,121	62.36	51.99	138,871	75.23	40.83
3	SBH	Talcott Shoal	$1,288,672	$1,926.27	$1,533.30	$7.34	$0.68	43,480	58.92	54.99	53,092	71.94	54.29
4	SBH	Gull Island	$970,176	$2,012.81	$1,420.99	$6.91	$0.91	16,486	31.58	19.22	22,897	43.86	17.84
5	SBH	Albert Anchorage	$801,615	$1,746.44	$1,332.99	$6.86	$0.98	13,140	27.61	22.40	18,035	37.89	16.23
6	SBH	Carrington Point	$645,277	$1,782.53	$1,364.57	$7.26	$0.71	13,794	34.49	28.67	14,368	35.92	18.20
7	SBH	Bee Rock	$629,709	$2,749.82	$1,711.03	$7.47	$0.56	9,970	37.77	30.46	11,002	41.67	16.84
8	SBH	Yellowbanks Anchorage	$625,683	$1,444.99	$1,373.73	$6.84	$0.99	18,154	40.08	27.37	35,144	77.58	42.03
9	SBH	Valley Anchorage	$538,567	$1,980.03	$1,542.07	$6.76	$0.86	11,145	38.04	24.78	14,477	49.41	17.80
10	SBH	West Point	$524,613	$1,950.23	$1,369.99	$7.11	$0.71	8,098	26.90	21.78	9,943	33.03	17.42
11	SBH	Kinton Point	$505,826	$1,975.88	$1,365.99	$6.90	$0.91	8,201	28.38	21.03	9,771	33.81	16.59
12	SBH	Brockway Point	$492,524	$1,817.43	$1,412.37	$7.21	$0.77	12,413	44.33	33.43	16,042	57.29	23.19
13	SBH	Rodes Reef	$450,864	$2,106.84	$1,704.43	$7.37	$0.84	8,963	39.14	31.46	8,738	38.16	15.09
14	VNH	Yellowbanks Anchorage	$449,031	$634.22	$458.94	$6.86	$0.91	26,113	35.77	24.63	103,240	141.42	42.09
15	SBH	Willows Anchorage	$441,926	$1,612.87	$1,255.83	$6.86	$1.14	6,385	22.89	16.01	8,757	31.39	16.66
16	SBH	Chinese Harbor	$440,023	$1,880.44	$1,430.56	$6.92	$0.95	6,140	24.96	29.23	6,675	27.13	13.50

