CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

DRAFT SPINY LOBSTER FISHERY MANAGEMENT PLAN

Preliminary Public Draft

*****Please Note: public feedback is not being solicited on the preliminary draft, as sections of the FMP could be revised as a result of the scientific peer review*****

11/20/2014

The Lobster FMP is scheduled to be introduced to the Fish and Game Commission during the first Quarter of 2015. At which time the formal public review process will begin and public comment on the Lobster FMP is encouraged.

Executive Summary

The California Spiny Lobster (CA lobster) is an important natural resource managed by the state of California for over 100 years. The species supports a valuable commercial fishery and a significant recreational fishery. CA lobsters also act as important keystone predators within the southern California nearshore ecosystem. The commercial fishery in California extends from Pt. Conception south to the U.S.-Mexico border, and accounted for over 385.55 mt (metric tonne) (850,000 lb (pound)) in ex-vessel landings and $14.3 million in ex-vessel value during the 2012-13 fishing season. The California recreational fishery ranges from Central San Luis Obispo County south to the US-Mexico border, and contributes between $33-$40 million in consumer spending to the California economy each year.

The 2011 California Department of Fish and Wildlife (CDFW) stock assessment indicates that the CA lobster stock is stable under the management actions currently in place. The current minimum size limit allows lobsters to reproduce for 1-2 years before reaching the legal size limit. The seasonal closure (March-October) protects the sensitive spawning period of the species. The limited-entry nature of the commercial fishery further restricts commercial fishing pressure on the stock.

A substantial increase in average landing price ($/lb) has occurred within the commercial fishery during recent years. Around the same time, overall commercial trap effort as measured by the amount of trap pulls recorded on CDFW-issued daily lobster fishing logs has also increased. The increase in commercial fishing effort has raised questions about the long-term sustainability of the fishery, the negative consequences on the fishing grounds and associated ecosystems from increased gear usage, and the economic health of the commercial fishery.

The recent rise in commercial effort is also accompanied by changes in the dynamics of the recreational fishery. The recreational sector has traditionally been dominated by divers, but in the early 2000s, the popularity of boat-based hoop nets began to rise. Starting in 2008, recreational lobster fishermen are required by CDFW to record their daily fishing activity and catch on standardized report cards.

Report card sales have increased over the last 6 years, suggesting that participation has increased. However, card sales do not directly reflect actual fishing effort or catch. Report card return rates have steadily increased since the program was first implemented due to proactive CDFW effort to educate the public and the establishment of non-reporting fee in 2013. Approximately 22 percent of cards returned to CDFW for the 2013-14 season were never used. Recreational fishermen harvested an estimated 28 percent of the total catch (commercial + recreational) during the same time period. As return rate continues to improve from new public outreach and reporting requirements, CDFW will be better able to estimate recreational effort and catch.

In 2012, the state implemented a set of new marine protected areas (MPAs) under the **Marine Life Protection Act** (MLPA). The 50 MPAs and 2 special closures are designed to serve a myriad of objectives, the objectives include conservation of valuable fishery resources. These MPAs create safe zones for species such as CA lobsters to reproduce without fishing pressure, but at the same time shift and compress fishing effort to the remaining non-MPA areas.

Marine Life Protection Act (MLPA) - The MLPA, enacted in 1999, required the California Department of Fish and Wildlife to develop a Marine Life Protection Program, including a Master Plan for a network of Marine Protected Areas (MPAs) within state waters. The network of MPAs includes an improved State Marine Reserve (complete no-take areas) component and other classifications of MPAs (State Marine Parks and State Marine Conservation Areas). The goals of the MLPA are varied and include protecting portions of ecosystems in a variety of habitats, preserving biodiversity, and helping to sustain and protect populations of fished species.

In light of the changes within the fisheries, it is important for CDFW to adopt a cohesive management strategy for the CA lobster fisheries. This Fishery Management Plan (FMP) prescribes a harvest control rule for the California spiny lobster fishery. The harvest control rule serves as the foundation for managing the fishery in the future as well as the primary mechanism to prevent, detect, and recover from overfishing as required by the **Marine Life Management Act** (MLMA). The rule is a type of adaptive management framework that identifies potential conservation problems and prescribes appropriate management responses. The harvest control rule consists of three parts: 1) reference points, 2) a control rule toolbox, and 3) a control rule matrix. Reference points are the metrics used to gauge the status of the fishery. The three CA lobster reference points are: 1) Catch, 2) **Catch Per Unit Effort** (CPUE), and 3) **Spawning Potential Ratio** (SPR):

REFERENCE POINT	THRESHOLD	RATIONALE
Catch	$\frac{average\ catch\ for\ 3\ most\ recent\ seasons}{average\ catch\ for\ 10\ most\ recent\ seasons} \leq 0.8$	Identifies possible change in stock stability, particularly growth overfishing
CPUE	$\frac{CPUE\ for\ 3\ most\ recent\ seasons}{CPUE\ for\ 10\ most\ recent\ seasons} \leq 0.8$	Identifies potential adverse changes in the fishery, mainly economic overfishing
SPR	SPR ≤ 0.18	Detects biological sustainability, particularly recruitment overfishing

The reference points incorporate important information regarding the fisheries such as the effects of fishing and MPAs, and new information is interpreted in relation to prescribed reference point thresholds that signal when changes within the fishery may warrant management responses. Once these changes are detected within the fishery, resource managers have flexibility to choose the appropriate management response from a toolbox of eight management tools. These consist of: 1) Change commercial trap limit, 2) Change recreational bag limit, 3) Establish a Total Allowable Catch (TAC), 4) Implement district closures, 5) Change season length, 6) Change minimum size limit, 7) Implement a maximum size, 8) Establish a sex selective fishery (Male-only fishery or female-specific size restrictions). The control rule matrix links specific reference point results to the appropriate management response.

This FMP also describes various management tools considered during the stakeholder **Lobster Advisory Committee** (LAC) process. The LAC

Marine Life Management Act (MLMA)- The Marine Life Management Act (MLMA), which became California law January 1, 1999, calls for using several tools to meet its goals of conserving entire ecosystems, placing value on non-consumptive benefits, sustainability, habitat conservation, restoring depressed fisheries, limiting bycatch, and recognizing the interests of people dependent on fishing. FMPs are one of those tools.

Catch Per Unit Effort (CPUE) - The rate at which fish are caught; typically a number or weight of fish captured per unit of effort. Units of effort can be assigned many ways, including the time spent fishing (hours or days), the amount of fishing gear deployed (number of vessels, traps, nets, etc.), the number of times that fishing gear is deployed and retrieved (e.g., net hauls, trap pulls), or a combination of these estimates. Because it is difficult and expensive to scientifically measure the number of fish in an area (abundance), CPUE is often used as an index for the relative abundance of organisms across time or space. For spiny lobster in California, CPUE is typically defined as the number of legal (or sublegal-sized) lobsters per trap pull for the commercial fishery, and number of legal lobsters retained per fishing trip for the recreational fishery. Effort is most often described in terms of trap pulls, total traps, and number of active permits for the commercial fishery, and number of fishing trips for the recreational fishery.

Spawning potential ratio (SPR) – A ratio of the number of eggs produced by a fished population over the number of eggs produced by an unfished population; used to characterize the amount of impact fishing has on a population's ability to reproduce.

Lobster Advisory Committee – A committee composed of representatives from the recreational fishery, the commercial fishery, environmental interest groups, scientific experts, non-consumptive recreational interest groups, and federal resource managers. The committee was responsible for providing crucial constituent inputs during the drafting process of this FMP, in part through a consensus recommendation.

reached consensus on several regulatory tools that will assist future fishery management. These recommendations are: 1) Commercial permit-based trap limit (with the ability for fishermen to stack 2 permits), 2) Tail clipping or hole punching of recreationally caught CA lobsters, 3) An additional grace period for commercial fishermen to deploy traps before the season and an additional period to retrieve traps after the season, 4) Changing the opening time for recreational season, 5) Restrictions on mechanical pullers for the recreational fishery, 6) Allowance to carry SCUBA gear on commercial vessels, 7) Requirement to mark recreational hoop net floats, and 8) Clarifying regulatory language on the take of lobster by hand.

CDFW currently collects substantial fishery-dependent data on CA lobster through commercial logbooks, landing receipts, recreational lobster report cards, creel sampling, and at-sea sampling. However, better information on the species stock distribution, ecological role, and life history (e.g., movement, **recruitment**, reproduction, mortality) would allow CDFW to improve its future management activities. Pursuant to the MLMA mandates, CDFW will continue to work with its constituents to improve its research and monitoring efforts in order to better maintain sustainable CA lobster populations and its associated fisheries.

Recruitment - The process, event, or rate by which individuals enter new life stages or segments of a population. *Larval recruitment* refers to the process or event by which larvae of lobster (or other marine species) exit the planktonic life stage (during which they drift in ocean currents) and turn into miniature versions of adult lobsters that settle on the seafloor. *Fishery recruitment* (or, recruitment to the fishery) refers to the moment that an animal becomes vulnerable to capture in a fishery – usually because it has attained some minimum size or age for harvest.