Rank	Port	Landmark	Ex-Vessel Value			Ex-Vessel Price		Catch			Traps Pulled		
			Total	Mean	StDev	Mean	StDev	Total	Mean	StDev	Total	Mean	StDev
17	SBH	Cavern Point	$412,720	$1,974.74	$1,385.06	$7.00	$1.09	5,662	26.09	20.93	6,800	31.34	15.42
18	SBH	Ford Point	$398,736	$1,661.40	$1,307.33	$6.92	$0.90	9,018	35.64	31.73	12,780	50.51	20.10
19	VNH	Santa Cruz Island	$353,698	$982.49	$816.74	$6.98	$0.92	14,575	40.49	38.16	32,898	91.38	72.52
20	SBH	East Point	$325,295	$1,694.24	$1,306.08	$7.42	$0.82	5,257	25.77	26.48	5,776	28.31	16.63
21	SBH	Forney Cove	$264,696	$1,350.49	$912.79	$7.26	$1.21	6,165	31.45	29.86	9,985	50.94	21.66
22	SBH	Bechers Bay	$263,808	$1,659.17	$1,249.40	$7.18	$0.87	3,491	20.90	23.35	5,157	30.88	18.93
23	SBH	Scorpion Anchorage	$238,056	$1,408.61	$1,344.05	$6.93	$0.79	3,525	20.61	20.03	4,127	24.13	15.30
24	SBH	Arch Rock	$207,659	$2,386.88	$1,436.90	$6.59	$0.50	3,941	33.97	42.50	3,450	29.74	17.62
25	SBH	Sandstone Point	$191,771	$2,282.99	$1,250.49	$6.79	$0.87	4,151	43.24	22.18	6,497	67.68	25.43
26	OXH	Santa Cruz Island	$167,714	$1,206.58	$925.56	$6.82	$0.77	6,939	44.20	35.20	9,686	61.69	38.36
27	SBH	Diablo Point	$166,593	$1,699.93	$1,418.21	$6.88	$0.71	3,119	31.19	37.78	4,002	40.02	24.18
28	SBH	Coche Point	$157,291	$1,747.68	$1,349.88	$6.44	$0.78	1,807	19.22	12.70	1,941	20.65	10.14
29	SBH	Smugglers Cove	$148,112	$1,424.16	$804.54	$6.47	$0.91	5,623	54.07	37.51	7,947	76.41	44.60
30	SBH	Cueva Valdez	$145,712	$1,349.18	$1,458.17	$6.93	$0.74	2,050	18.98	15.94	3,753	34.75	13.17
31	SBH	Prisoners Harbor	$132,586	$1,250.81	$1,441.64	$7.04	$0.53	3,841	36.24	40.01	4,453	42.01	17.02
32	OXH	Yellowbanks Anchorage	$131,225	$857.68	$648.00	$7.02	$0.68	5,514	33.42	32.53	16,663	100.99	54.07
33	SBH	Santa Cruz Island	$125,370	$1,011.05	$977.95	$7.05	$1.02	3,146	25.37	30.63	7,408	59.74	54.81
34	SBH	Morse Point	$123,005	$1,863.71	$1,328.17	$7.46	$0.85	1,311	19.57	10.97	1,749	26.10	10.48
35	SBH	Pelican Bay	$105,885	$1,890.80	$2,318.69	$7.56	$0.99	1,072	18.81	19.01	1,189	20.86	12.81
36	SBH	Bowen Point	$90,535	$1,775.19	$1,268.64	$6.56	$0.57	1,657	31.26	21.53	1,982	37.40	26.28

Rank	Port	Landmark	Ex-Vessel Value			Ex-Vessel Price		Catch			Traps Pulled		
			Total	Mean	StDev	Mean	StDev	Total	Mean	StDev	Total	Mean	StDev
37	VNH	Santa Rosa Island	$87,471	$1,749.41	$974.71	$7.49	$0.54	1,680	33.60	43.05	2,575	51.50	50.38
38	SBH	Frys Harbor	$81,924	$1,204.76	$928.62	$6.62	$1.21	865	12.72	10.71	1,311	19.28	12.90
39	OXH	San Pedro Point	$28,913	$566.92	$349.61	$7.13	$0.38	774	13.82	15.84	2,863	51.13	7.20
40	VNH	Sandstone Point	$6,599	$101.52	$55.04	$8.55	$1.44	170	2.24	2.68	602	7.92	4.03

Table 56: Landmarks Ranked By Total Ex-Vessel Value, 1999 – 2003 Seasons. Sources: (DFG, 2003c, 2003d).