DRAFT

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DRAFT

Contents

Executive Summary i
Contents v
List of Table vii
List of Figures vii
Acronyms x
Glossary xi
1. Introduction 1
1.1 The Goal of the Spiny Lobster FMP 1
1.2 Efforts Leading Up to the Spiny Lobster FMP – The Lobster Advisory Committee 1
2. Background of the California Spiny Lobster Fishery 2
2.1 Commercial Fishery History and Description 2
2.2 Recreational Fishery History and Description 6
2.3 Bycatch within the Fishery 8
2.3.1 Commercial Fishing Bycatch 8
2.3.2 Recreational Fishing Bycatch 10
2.3.3 Legality of the Bycatch 10
2.4 History of Conservation and Management Measures Affecting the Fishery 11
2.5 Economic and Social Factors of the CA Lobster Fisheries 12
3. Natural History and Population Dynamics of the California Spiny Lobster 13
3.1 Critical Habitat and Known Threats to the Habitat 13
3.2 Growth 15
3.3 Reproduction and Larval Biology 16
3.4 Pathology 19
3.5 Movement 19
3.6 Predation and Defense 20
3.7 Prey 21
3.8 Ecosystem Role of CA Lobster 22
3.9 Climate Change Impacts on CA Lobsters 23
4. Measures for Conservation and Management of the CA Lobster Fishery 25
4.1 Overfishing, Sustainable Yield, and Overfished 25
4.2 Introduction to Harvest Control Rules 28
4.2.1 Harvest regulations 28
4.2.2 Data collection 31
4.2.3 Data Analysis 31

DRAFT

4.2.4 Fishery Management Reference Points 31
4.2.5 Harvest Control Rule Matrix 34
4.3 HCR for the California Spiny Lobster Fishery 35
4.3.1 Reference Points for CA Lobster Fishery 35
4.3.2 Implementation: HCR Matrix 39
4.3.3 Regulatory options linked to the control rule 42
4.4 Management of Other Lobster Fisheries 47
4.4.1 South Australia *Jasus edwarsii* Fishery 47
4.4.2 Florida *Panulirus argus* Fishery 48
4.4.3 Western Australia *Panulirus cygnus* Fishery 48
4.4.4 Maine *Homarus americanus* Fishery 48
4.5 The LAC Process and the Resulting Regulatory proposals 50
4.6 Management Strategy Evaluation Model (MSE) 53
4.6.1 Capability of the MSE 53
4.6.2 Incorporating the MSE 53
4.7 Additional Initiatives 54
4.8 Fitting the FMP into the Big-picture Ecosystem Management 54
5. Fishery Research Protocol – Essential Fishery Information 56
5.1 Research and Monitoring Needs for Essential Fishery Information 56
5.1.1 Existing CDFW Research Methods 56
5.1.2 Potential Improvements and Expansions 59
5.2 Biological EFI: Status, Application to Management, and Methods for Obtaining Data 60
5.3 Socioeconomic EFI: Update on the 2013 Economic Report 67
5.4 Cooperation and Collaboration in Fisheries Research 68
6. Implementation and Amendment Process of the FMP 68
6.1 Implementation 68
6.1.1 Enforcement 68
6.1.2 Research and Monitoring 69
6.1.3 Management 69
6.2 Adjustment and Amendment to Administration, Regulations, and the FMP 69
6.2.1 Regulatory Amendments that Do Not Warrant FMP Amendments 69
6.2.2 When and How FMP Will Be Amended 70
6.3 List of Inoperative Statutes 70
6.4 Amended Regulations 71
References 72

DRAFT

Appendix I – Letter to Tribes 92
Appendix II – Executive Summary of the Constituent Involvement Plan 96
Appendix III: Habitat Maps by Areas 100
Appendix IV: Sample Logs and Landing Receipt 107
Appendix V: Climate Change Vulnerability of the CA Spiny Lobster 109
Appendix VI: Economic Report 116

List of Table

Table 2-1: Estimate of Total Recreational Lobster Fishing Effort and Catch based on recreational report cards 7
Table 2-2: Bycatch found in 2,520 commercial lobster fishing traps (Source: CASP, Culver pers. comm. 2013). 9
Table 2-3: Regulatory history of the California spiny lobster fishery 11
Table 3-1: Size at which 50% of females in various population samples were sexually mature (size at maturity: SAM). 16
Table 3-2: Age at sexual maturity and legal size for P. interruptus 17
Table 3-3: Predators of California spiny lobster. 20
Table 3-4: Prey items eaten by P. interruptus, categorized by three study types 22
Table 4-1: SPR used around the world 34
Table 4-2: HCR Matrix 40
Table 4-3: Control rule toolbox 45
Table 4-4: Global Lobster Fishery Overview 49
Table 5-1: Categories of EFI identified by the MLMA Master Plan and specific data types identified by this FMP that are within each EFI category 66

List of Figures

Figure 2-1: Geographic range of P. interruptus 2
Figure 2-2: California commercial lobster landings from the 1936-37 fishing season through 2012-13 season. 3
Figure 2-3: Total Commercial Landings by CDFW commercial fishing block between 2000-2013 overlayed with area closures 3
Figure 2-4: Mean commercial lobster landings value by fishing year season 4
Figure 2-5: California commercial fishing trap 4
Figure 2-6: Historical total trap pull by year compared to total number of active fishermen by year 4
Figure 2-7: Historical total ex-vessel value of the CA lobster fishery 5
Figure 2-8: The cumulative percentage contribution of fishermen to the 2013-14 fishing season landing 5
Figure 2-9: Traditional hoop net and rigid conical hoop net 6
Figure 2-10: Number of legal lobsters retained from recreational lobster report cards in 2013 overlayed with area closures 8
Figure 3-1: External anatomy of *P. interruptus* 13
Figure 3-2: Locations of critical CA spiny lobster habitat in the southern California Bight. 15
Figure 3-3: Timing of reproduction, larval development, and settlement for *P. interruptus* 17
Figure 3-4: Fecundity of *P. interruptus* from a number of studies throughout its range. 18
Figure 3-5: A simplified diagram of the North-South California Current 18

Figure 3-6: Lobsters inhabiting dens in the natural environment 21
Figure 3-7: Schematic showing relationships between Climate Change variables, habitat, lobster biology, and the fishery 24
Figure 4-1: The general relationship between fishing mortality and fishery yield 27
Figure 4-2: The general relationship between harvest rate and stock size 28
Figure 4-3: The relationship among the five elements of a general fishery management framework. 28
Figure 4-4: Methods for achieving fishery sustainability 29
Figure 4-5: The general relationship between fishing mortality and spawning potential ratio 33
Figure 4-6: Annual catch and catch reference values. 36
Figure 4-7: CPUE for individual fishing seasons and CPUE reference values 37
Figure 4-8: SPR curve output from the Parrish Model 39
Figure 4-9: Catch, effort, and CPUE in the South Australia lobster fishery for *Jasus edwarsii* 47
Figure 4-10: An example of an MSE model run 54

DRAFT

[Acknowledgement]

DRAFT

Acronyms

CA lobster – California spiny lobster, *Panulirus interruptus*
CalCOFI – California Cooperative Oceanic Fisheries Investigations
CC – Climate Change
CCR – California Code of Regulations
CDFW – California Department of Fish and Wildlife
CL – Carapace length
Commission – California Fish and Game Commission
CPUE – Catch per Unit Effort
EFI – Essential Fishery Information
FGC – California Fish and Game Code
FMP – Fishery Management Plan
GHG – Green House Gas
HCR – Harvest Control Rules
ITQ – Individual Transferrable Quota
LAC – Lobster Advisory Committee
Max LS – Maximum Legal Size
MEY – Maximum Economic Yield
Min LS – Minimum Legal Size
MLMA – Marine Life Management Act
MLPA – Marine Life Protection Act
MPA – Marine Protected Areas
MSE – Management Strategy Evaluation Model
MSY – Maximum Sustainable Yield
SAM – Size at Maturity
SCB – Southern California Bight
SPR – Spawning Potential Ratio
SST – Sea Surface Temperature
TAC – Total Allowable Catch
TAC – Total Allowable Catch
YPR – Yield per Recruit

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Glossary

Abundance - The total number of animals in a population. This is rarely known, but usually estimated from relative abundance (see **Relative abundance**), although other methods may be used.

Adaptive management - In regard to a marine fishery, it means a scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that even if they fail, they will provide useful information for future actions. Monitoring and evaluation shall be emphasized so that the interaction of different elements within the system can be better understood.

Advisory Committee - The Advisory Committee is a body composed of public constituent representatives that provide important advice to the spiny lobster fishery, especially those involving local knowledge.

Allocation - In the LFMP allocation means a certain amount of lobster set aside for recreational, commercial, and ecosystem needs.

Bag limits - The total amount of fish or other species that may be captured per person per day by law.

Benthic - On or relating to the region at the bottom of a sea or ocean.

Biomass (B) - The total weight of organisms at a given point in time in a defined stock, area, population, or catch.

Bycatch - Fish or other marine life that are taken in a fishery but not the target of the fishery. Includes non-target organisms whether or not they are discarded, and includes organisms discarded because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained.

Capacity - The potential ability of a vessel or a fleet of vessels to capture organisms. This ability is based on the number of fishing vessels in the fleet, the size and technical efficiency of each vessel, time spent fishing, and management regulations.

Catch Per Unit Effort (CPUE) - The rate at which fish are caught; typically a number or weight of fish captured per unit of effort. Units of effort can be assigned many ways, including the time spent fishing (hours or days), the amount of fishing gear deployed (number of vessels, traps, nets, etc.), the number of times that fishing gear is deployed and retrieved (e.g., net hauls, trap pulls), or a combination of these estimates. Because it is difficult and expensive to scientifically measure the number of fish in an area (abundance), CPUE is often used as an index for the relative abundance of organisms across time or space. For spiny lobster in California, CPUE is typically defined as the number of legal (or sublegal-sized) lobsters per trap pull for the commercial fishery, and number of legal lobsters retained per fishing trip for the recreational fishery. Effort is most often described in terms of trap pulls, total traps, and number of active permits for the commercial fishery, and number of fishing trips for the recreational fishery.

Commercial fishery - Describes a group of enterprises and individuals as well as their actions associated with fishing for certain species with the intent of selling the catch.