Rank	Landmark	Ex-Vessel Value			Ex-Vessel Price	
		Total	Mean	StDev	Mean	StDev
1	Santa Rosa Island	$3,482,426	$1,800	$1,413	$7.15	$0.88
2	Anacapa Island	$2,589,705	$1,466	$1,042	$6.78	$0.78
3	Talcott Shoal	$1,288,672	$1,926	$1,533	$7.34	$0.68
4	Yellowbanks Anchorage	$1,205,938	$932	$966	$6.87	$0.92
5	Gull Island	$970,176	$2,013	$1,421	$6.91	$0.91
6	Albert Anchorage	$804,754	$1,749	$1,333	$6.86	$0.98
7	Santa Cruz Island	$646,782	$1,038	$879	$6.96	$0.91
8	Carrington Point	$645,277	$1,783	$1,365	$7.26	$0.71
9	Bee Rock	$629,709	$2,750	$1,711	$7.47	$0.56
10	Valley Anchorage	$541,706	$1,984	$1,541	$6.76	$0.86
11	West Point	$524,613	$1,950	$1,370	$7.11	$0.71
12	Kinton Point	$505,826	$1,976	$1,366	$6.90	$0.91
13	Brockway Point	$492,524	$1,817	$1,412	$7.21	$0.77
14	Rodes Reef	$450,864	$2,107	$1,704	$7.37	$0.84
15	Chinese Harbor	$446,302	$1,891	$1,429	$6.92	$0.95
16	Willows Anchorage	$445,065	$1,618	$1,257	$6.86	$1.14
17	Cavern Point	$418,999	$1,986	$1,383	$7.00	$1.08
18	Ford Point	$398,736	$1,661	$1,307	$6.92	$0.90
19	East Point	$325,295	$1,694	$1,306	$7.42	$0.82
20	Forney Cove	$264,696	$1,350	$913	$7.26	$1.21
21	Bechers Bay	$263,808	$1,659	$1,249	$7.18	$0.87
22	Scorpion Anchorage	$246,257	$1,361	$1,315	$6.91	$0.80
23	Sandstone Point	$209,022	$1,331	$1,432	$7.55	$1.42
24	Arch Rock	$207,659	$2,387	$1,437	$6.59	$0.50
25	Diablo Point	$166,593	$1,700	$1,418	$6.88	$0.71
26	Coche Point	$157,291	$1,748	$1,350	$6.44	$0.78
27	Smugglers Cove	$148,699	$1,390	$819	$6.45	$0.90
28	Cueva Valdez	$145,712	$1,349	$1,458	$6.93	$0.74
29	Prisoners Harbor	$132,586	$1,251	$1,442	$7.04	$0.53
30	Morse Point	$123,005	$1,864	$1,328	$7.46	$0.85

Rank	Landmark	Ex-Vessel Value			Ex-Vessel Price	
		Total	Mean	StDev	Mean	StDev
31	Pelican Bay	$105,885	$1,891	$2,319	$7.56	$0.99
32	Bowen Point	$90,535	$1,775	$1,269	$6.56	$0.57
33	Frys Harbor	$81,924	$1,205	$929	$6.62	$1.21
34	San Pedro Point	$71,798	$984	$1,964	$7.32	$0.53

Table 57: Landmarks Ranked By Total Catch (As Number Of Lobsters And As Weight), 1999 – 2003 Seasons. The second column shows the rankings from **Table 56**. Sources: (DFG, 2003c, 2003d).

Rank	Value Rank	Landmark	Catch			Weight (lbs)		
			Total	Mean	StDev	Total	Mean	StDev
1	2	Anacapa Island	115,674	62.12	51.90	392,265	210.67	160.83
2	1	Santa Rosa Island	110,985	57.06	48.99	501,811	258.00	207.69
3	4	Yellowbanks Anchorage	49,781	36.93	26.72	181,034	134.30	139.75
4	3	Talcott Shoal	43,480	58.92	54.99	176,475	239.13	213.47
5	7	Santa Cruz Island	24,660	38.47	36.64	93,747	146.25	122.21
6	5	Gull Island	16,486	31.58	19.22	144,533	276.88	213.61
7	8	Carrington Point	13,794	34.49	28.67	89,916	224.79	194.72
8	6	Albert Anchorage	13,157	27.58	22.38	119,108	249.70	199.13
9	13	Brockway Point	12,413	44.33	33.43	67,944	242.66	193.53
10	10	Valley Anchorage	11,217	38.15	24.82	82,280	279.86	240.56
11	9	Bee Rock	9,970	37.77	30.46	85,701	324.63	253.35
12	18	Ford Point	9,018	35.64	31.73	57,338	226.63	185.66
13	14	Rodes Reef	8,963	39.14	31.46	61,127	266.93	233.90
14	12	Kinton Point	8,201	28.38	21.03	74,489	257.75	210.32
15	11	West Point	8,098	26.90	21.78	75,295	250.15	204.61
16	16	Willows Anchorage	6,405	22.88	15.98	65,769	234.89	190.68
17	15	Chinese Harbor	6,183	24.93	29.12	65,693	264.89	216.40
18	20	Forney Cove	6,165	31.45	29.86	36,592	186.69	126.47
19	17	Cavern Point	5,704	26.05	20.84	61,547	281.04	214.27
20	27	Smugglers Cove	5,686	53.14	37.38	23,304	217.79	137.40
21	19	East Point	5,257	25.77	26.48	44,245	216.89	181.57