Conical hoop net - A modified style of hoop net used to catch lobster by the recreational lobster fishing sector in California; it is basket shaped, does not collapse, and does not lie flat on the seafloor.

Creel survey - Catch information gathered from recreational sources.

California Recreational Fisheries Survey (CRFS) - The California Recreational Fisheries Survey (CRFS) is the method for estimating total marine recreational finfish catch and effort in California. The CRFS is a coordinated sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing.

Department - In the context of the LFMP, refers to the California Department of Fish and Wildlife (CDFW).

Depleted/Depletion - Exploitation of a resource down to unsustainable levels.

Depressed fisheries - The condition of a fishery for which the best available scientific information and other relevant information that the Commission or Department possesses or receives, indicates that a declining population trend has occurred over a period of time appropriate to that fishery. With regard to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, "depressed" means the condition of a fishery that exhibits declining fish population abundance levels below those consistent with maximum sustainable yield.

Economic output - Represents deliveries of final goods and services by the sector to domestic households, investment, government and non-profit institutions, and net exports outside the local economy.

Economic overfishing - Fishing levels that exceed maximum economic yield

Ecosystem - The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of matter and energy, which together produce and maintain a characteristic type of biological community. Ecosystems can range in size.

Effort - A measure of some expenditure in pursuing an activity. The measure in lobster fishing effort is usually in terms of number of traps fished (in commercial fishery), number of fishing trips, or time spent fishing.

Effort Creep - A phenomenon where technology advancements in a fishery are able to mask the declining efficiency of a fishery caused by stock declines

El Niño - A periodic warming of the ocean surface waters in the eastern Pacific Ocean. It is characterized by a lack of upwelling of cold, nutrient-rich waters nearshore.

Essential fishery information (EFI) - With regard to a marine fishery, means information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on fish age structure and on other marine living resources and users; and any other information related to the biology of a fish species or to taking in the fishery that is necessary to permit fisheries to be managed according to the requirement of this code.

Ex-vessel price/Ex-vessel value - The value of fish at first sale by fishermen at the dock, distinguished from wholesale or retail value.

Fecundity - The reproductive capacity of an individual female animal during a reproductive event or breeding season, generally expressed as the number of eggs or larvae per unit weight or per individual.

Finfish - Fishes with fins with vertebrates, as opposed to shellfish, which lack vertebrates

Fishery - The people involved in fishing, species being targeted, area of water or seabed, method of fishing, class of boats, purpose of the activities, or a combination of these features.

Fishery-dependent data - Information collected directly from or during the process of fishing, or from fishery landing data. May be collected from commercial and/or recreational sources, and may include catch/effort reported by fishermen, size and age composition of the catch, and biological samples collected at port.

Fishery-independent data - Information collected during processes that do not involve fishing (e.g. scientific research) and separately or independent of fishery landing data. May be collected using fishing gear such as trawls or seine nets, or surveys done using acoustics, SCUBA, or video to observe fish. Fishery-independent studies are often difficult and sometimes not feasible to conduct during fishing, such as mark-and-recapture studies to estimate movement, migration, growth rates, and natural mortality.

Fishing mortality (F) - The rate at which organisms in a population die due to fishing.

Growth overfishing - Fishing in which yield per recruit is lower than theoretical maximum values due to the removal of small and rapidly growing fish.

Habitat - The physical, chemical, and biological features of the environment where an organism lives.

Harvest control rules (HCR) -Harvest control rules are plans of action that prescribe adjustments in harvest regulations (e.g. fishing effort, total allowable catch, minimum legal size) and are activated ("triggered") when the calculated amount of a resource that can be taken (the defined upper limit, also known as "threshold reference point") is reached or surpassed. Harvest control rules must be based on objective, measurable criteria such as population size, productivity, density, or other inputs. Formulas are often used to calculate an allowable catch (fishing mortality); however, harvest control rules do not have to be cast in terms of fishing mortality rates or biomass levels. In general, harvest control rules are key management measures appropriate to the fishery. They are the primary mechanism for achieving sustainable use, preventing overfishing, preserving habitat, rebuilding depressed stocks, and recognizing the importance of non-consumptive uses.

Harvest rate (u) - The percentage of legally harvestable individuals in a population that are removed each year due to fishing.

Harvest regulations - The rules that define how fishermen are allowed to harvest fish. Harvest regulations are diverse and include restrictions on size of animals harvested, effort, total catch, gear types, season, or location where fishing is permitted.

Hoop net - A round net used to catch lobster by the recreational lobster fishing sector in California; it traditionally lies flat on the seafloor and assumes a basket shape upon retrieval to the surface.

Indices of Abundance - Measurements of the abundance of an organism made over time; used to make inferences about the abundance of an entire population.

Individual transferable quota (ITQ) - A program which limits the catch allowed per license or individual as well as the number of individuals who participate.

Input (from **stock assessment models) –** The numerical parameters that a stock assessment model calculate its **output** on; these can be a biological parameter such as the growth rate of the species, or it can be a management parameter, such as the legal size limit.

Intertidal - The part of the shore that lies between the low and high water lines.

Instantaneous Fishing mortality (F) - The rate at which organisms are harvested or killed due to fishing; F is an instantaneous rate that reflects the rate at which a proportion of a population is being lost, whereas the harvest rate (u) is an annual rate that reflects the rate at which a number of fish from a population is being lost.

Landing receipt - A document provided by the Department to commercial fish markets for recording landing information. Information required includes date, port of landing, species or market category of fish, pounds landed, and price paid.

Landings - The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points where fish are brought to shore. Note that landings, catch, and harvest define different things.

Length frequency distribution - A graphical representation of the number of organisms by length.

Life history - The history of changes an organism passes through in its development from egg, spore, or other primary stage until its natural death.

Limited entry program - Regulatory program that restricts the total number of permitted fishing licenses or vessels.

Lobster Advisory Committee – A committee composed of representatives for the recreational fishery, the commercial fishery, environmental interest groups, scientific experts, non-consumptive recreational interest groups, and federal resource managers; the committee was responsible for providing crucial constituent inputs during the drafting process of this FMP in the form of a consensus recommendation.

Logbooks – Records of fishing activity and catch maintained by commercial fishermen. Typically used to estimate CPUE in assessment models.

Management strategy evaluation (MSE) – For the purposes of the spiny lobster FMP, the MSE is a computer model that simulates lobster population dynamics, designed by a team led by Dr. Yong Chen, University of Maine. The MSE will allow CDFW to monitor and evaluate the effects of vetted management measures and the lobster fisheries on the lobster population. The MSE includes: 1) an operating model for simulating the dynamics of the spiny lobster stock and fishery; 2) historical and simulated fishery-dependent, fishery-independent, and biological data; 3) a stock assessment model yielding estimates of the current stock biomass/abundance and fishing mortality; 4) a set of alternative management actions that are practical, enforceable, and can be simulated; 5) a set of performance measures for evaluating the performance of these management actions with respect to management objectives; and 6) a set of harvest control rules determining how the management regulations should be adjusted based on a set of defined biological reference points and stock assessment results. The model is very sophisticated, and it requires tremendous resources to run effectively. The model will not be ready for use until CDFW adapts its scripts to the state's fishery management framework.

Marine Life Management Act (MLMA)- The Marine Life Management Act (MLMA), which became California law January 1, 1999, calls for using several tools to meet its goals of conserving entire

ecosystems, placing value on non-consumptive benefits, sustainability, habitat conservation, restoring depressed fisheries, limiting bycatch, and recognizing the interests of people dependent on fishing. FMPs are one of those tools.

Marine Life Protection Act (MLPA) - The MLPA, enacted in 1999, required the California Department of Fish and Wildlife to develop a Marine Life Protection Program, including a Master Plan for a network of Marine Protected Areas (MPAs) within state waters. The network of MPAs includes an improved State Marine Reserve (complete no-take areas) component and other classifications of MPAs (State Marine Parks and State Marine Conservation Areas). The goals of the MLPA are varied and include protecting portions of ecosystems in a variety of habitats, preserving biodiversity, and helping to sustain and protect populations of fished species.

Marine protected areas (MPAs) - Areas closed to all fishing, or to specific user groups, or to the take of certain species; they are used to geographically limit effort and to protect portions of stocks as well as various ecosystem services and non-consumptive uses.

Maximum economic yield (MEY) - The total amount of profit that could be earned from a fishery if it were owned by one individual. An open entry policy usually results in too many fishermen so profits are barely higher than opportunity costs.

Maximum sustainable yield (MSY) - In a marine fishery, means the largest catch that can be taken from a stock continuously over time that does not result in a continuing reduction in stock abundance, assuming constant environmental conditions. MSY is generally presented as a maximum annual catch that can be maintained indefinitely; however, MSY can change with fluctuations in abundance and environmental variability (e.g. shifts in ocean regimes), requiring adjustments in allowable harvest.

Natural mortality (M) - The rate at which organisms in a population die due to natural causes.

Nearshore - All oceanic state waters within 0-3 miles from shore or less than 100 fathoms deep, whichever is greater.

Nocturnal - Relating to, or occurring at night.

Non-consumptive uses - Activities which involve the specified resource but no harvest is involved.

Offshore - All oceanic waters outside state waters or deeper than 100 fathoms (for comparison see **Nearshore**).

Optimum Yield (OY) - With regard to a marine fishery, means the amount of catch taken in a fishery that: 1) provides the greatest overall benefit to the people of California, particularly with respect to food production and recreational opportunities, and takes into account the protection of marine ecosystems; 2) is the maximum sustainable yield of the fishery, as reduced by relevant economic, social, or ecological factors; and 3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing maximum sustainable yield in the fishery. Optimum yield should be no greater than maximum sustainable yield.

Output (of stock assessment models) - The substantive predictions of a model; for this FMP, it usually corresponds to the reference points (what would the SPR of the stock be with management action X?)

Overfished - A stock that is at unacceptably low levels because it has experienced overfishing and has not been rebuilt.

Overfishing - Means a rate or level of take that the best available scientific information (and other relevant information that the Commission or Department possesses or receives) indicates is not sustainable or that jeopardizes the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis. The depletion of fish stocks to unacceptably low levels. See **Growth overfishing, Recruitment overfishing, and Economic overfishing**.

Parrish Model - A simplified and efficient fishery stock model developed for the California spiny lobster by Dr. Richard Parrish. CDFW currently uses this model to calculate the SPR of the stock.

Pelagic - Of or relating to aquatic organisms that live in the ocean without direct dependence on the shore or bottom.

Physiological - Of or relating to the normal functioning of an organism.

Plankton - Very small organisms that passively drift with tide and current.

Planktonic - Of or related to **planktons**

Population – All the individuals of a species that live in the same geographic area. A population may contain several discrete breeding groups or stocks.

Productivity - Describes the birth, growth, and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence has a high turnover. Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.

Proxy - A number that is used as a substitute for another number. In fisheries management, landing information is often used as a proxy for other types of information not yet available.

Recreational fishery - Describes a fishery associated with taking of any fish for any purpose other than profit.

Recruit - An organism entering the exploitable stage of its life cycle; or a larval or juvenile organism as it settles or appears in the adult ecological niche. See **Recruitment**.

Recruitment - The process, event, or rate by which individuals enter new life stages or segments of a population. *Larval recruitment* refers to the process or event by which larvae of lobster (or other marine species) exit the planktonic life stage (during which they drift in ocean currents) and turn into miniature versions of adult lobsters that settle on the seafloor. *Fishery recruitment* (or, recruitment to the fishery) refers to the moment that an animal becomes vulnerable to capture in a fishery – usually because it has attained some minimum size or age for harvest.

Recruitment overfishing - Fishing that depletes the mature adult population (spawning stock) to low levels at which reproduction (and subsequent recruitment) is inadequate to replenish the population.

Reference points (biological reference points) - Reference points are quantitative (numerical) values that inform managers about the current status of a stock. Two important types must be considered, target and threshold (or limit) reference points. *Target reference point* is a numerical value that indicates that the status of a stock is at a desirable level; often times management is geared towards achieving or maintaining this target. *Threshold (limit) reference point* is a numerical value that indicates

that the status of a stock is unacceptable (e.g. overfished or too small), and that management action should be taken to improve stock status.

Relative abundance - Usually measured with indices that track trends of a population biomass (e.g., CPUE) over time. It is not a direct or (usually) precise estimate of biomass.

Report card - A mean of collecting fishery-dependent data on the recreational lobster fishery in California. Lobster report cards collect information on the number of people recreationally fishing for lobster each year, the gear they use, and their harvest and success rates. Required since 2008 for all persons fishing recreationally for lobster in California

Scavengers – Animals that feed on dead or decaying organisms

SCUBA - "Self Contained Underwater Breathing Apparatus" utilized to catch lobster by hand by the recreational lobster fishing sector in California; proposed here as a way for commercial fishermen to retrieve lost traps or cut out of entanglement

Settlement - In marine ecology, it means the process by which organisms change from an open ocean life history phase to assume a new mode of life as a member of a sea-floor community. In lobster, it is the stage at which juveniles move into the adult habitat where they become resident.

Size at maturity (SAM) - The size at which 50% of animals in a population have reached sexual maturity and are capable of reproduction.

Size limit - The minimum size a fish or other organism must be for it to be possessed.

Skin diving - Breath hold diving (freediving) utilized to catch lobster by hand by the recreational lobster fishing sector in California.

Southern California Bight (SCB) - The coastal and its immediate offshore areas between Point Conception to the north and the U.S. – Mexico border to the south. The curvature of the coastline and the relatively shallow depth of the area lead to oceanographic and biological characteristics that are clearly distinguishable from the central California coast.

Spawning potential ratio (SPR) – A ratio of the number of eggs produced by a fished population over the number of eggs produced by an unfished population; used to characterize the amount of impact fishing has on a population's ability to reproduce.

Spillover - The emigration of adults from a protected area to the fishing grounds, and/or larval export from the protected area to surrounding areas.

Stock - A group of fish of the same species in a given management area. A single stock may be comprised of multiple populations or be a portion of a single larger population.

Stock assessment - An evaluation of the status of a stock, including past and current stock levels and information to help guide future harvest. Assessments may integrate many different biological data, including growth rates of fish, mortality rates, age at first reproduction, fecundity, size classes present in the catch, and selectivity of fishing gear.

Stock Composition - Any description of the population attributes of a stock (age, size, sex), usually within a spatial context. This commonly refers to the spatial distribution of breeding groups or genetically-related organisms.

Stock Size – Total estimated number or biomass of fish within a stock

Substrate - The surface or medium on or in which an organism lives (i.e., mud, sand, rocks).

Sustainable, Sustainable use, and Sustainability - With regard to a marine fishery, means both of the following: 1) continuous replenishment of resources, taking into account fluctuations; and 2) securing the highest possible present and long-term social and economic benefits, maintaining biological diversity, and managing fisheries in a way that does not exceed **optimum yield**.

Thresholds (threshold reference points) – For the purpose of this FMP, the levels of stock size, reproductive potential, or fishing mortality rates that managers attempt to avoid. When threshold reference points are crossed, they would lead to adjustment via a control rule.

Total allowable catch (TAC) - A specified numerical catch objective for each fishing season, the attainment (or expected attainment) of which may cause closure of the fishery.

Total allowable effort (TAE) - A specified numerical effort objective for each fishing season. This can be expressed in number of boats, amount of gear used, etc.

Total economic output – The total amount of economic output that does not take into account the amount of intermediate goods consumed during the harvest/production process; for lobsters, this means the amount of money sales generate before costs such as trap cost are considered. Also known as Gross Economic Output.

Total economic value added – Total economic output less the goods and services used up to create that output; for lobster fishery, it means the net value of the lobsters after costs like trap purchases are accounted for. Also known as Net Economic Output.

Total mortality - Natural mortality and Fishing mortality combined.

Traps - Generally, a wire basket or cage used for trapping certain types of organisms.

Trap limit – A type of regulatory measure that restricts the amount of traps a fisherman may have within a given season.

Unfished - The unfished or pristine biomass.

Upwelling - On the California coast, upwelling is the upward movement of deep waters into the nearshore ecosystem due to springtime winds moving the topmost layers of water away from land.

Yield - The total number or biomass of fish captured.

Yield per recruit (YPR) - A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

Zooplankton - Small animals passively carried along with water currents and other water movement.

DRAFT

1. Introduction

The Marine Life Management Act (MLMA) addresses the conservation and **sustainable** use of California's living marine resources (FGC § 7050(b)). The MLMA states that Fishery Management Plans (FMP) "shall form the primary basis for managing California's sport and commercial marine fisheries (FGC § 7072). FMPs are framework documents that consolidate available information under the statutorily prescribed frameworks (FGC §§ 7072, 7075, 7080-7088); their contents and any subsequent amendments form the basis for all **fishery** management decisions. The California Department of Fish and Wildlife (CDFW) is responsible for drafting the FMPs and presenting them to the California Fish and Game Commission (Commission). FMPs become effective upon adoption by the Commission through a public process. Implementation is done through a separate Commission rulemaking process, and the implementing regulations are codified in Title 14 of the California Code of Regulations. This FMP is developed for the California spiny lobster (*Panulirus interruptus*; CA lobster) in U.S. waters.

Sustainable, Sustainable use, and Sustainability - With regard to a marine fishery, means both of the following: 1) continuous replenishment of resources, taking into account fluctuations; and 2) securing the highest possible present and long-term social and economic benefits, maintaining biological diversity, and managing fisheries in a way that does not exceed **optimum yield**. See also FGC § 7050(b).
Fishery - The people involved in fishing, species being targeted, area of water or seabed, method of fishing, class of boats, purpose of the activities, or a combination of these features.
Commercial fishery - Describes a group of enterprises and individuals as well as their actions associated with fishing for certain species with the intent of selling the catch.
Recreational fishery - Describes a fishery associated with taking of any fish for any purpose other than profit
Ecosystem - The physical and climatic features and all the living and dead organisms in an area that are interrelated in the transfer of matter and energy, which together produce and maintain a characteristic type of biological community. Ecosystems can range in size.

1.1 The Goal of the Spiny Lobster FMP

The goal of this FMP is to formalize a management strategy that can respond effectively to changes in the CA lobster fisheries pursuant to the tenets of the MLMA. CA lobsters have long supported major **commercial** and **recreational fisheries**, and the species plays a key role in maintaining the health of the southern California kelp forest **ecosystem**. This ecosystem is important to a number of non-consumptive users such as divers, eco-tourists, researchers, educators, and the conservation community.

To achieve responsive and effective management, this fishery must be adaptable and sustainable. This FMP uses an **adaptive management** framework (Holling et al., 1978; Walters and Hilborn, 1978) based on a harvest control rule (Section 4.3). Section 90.1 of the Fish and Game Code (FGC) defines adaptive management as "a policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning."

1.2 Efforts Leading Up to the Spiny Lobster FMP – The Lobster Advisory Committee

This FMP incorporates input from the Lobster Advisory Committee (LAC). The LAC was formed in early 2012 following a call for volunteers to various public stakeholder groups by CDFW. The purpose of the LAC is to involve constituent representatives with the development of this FMP. The LAC provided guidance on FMP objectives and end products as well as ideas for management options that addressed the key issues put forth by members of the public. The LAC consists of representatives from the marine science community, the recreational fishing sector, commercial fishing sector, the non-consumptive recreational sector, the environmental community, and the federal government.