Rank	Value Rank	Landmark	Catch			Weight (lbs)		
			Total	Mean	StDev	Total	Mean	StDev
22	23	Sandstone Point	4,567	25.37	26.53	30,749	170.83	208.70
23	24	Arch Rock	3,941	33.97	42.50	31,922	275.19	237.13
24	29	Prisoners Harbor	3,841	36.24	40.01	18,926	178.55	200.02
25	22	Scorpion Anchorage	3,816	20.85	20.60	35,567	194.36	184.81
26	21	Bechers Bay	3,491	20.90	23.35	36,484	218.47	173.97
27	25	Diablo Point	3,119	31.19	37.78	24,684	246.84	214.67
28	28	Cueva Valdez	2,050	18.98	15.94	20,759	192.21	200.68
29	26	Coche Point	1,807	19.22	12.70	24,974	265.68	218.27
30	32	Bowen Point	1,657	31.26	21.53	14,322	270.23	213.46
31	30	Morse Point	1,311	19.57	10.97	17,327	258.61	211.55
32	34	San Pedro Point	1,258	16.13	14.98	9,669	123.96	227.24
33	31	Pelican Bay	1,072	18.81	19.01	13,868	243.30	279.89
34	33	Frys Harbor	865	12.72	10.71	12,456	183.18	135.66

Table 58: Landmarks Ranked By Mean Catch Performance, 1999 – 2003 Seasons. The second column shows the rankings from Table 56. Sources: (DFG, 2003c, 2003d).

Rank	Value Rank	Landmark	Catch Performance	Catch			Traps Pulled		
			Mean	Total	Mean	StDev	Total	Mean	StDev
1	24	Arch Rock	1.142	3,941	33.97	42.50	3,450	29.74	17.62
2	14	Rodes Reef	1.026	8,963	39.14	31.46	8,738	38.16	15.09
3	8	Carrington Point	0.960	13,794	34.49	28.67	14,368	35.92	18.20
4	26	Coche Point	0.931	1,807	19.22	12.70	1,941	20.65	10.14
5	15	Chinese Harbor	0.918	6,183	24.93	29.12	6,733	27.15	13.45
6	19	East Point	0.910	5,257	25.77	26.48	5,776	28.31	16.63
7	9	Bee Rock	0.906	9,970	37.77	30.46	11,002	41.67	16.84
8	31	Pelican Bay	0.902	1,072	18.81	19.01	1,189	20.86	12.81
9	29	Prisoners Harbor	0.863	3,841	36.24	40.01	4,453	42.01	17.02
10	12	Kinton Point	0.839	8,201	28.38	21.03	9,771	33.81	16.59
11	32	Bowen Point	0.836	1,657	31.26	21.53	1,982	37.40	26.28
12	17	Cavern Point	0.831	5,704	26.05	20.84	6,860	31.32	15.35
13	2	Anacapa Island	0.828	115,674	62.12	51.90	139,741	75.05	40.79
14	3	Talcott Shoal	0.819	43,480	58.92	54.99	53,092	71.94	54.29
15	11	West Point	0.814	8,098	26.90	21.78	9,943	33.03	17.42
16	25	Diablo Point	0.779	3,119	31.19	37.78	4,002	40.02	24.18
17	13	Brockway Point	0.774	12,413	44.33	33.43	16,042	57.29	23.19
18	10	Valley Anchorage	0.771	11,217	38.15	24.82	14,552	49.50	17.83
19	30	Morse Point	0.750	1,311	19.57	10.97	1,749	26.10	10.48
20	22	Scorpion Anchorage	0.744	3,816	20.85	20.60	5,132	28.04	25.28
21	16	Willows Anchorage	0.730	6,405	22.88	15.98	8,779	31.35	16.64
22	6	Albert Anchorage	0.728	13,157	27.58	22.38	18,067	37.88	16.22
23	5	Gull Island	0.720	16,486	31.58	19.22	22,897	43.86	17.84
24	18	Ford Point	0.706	9,018	35.64	31.73	12,780	50.51	20.10
25	27	Smugglers Cove	0.702	5,686	53.14	37.38	8,097	75.67	44.18
26	21	Bechers Bay	0.677	3,491	20.90	23.35	5,157	30.88	18.93
27	33	Frys Harbor	0.660	865	12.72	10.71	1,311	19.28	12.90
28	1	Santa Rosa Island	0.625	110,985	57.06	48.99	177,652	91.34	59.44
29	20	Forney Cove	0.617	6,165	31.45	29.86	9,985	50.94	21.66