A total of nine LAC meetings occurred between June 2012 and September 2013. All meetings were open to the public, and public input was encouraged. Meeting announcements were posted on the CDFW website, and the public was encouraged to sign up for the Lobster FMP news email service. Meeting

summaries as well as various background documents are available on the CDFW website (www.dfg.gov/marine/lobsterfmp). The LAC reached consensus on several management recommendations for CDFW and the Commission (Section 4.5; Appendix II – Executive Summary of the Constituent Involvement Plan).

2. Background of the California Spiny Lobster Fishery

CA lobsters have been fished since the 1800s. U.S. fishermen target CA lobsters primarily from Point Conception south to the U.S. – Mexico border, and off southern California islands and banks (Barsky, 2001; Figure 2-1). Some fishing takes place north of Pt. Conception, but as of 2013 effort has not been significant. The fisheries run from early October to mid-March, with the recreational sector starting 4 days earlier than the commercial fishery (FGC § 8251; 14 CCR § 29.90). This results in a 24 week commercial fishing season and a 24.5 week recreational fishing season.

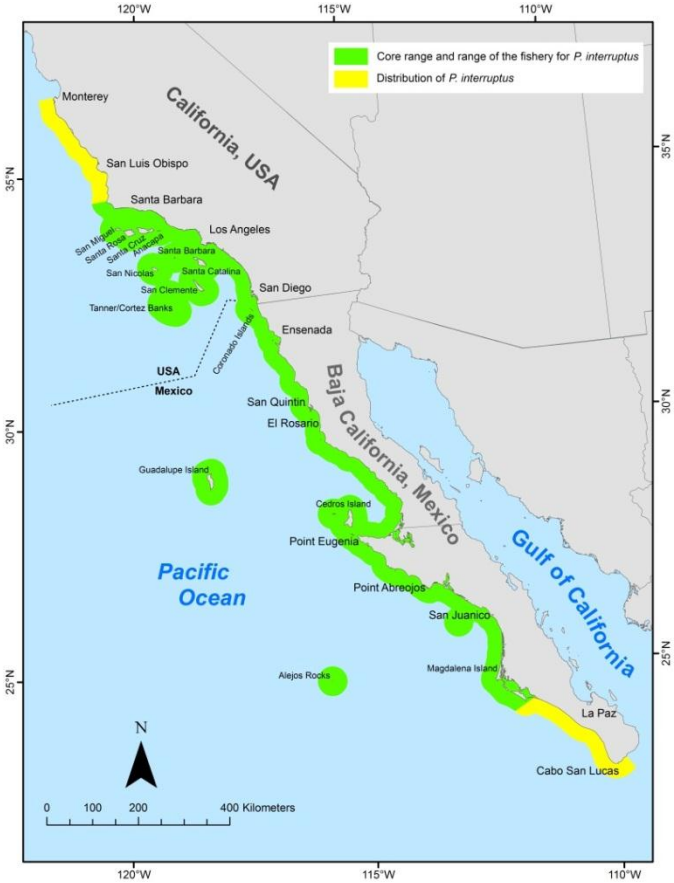

Figure 2-1: Geographic range of P. interruptus
***A 20mi buffer from the coast was used to indicate the approximate range of the species, and does not represent fine-scale distribution**

A 2011 **stock assessment** suggested that the post-2000 CA lobster **population** is at a sustainable level where surplus production provides the majority of the harvestable lobster each season (Neilson, 2011). This conclusion was based mostly on consistency in the size of the captured lobsters, **harvest rates**, catch totals, and level of fishing effort since 2000.

Biological sustainability of the **stock** is attributed to multiple factors. The minimum legal size for the CA lobster fisheries is larger than the size at which individuals reach sexual maturity (Section 3.3). The number of sublegal-size lobsters caught by commercial fisherman has increased in recent years, which suggests that the current size limit is effective, and that a sizable number of sublegal-size lobsters are present in the wild and contributing to reproduction (Neilson, 2011).

Stock assessment - An evaluation of the status of a stock, including past and current stock levels and information to help guide future harvest. Assessments may integrate many different biological data, including growth rates of fish, mortality rates, age at first reproduction, fecundity, size classes present in the catch, and selectivity of fishing gear.
Population – All the individuals of a species that live in the same geographic area. A population may contain several discrete breeding groups or stocks.
Harvest rate (u) - The percentage of legally harvestable individuals in a population that are removed each year due to fishing.
Stock - A group of fish of the same species in a given management area. A single stock may be comprised of multiple populations or be a portion of a single larger population.

2.1 Commercial Fishery History and Description

The commercial CA lobster fishery can be characterized by several distinct periods. Commercial landings peaked at an all-time high of 485 mt (1.07 million pounds) during the 1949-50 fishing season,

and declined to a record low of 69 mt (152,000 pounds) during the 1974-75 fishing season (Figure 2-2). The reason for this decline was thought to have been the illegal take of sublegal-size adults, and was corrected by the introduction of escape ports in 1976 which allowed sublegal-size individuals to exit **traps** (Barsky, 2001). After 1976, the harvest slowly increased until the 2000-01 fishing season, when 319 mt (702,000 pounds) were landed. Since 2000, **landings** have fluctuated within a relatively narrow range, exceeding 300 mt (661,000 pounds) each season. Figure 2-3 provides a snap shot of CA lobster landings based on commercial fishing blocks between 2000 and 2013 along with the various areas closed to at least one of the fisheries. Since 2000, the number of participants has remained relatively consistent at between 145 to 160 participants (Figure 2-6).

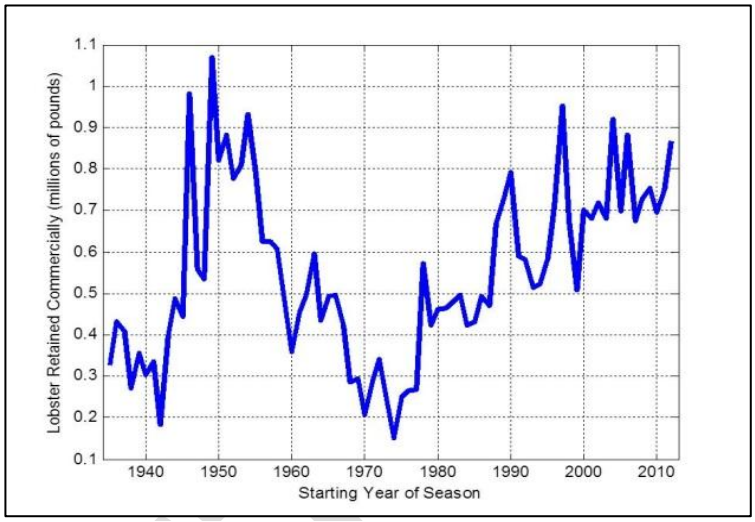

Figure 2-2: California commercial lobster landings from the 1936-37 fishing season through 2012-13 season.

Traps - Generally, a wire basket or cage used for trapping certain types of organisms.
Landings - The number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use. Landings are reported at the points where fish are brought to shore. Note that landings, catch, and harvest define different things.

Commercial fishermen use wire box-like traps deployed from boats to catch CA lobsters (Figure 2-5). Properly placed and serviced traps do not generally cause significant physical disturbance to the environment (Eno et al., 2001). Traps are usually deployed in less than 31m (100 ft) of water, but some are deployed as deep as ~93 m (300 ft). According to a 2013 CDFW commercial fishery survey, a fisherman

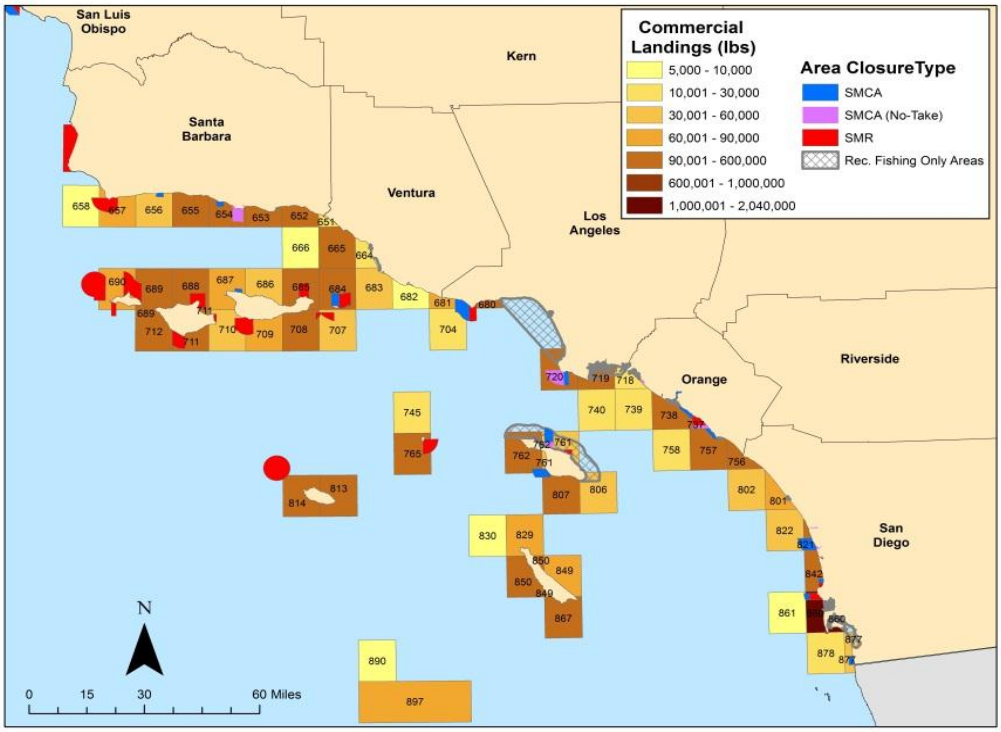

Figure 2-3: Total Commercial Landings by CDFW commercial fishing block between 2000-2013 overlayed with area closures (MPAs and recreational-only fishing areas)
***SMCA = State Marine Conservation Area**
****SMR = State Marine Reserve**

generally operates a total of between 75 to 1,000 traps each season, with a median of 300 traps. California law requires fishermen to service (pull and clean) each deployed trap at least once every 96-hours, weather conditions permitting (FGC § 9004).

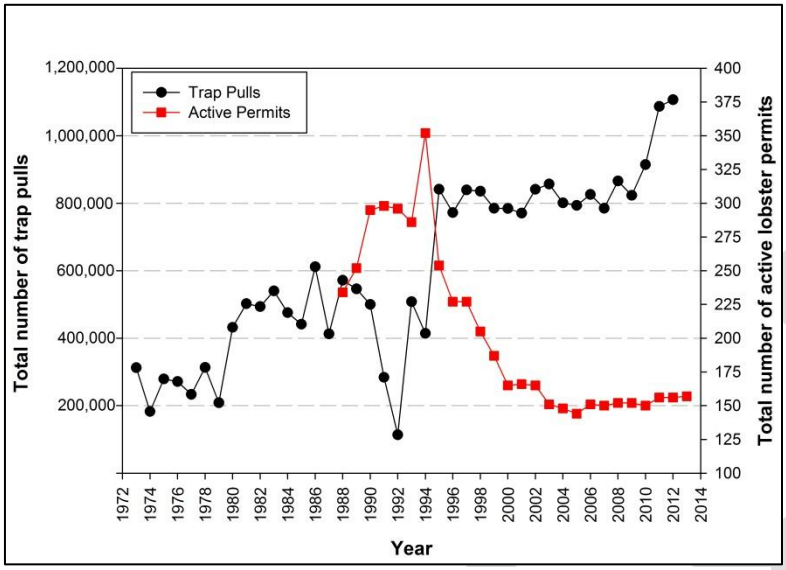

Figure 2-6: Historical total trap pull by year (black) compared to total number of active fishermen by year (red)
***Active Permits defined as individuals who made at least one landing during a particular fishing season**

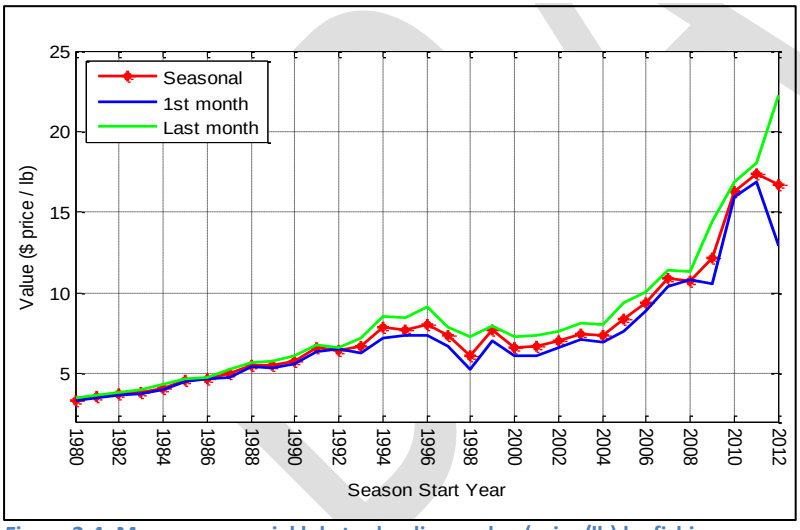

Figure 2-4: Mean commercial lobster landings value (price/lb) by fishing year season. Lines indicate the total season, beginning (Sept+Oct), and ending (Feb+Mar) average value.

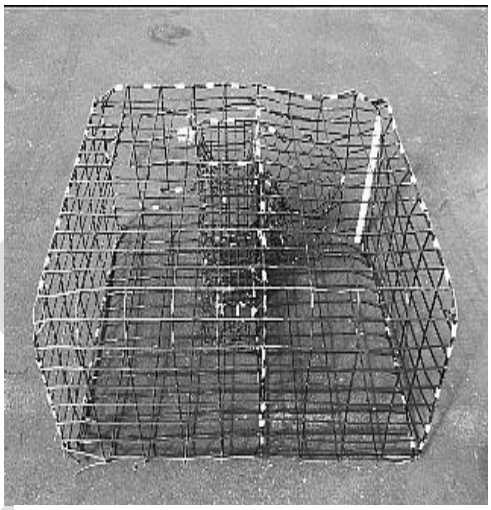

Figure 2-5: California commercial fishing trap

Commercial Landings tend to be distributed evenly between San Diego County, Los Angeles/ Orange Counties, and Santa Barbara/ Ventura Counties. In general, 80% of a season's catch is landed within the first half of the commercial season by mid-January. Lobsters caught by the commercial fishery average approximately 0.64 kg (1.4lb), corresponding to lobsters that have reached legal size in the last 1-2 years, although larger lobsters are still landed (Neilson, 2011).

Commercial fishing effort (i.e., number of trap pulls) has been increasing in recent years despite an overall decrease in the number of active fishermen since the late 1990s (Figure 2-6). Between 1995 and 2009, the annual total trap pulls of the commercial fleet hovered near 800,000 pulls. In 2012, the number has risen to just over 1.1 million pulls, despite the fact that the number of total active fishermen has remained around 150 individuals since 2003. This effort increase could be driven by several factors. Permit transferability adopted in 2005 can create considerable debt for new entrants into the fishery. These permits currently sell for $75-100K on the private market based on online permit exchange (e.g., http://www.permitmaster.com); the price has been corroborated by public testimonies from

commercial fishermen during Commission's Marine Resources Committee meetings. It is reasonable to expect the owners of this debt to fish harder than unindebted permit holders.

Furthermore, latent permits are becoming increasingly active because of the rapidly rising ex-vessel price of CA lobster in recent years. The average landing price of CA lobster has consistently increased over each season since the early 1990s (Figure 2-4). In the 2013-14 fishing season the fishery hit a record average seasonal landing price of $16.98/lb. The average landing price ($/lb) of CA lobster increased from $6.50 in the 1993-94 fishing season to $11.61 in the 2009-10 fishing season as domestic demand slowly grew. However, the average price increased by the same amount in just 4 years between the 2010-11 fishing season and the 2013-14 fishing season. Total **ex-vessel value** increased gradually between late 1960s and 1990s, after which the value increased at a much faster rate and reached a record high of $14.3 million in the 2012-13 fishing season (Figure 2-7).

Ex-vessel price/Ex-vessel value - The value of fish at first sale by fishermen at the dock, distinguished from wholesale or retail value.
Yield per recruit (YPR) - A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

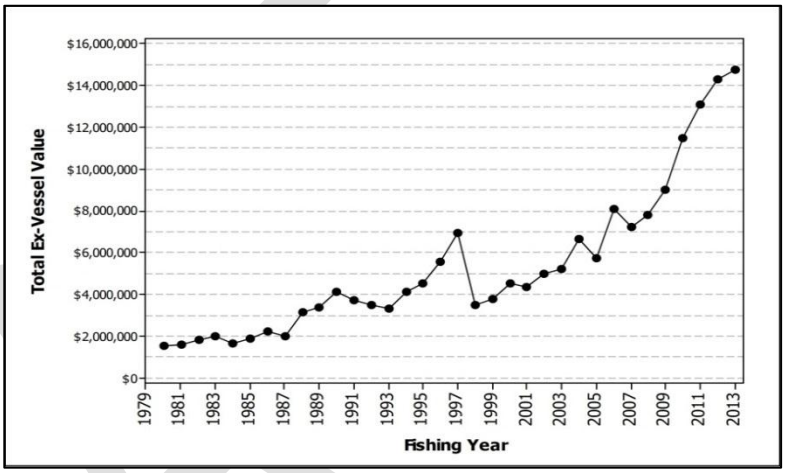

Figure 2-7: Historical total ex-vessel value of the CA lobster fishery

Figure 2-8 shows the cumulative percentage contribution of fishermen, ranked from highest to lowest catch, to the total catch of the fishery in the 2013-14 fishing season. If all fishermen land similar levels of catch, the cumulative catch will be a straight line. Here the slope is curved, which means that ranks exist with some fishermen landing more than others. Furthermore, the curve is very gradual with no significant break, suggesting that competition within the fishery may be fierce, and a fisherman can easily trade ranks with those immediate before or after him/her from one season to the next. However, this graph does not show the difference in operational costs between fishermen, and a more efficient fisherman (e.g., loses less traps or running more efficient boat) may generate more profit than a more highly ranked competitor.