30	23	Sandstone Point	0.616	4,567	25.37	26.53	7,412	41.18	35.24
31	28	Cueva Valdez	0.546	2,050	18.98	15.94	3,753	34.75	13.17
32	7	Santa Cruz Island	0.493	24,660	38.47	36.64	49,992	77.99	64.16
33	34	San Pedro Point	0.341	1,258	16.13	14.98	3,690	47.31	9.73
34	4	Yellowbanks Anchorage	0.321	49,781	36.93	26.72	155,047	115.02	52.73

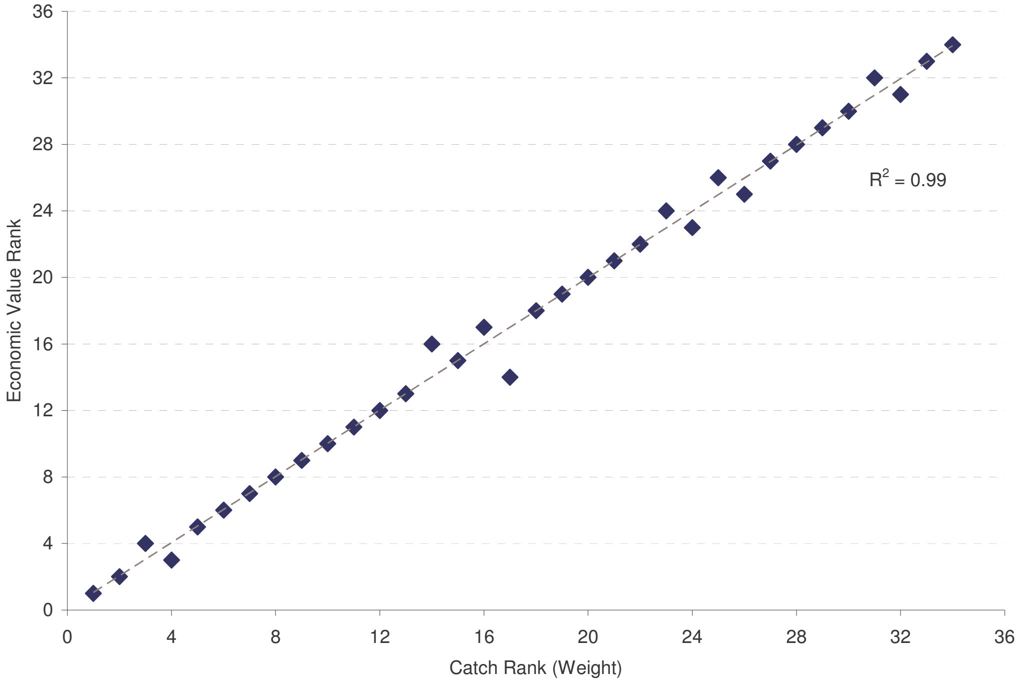


Figure 62: Correlations Between Economic Value And Catch (Weight) Rankings.