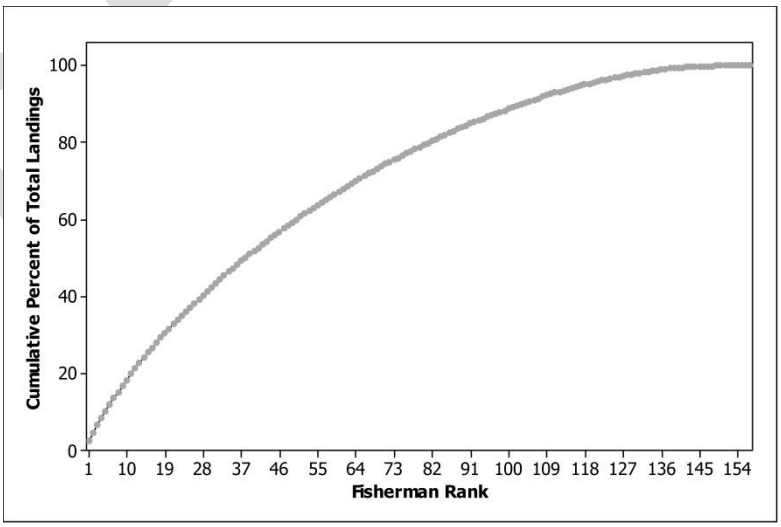

Figure 2-8: The cumulative percentage contribution of fishermen to the 2013-14 fishing season landing
*The graph starts with the fisherman with the highest landing and incrementally adds the landing of the next highest-landing fishman until all fishermen are accounted for.

High effort in the commercial fishery may present challenges to sustainability because it results in a high harvest rate. Instantaneous harvest rate (Section 4.1) for the sub-stock in Santa Barbara is estimated to be higher than San Diego. For CA lobster, however, **yield per recruit** (YPR) increases very little when

harvest rates are increased beyond a certain point, leading to **economic overfishing** (Kay, 2011; Section 4.1). This scenario is nearly universal among the world's lobster fisheries (Gardner et al., 2013). The economic inefficiency of high harvest rates is accompanied by other challenges to California's MLMA objectives (Chapter 4). These include a lower spawning potential, diminished non-consumptive user experiences, and greater risk of undesired ecological interactions (e.g., bycatch, lost gear, ghost fishing).

Economic overfishing - Fishing levels that exceed maximum economic yield
Hoop net - A round net used to catch lobster by the recreational lobster fishing sector in California; it traditionally lies flat on the seafloor and assumes a basket shape upon retrieval to the surface.
SCUBA - "Self Contained Underwater Breathing Apparatus" utilized to catch lobster by hand by the recreational lobster fishing sector in California; proposed here as a way for commercial fishermen to retrieve lost traps or cut out of entanglement
Creel survey - Catch information gathered from recreational fishermen.
Conical hoop net - A modified style of hoop net used to catch lobster by the recreational lobster fishing sector in California; it is basket shaped, does not collapse, and does not lie flat on the seafloor.
Report card - A mean of collecting fishery-dependent data on the recreational lobster fishery in California. Lobster report cards collect information on the number of people recreationally fishing for lobster each year, the gear they use, and their harvest and success rates. Required since 2008 to be filled out by all persons fishing recreationally for lobster in California

2.2 Recreational Fishery History and Description

The recreational fishery targets CA lobster using **hoop nets** (Figure 2-9) or by hand when diving (**SCUBA** or skin diving). Historically, diving has been more prevalent than hoop netting. Eighty percent of the interviewees in a 1992 CDFW recreational **creel survey** were composed of divers, with hoop netters accounting for 20%. This pattern has since changed with 80% of the recreational interviewees in the more recent 2007 CDFW recreational creel survey hoop netting.

CDFW allows two types of hoop nets: traditional hoop nets and rigid **conical hoop nets** (14 CCR § 29.80). The traditional hoop nets lie flat on the seafloor and only take their three-dimensional shape when pulled to the surface. A slow or jerky pull can allow lobster to escape out the top or sides. Conical hoop nets have rigid sides and do not lie flat on the seafloor. The lobster must climb up and into the net to reach the bait. When disturbed, lobsters fleeing sideways are blocked by the net regardless of how the hoop net is pulled. A CDFW study found that conical nets catch about 57% more lobster than traditional style nets over time (Neilson et al., 2009).

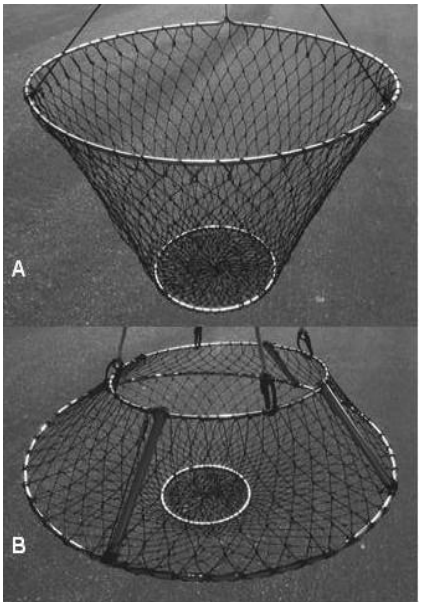

Figure 2-9: Traditional hoop net (A) and rigid conical hoop net (B).

CDFW has not been able to accurately quantify the sport fishery catch until recent years through the recreational lobster **report card** (Section 5.1.1; Table 2-1). The report cards in turn have not been able to produce reliable results until the most recent season due to low return rates. Statistical comparison between hoop net fishermen and divers has been particularly problematic. For example, in 2009, only 50.9% of all report cards returned were from hoop net fishermen, even though both the creel survey and the recreational industry representatives indicated that a large majority of the recreational fishermen at that point were hoop net fishermen. The most recent set of report card returns (2013-14 fishing season) was composed of 60% hoop net fishermen. However, this result may still be underrepresenting the overall fraction of hoop net fishermen.

When the requirement was first implemented, report cards tracked the calendar years. Starting in 2013, CDFW adjusted report cards to track individual lobster fishing

seasons which cross consecutive calendar years, using inputs from various constituent representatives. Data from the 2013-14 fishing season lobster report cards estimated the recreational catch to be 141.8 mt (312,634 lb), or about 28% of the total (i.e., recreational plus commercial) catch. The report cards also indicate that most CA lobsters captured by the recreational fishery are caught in areas where the commercial fishery is prohibited (Figure 2-10; FGC § 8258). It is unclear whether this pattern is caused by ease of access from ports or better fishing conditions. Communication with hoop net retailer representatives suggests that public interest in hoop nets may have plateaued. (J. Salazar, pers. comm.), but future recreational effort increases may be inevitable due to human population growth in California. CDFW will continue to improve its data collection on the recreational sector and remain adaptive towards any change.

Table 2-1: Estimate of Total Recreational Lobster Fishing Effort and Catch based on recreational report cards

Estimates of Total Recreational Lobster Fishing Effort and Catch

Calendar Year	Number of Cards Sold	Card % Return Rate	Estimated Number of Active Lobster Cards (Cards that recorded at least one trip)	Estimated Number of Fishing Trips	Average CPUE (Avg. # of Lobsters Kept Per Trip)	Estimated Weight of Landings in Tons (pounds)	Percent of Total (Recreational + Commercial) Landings
2008*	27,472	22%	24,038	104,085	2.1	130.12 Mt (286,858 lbs)	33%
2009	32,343	14%	27,847	147,868	2.2	193.57 Mt (426,747 lbs)	38%
2010	29,108	12%	25,033	127,168	2.1	157.47 Mt (347,169 lbs)	33%
2011	33,376	16%	28,870	154,743	2.0	177.93 Mt (392,274 lbs)	34%
2012	37,193	33%	28,527	127,801	2.0	152.23 Mt (335,605 lbs)	28%
2013	14,514**	49%	11,437	71,024	2.1	132.65 Mt** (292,442 lbs)	27%***
2013-14	33,668	48%	26,295	88,351	1.6	141.81 Mt*** (312,634 lbs)	28%****

***Lobster report card was implemented in the fall of 2008; CDFW only has estimates for the latter half of calendar year 2008**
****Season-length report card was implemented for the 2013-14 fishing season. While some recreational fishermen still purchased 2013 calendar year lobster report cards along with 2013-14 season-length report cards, other fishermen only purchased 2013-14 season-length report cards.**
***** 2013 "Estimated Weight of Landings in Tons" and "Percent of Total Landings" includes landings from 2013 calendar year cards, PLUS landings from September, October, November, and December on 2013-2014 full season cards.**
****** 2013-2014 "Estimated Weight of Landings in Tons" and "Percent of Total Landings" includes landings from 2013-2014 full season cards, PLUS landings from September, October, November, and December on 2013 calendar year cards.**