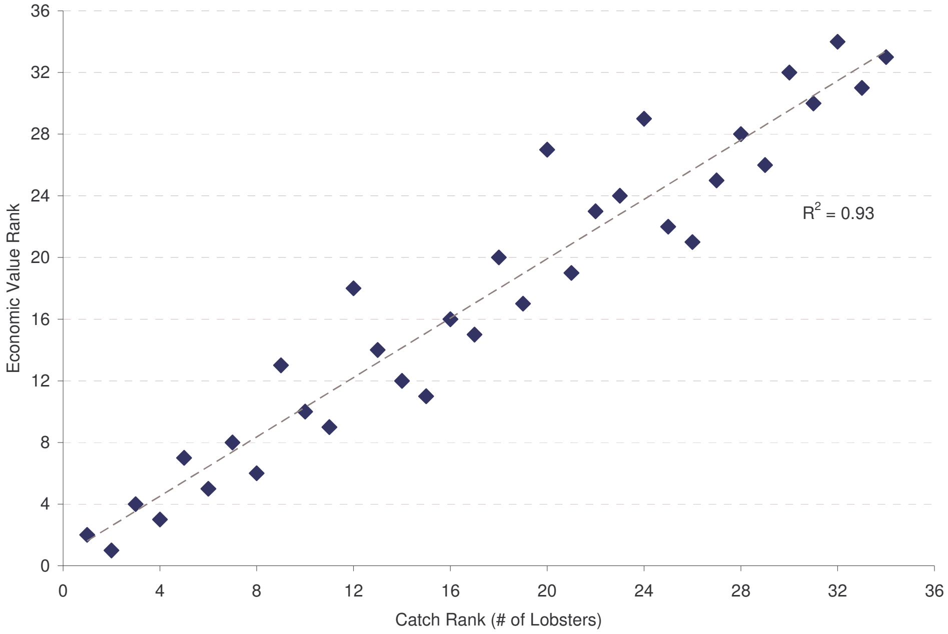


Figure 63: Correlation Between Economic Value And Catch (Number Of Lobsters) Rankings.

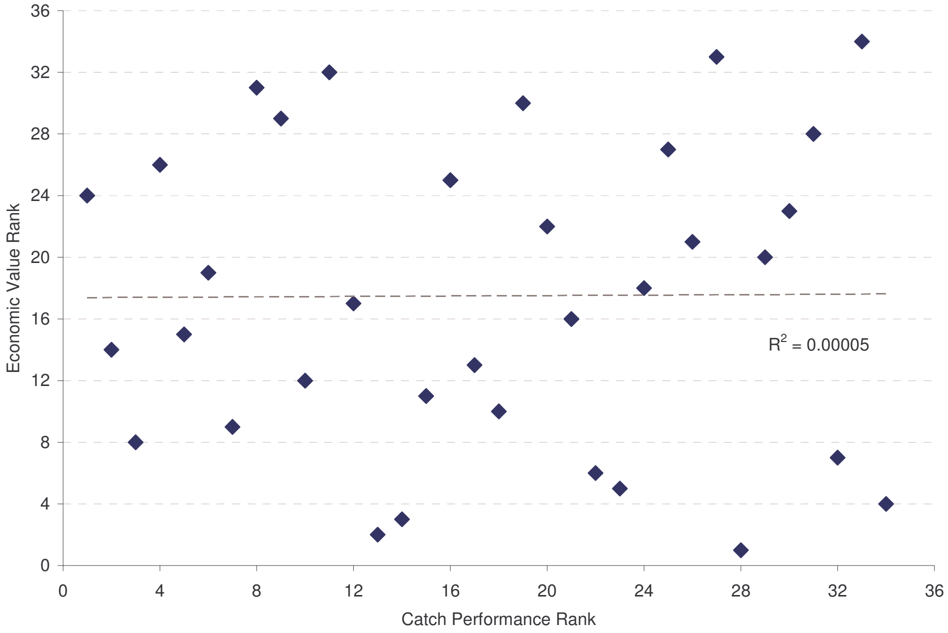


Figure 64: Correlation Between Economic Value And Catch Performance Rankings.

Appendix L: Funding Opportunities

Table 1: Potential Funding Sources.

Funding Organization	Contact Information	Types of Support	Areas of Interest	Grant Range	Deadlines	Additional Information
Andrew H. Burnett Foundation	Allen W. Finger, President 114 E. De la Guerra St, Studio 3 Santa Barbara CA 93101 805.963.8822	General support, operating expenses, project grants	Arts, culture, & humanities; environment; health & human services; social services	$1,000 to $5,000	Applications available January 1st, applications due April 1st	Only fund projects within Santa Barbara county; request grant applications by mail
The Crawford Idema Family Foundation	Philip VanderWilden 100 Main St, Suite 325 Concord, MA 01742 phone: 978.318.0505 fax: 978.318.0535 philipV@crawford-idema.org	Program/project support	Local initiatives to improve the environment, drug & alcohol abuse prevention and treatment, child/teen developmental services, elder care	Variable	Grants awarded in November	Fund projects in Santa Barbara, CA and Concord, MA; submit letter of inquiry prior to requesting funds
The Outhwaite Foundation	Marni Cooney P.O. Box 5159 Santa Barbara, CA 93150 phone: 805.690.6103 fax: 805.969.6675 marni@outhwaitefoundation.org	General support, projects, capital	Preservation of wildlife & natural resources; health care research & support; prevention of cruelty to animals; historic preservation; educational institutions; support for abused women & children	$1,000 to $25,000	Applications due July 31	Only fund within Santa Barbara County, with an emphasis on south Santa Barbara County; request application information by mail or email

Santa Barbara Foundation	Amy Schneider, Vice President of Programs 15 East Carrillo Street Santa Barbara 93101 phone: 805.963.1873 fax: 805.966.2345 info@sbfoundation.org www.sbfoundation.org	Capital and programs; emphasize programs that expand opportunities for less advantaged or enhance the lives of youth	Community enhancement, culture, environment, education, health, personal development, recreation	Maximum $75,000/year	Variable	Only fund within Santa Barbara County, phone or email for more information. Applicants must contact the Foundation to determine if they meet the criteria for the grant program to which they wish to apply and request to be on the mailing list to receive specific guidelines, applications, and workshop notices.
Wendy P. McCaw Foundation	Jon Clark, Executive Director P.O. Box 22458 Santa Barbara, CA 93121 phone: 805.965.8080 fax: 805.965.6050 jclark@wpmfoundation.org	Project grants, capital/building, startup money	Environment - focus on wildlife and select historic projects in Santa Barbara	$20,000 to $1,000,000	none	Fund local, national, and international projects; submit letter of inquiry prior to requesting funds
Shoreline Preservation Fund	Scott Bull, Grants Manager Associated Students, University of California Santa Barbara, CA 93106 phone: 805.893.5166 fax: 805.893.7734 spf@as.ucsb.edu	Project grants, partnership programs, research grants	Environment and education	$2,500 to $12,000	Beginning of each academic quarter	SPF provides funds to enhance, protect, and restore the coast associated with UCSB through preservation, education, open access, research, and restoration; projects outside these boundaries must exhibit their nexus to the UCSB campus and community

National Marine Sanctuary Program	Steve Gittings, Science Program Manager National Marine Sanctuary Program phone: 301.713.3125 Steve.Gittings@noaa.gov	Site Characterizations (Habitat, Living Marine Resources, Water Quality, Anthropogenic Influences); Monitoring (Habitat, Living Marine Resources, Water Quality, Anthropogenic Influences); Regional Observing Systems	Development of long-term science capabilities within each national marine sanctuary; encourages the integration of science, education and outreach	$1,000 to $50,000	November	Funds are dependent on yearly budget allotted to the National Marine Sanctuary Program
Pacific States Marine Fisheries Commission	www.psmfc.org/rfp/	Research grants	Fisheries research, fisheries economics, monitoring	Variable	Variable	Fund projects in Alaska, Washington, Oregon, and California
UC Davis Wildlife Health Center Seadoc Society	Dr. Joe Gaydos, SeaDoc Society Scientist and Regional Director phone: 360.376.3910 jkgaydos@ucdavis.edu Lavonne Hull, SeaDoc Society Administrative Assistant phone: 530.752.385 lwhull@ucdavis.edu www.seadocsociety.org	Research and education grants	Projects that address the health of all marine vertebrates and the biotic and abiotic environments upon which they depend for survival. All SeaDoc Society-funded projects, regardless of where they are conducted, must have implications for understanding or enhancing the health of the Pacific northwest and its wildlife.	$35,000 to $40,000	October	Program focuses on the North American Pacific, with emphasis at present given to issues facing the inland marine waters of Washington State and British Columbia (Puget Sound/Northwest Straits/Georgia Basin).

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