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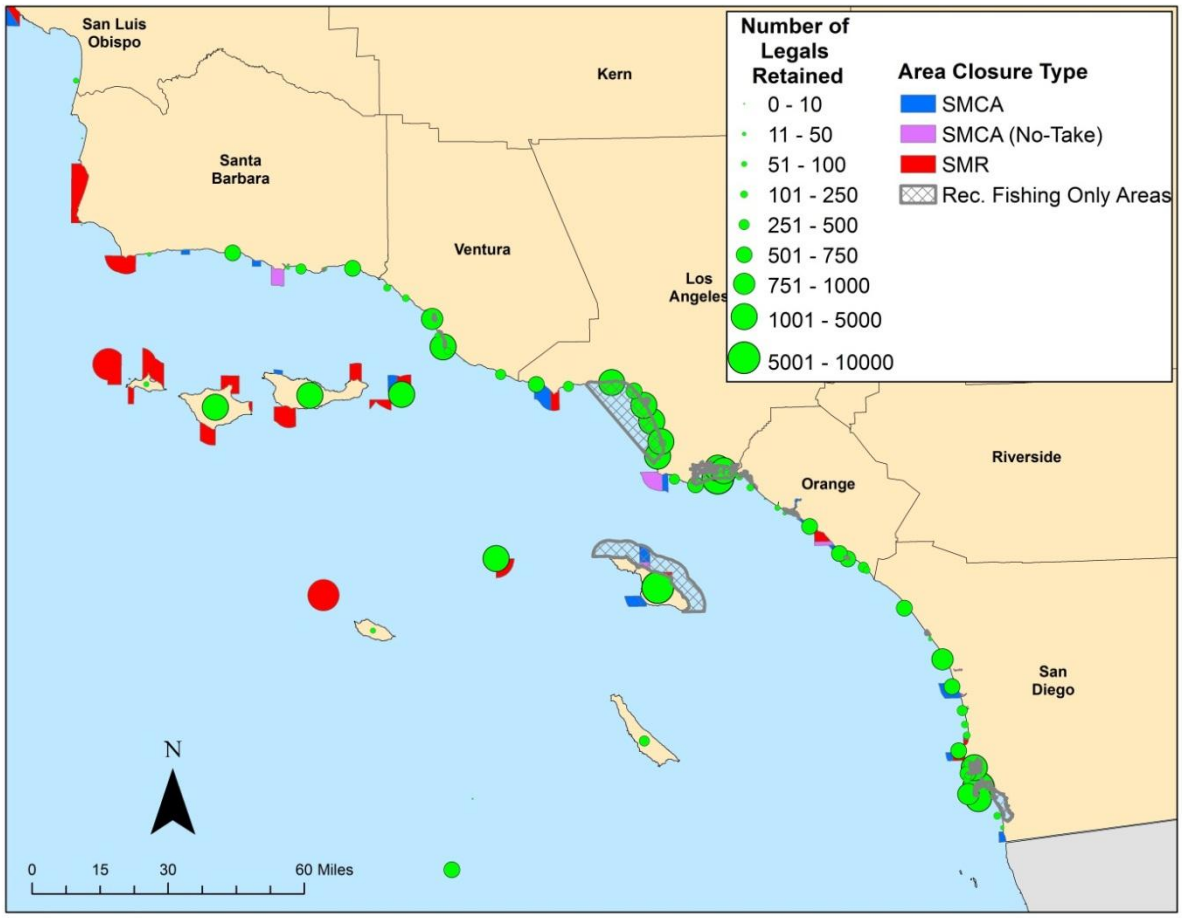

Figure 2-10: Number of legal lobsters retained from recreational lobster report cards in 2013 overlayed with area closures (MPAs and recreational-only fishing areas)
***SMCA = State Marine Conservation Area**
****SMR = State Marine Reserve**
*****Northern-most dot denotes total catch between San Luis Obispo up to CA-OR border**
****** Legals Retained represents the number of legal-size lobster captured in a particular report card site during 2013 up to the enumerated number**

2.3 Bycatch within the Fishery

Bycatch occurs in both the recreational and commercial CA lobster fisheries. There are generally two types of bycatch (FGC § 90.5) in the fisheries: 1) sublegal-size lobster; and 2) other non-targeted marine life. The MLMA calls for the minimization of bycatch when the amount or type is "unacceptable" (FGC § 7085(c)). Based on available data as of the end of the 2013-14 fishing season, CDFW concludes that there is no indication of unacceptable bycatch levels in either the commercial or recreational fisheries.

2.3.1 Commercial Fishing Bycatch

Trap fisheries generally have minimal bycatch of species other than invertebrates (Morgan and Chuenpagdee, 2003; Matthews et al., 2005). These traps are required to have both destruct devices (destruct clips/rings) to avoid ghost fishing as well as escape ports to minimize the catch of sublegal-size lobster. Traps are set on the bottom in rocky areas between about 30.5 to 91m (100 to 300ft) and are baited with whole or cut fish (CDFG, 2001). However, unattended traps can impact the marine ecosystem, and fishermen are required to raise and service them at intervals not exceeding 96 hours, weather permitting (FGC § 9004).

A Collaborative At-Sea Sampling Program made possible by Collaborative Fisheries Research West, California Sea Grant, and California Ocean Protection Council was initiated during the 2012-13 lobster fishing season. This program did not specifically focus on bycatch, however bycatch information was collected. Sampling was performed by fishermen throughout the **Southern California Bight** (SCB) with a total of 2,520 traps sampled. These data were recorded and reported in Table 2-2.

Table 2-2: Bycatch found in 2,520 commercial lobster fishing traps (Source: CASP, Culver pers. comm. 2013).

Common species name	Scientific name	% of total animals caught (5,284)
sublegal- sized CA Lobster	*Panulirus interruptus*	83.29%
Kellet's Whelk*	*Kelletia kelletii*	5.98%
Rock Crab*	*Cancer* spp.	4.20%
Wavy Top Snail	*Megastraea undosa*	0.47%
Sheep Crab*	*Loxorhynchus grandis*	1.29%
Cabezon	*Scorpaenichthys marmoratus*	0.45%
Lingcod	*Ophiodon elongates*	0.28%
Sculpin (CA. Scorpionfish)	*Scorpaena guttata*	0.04%
Swell Shark	*Cephaloscyllium ventriosum*	0.11%
Rockfish (Unidentified)	*Sebastes* spp.	0.02%
Goby (Unidentified)	Gobiidae spp.	0.02%
CA Sheephead	*Semicossyphus pulcher*	0.02%
Ocean Whitefish	*Caulolatilus princeps*	0.02%
Horn Shark	*Heterodontus francisci*	0.04%
Perch (Unidentified)	Embiotocidae spp.	0.04%
Skate (Unidentified)	Rajidae spp.	0.04%
Crab (Unidentified)	Decapoda spp.	0.02%
Sea Hare (Unidentified)	*Aplysia* spp.	0.09%
Sea Star (Unidentified)	Asteroidea spp.	2.44%
Kelp Crab (Unidentified)*	*Taliepus nuttallii / Pugettia producta*	0.09%
Octopus (Unidentified)*	Octopodidae spp.	0.23%
Urchin (Unidentified)	Echinoidea spp.	0.74%
Barred Sand Bass	*Paralabrax nebulifer*	0.02%
Snail (Unidentified)	Gastropoda spp.	0.06%

*Species that are legal to sell

Available information shows that a majority of CA lobster commercial fishing bycatch consists of invertebrates, with sublegal-size lobsters making up a great majority of the total bycatch. The other most common bycatch in the CA lobster commercial fishery are Kellet's whelk, rock crabs, starfish, sheep crabs, urchins, and wavy top snails (Culver pers. comm. 2013). Data from CDFW commercial fishing logs suggest that the amount of sublegal-size lobster bycatch has increased in recent years.

Fishermen may unintentionally break legs or antennae when handling sublegal-size lobsters. One Australian study found that spiny lobsters with broken appendages become less fecund due to extra energy being exerted for healing and repairing the broken appendages (Melville-Smith and de Lestang, 2007). Any similar impact on the **fecundity** of CA lobster is currently unknown.

Commercial CA lobster fishermen can legally retain certain crabs, Kellet's whelks, and octopi (FGC § 8250.5). These bycatch are reported and included in the

Southern California Bight – The coastal and its immediate offshore areas between Point Conception to the north and the U.S. – Mexico border to the south. The curvature of the coastline and the relatively shallow depth of the area lead to oceanographic and biological characteristics that are clearly distinguishable from the central California coast.
Fecundity - The reproductive capacity of an individual female animal during a reproductive event or breeding season, generally expressed as the number of eggs or larvae per unit weight or per individual.

calculation of the total annual landings of each species. Since most bycatch that are not legally retained by fishermen can be returned safely into the ocean with proper handling, the ecosystem impact through bycatch for this fishery is very limited (Hovel & Neilson, 2011; Miller, 1996). Data from Mexico reflect similar patterns in bycatch. While a 2004 study suggests that bycatch is practically non-existent in the Mexican lobster fishery (SCS, 2004), a more recent study found the weight of the bycatch in that fishery to be 15% of the total catch (Shester and Micheli, 2011). Most of the Mexican bycatch consists of crabs and other invertebrate species. Recent studies also observed sea bird (cormorant) bycatch in Mexico and Florida (Matthews et al., 2005; Shester and Micheli, 2011). However, there has not been any cormorant mortality attributed to lobster traps in California, which are all outfitted with escape ports.

Similarly, research conducted on sea otter entrapment and mortality in fish and shellfish traps suggests that the CA lobster fishery is not expected to contribute to otter mortality if the current geographic extent of the fishery and the current otter range both remain unchanged (USGS, 2014). Of the 15 reported instances of trap-related sea otter mortalities during 1974-2007, 14 occurred in either Pacific cod or crab traps (Hatfield et al., 2011). The majority of California's southern sea otter mortalities on record were the result of shark attacks, boat strikes, mating trauma, diseases, parasites, infections, and biotoxins (CDFW-MWVCRC, 2013).

2.3.2 Recreational Fishing Bycatch

Recreational fishing for CA lobster primarily occurs from Point Conception, CA to the U.S. – Mexico border, including **offshore** islands and reefs. Lobsters are caught by hand during dive trips, and divers are required to release sublegal-size individuals immediately after measuring. Certain other invertebrates may also be retained by divers targeting lobster. Hoop netters are primarily boat-based. They generally set the baited nets on the bottom in shallow waters < 30.5m (100 ft), and raise them after a soak time of <2 hours. Available information show that most of the hoop net bycatch are invertebrates such as sublegal-size lobsters, rock crabs of the *Cancer* genus, and sheep crabs. Some **finfishes** are also caught, with round stingrays being the most common (Neilson et al., 2009). Live finfishes and invertebrates can usually be released from hoop nets safely (Hovel and Neilson, 2011). Survival is high when sorting is on deck and animals are quickly returned to the water (Miller, 1996).

Data on hoop net bycatch is limited, and no data on diving bycatch exists. An unknown number of crabs are retained by hoop netters every year. Available data come from a CDFW hoop net study at Zuniga Jetty near San Diego Bay, CDFW video observations of hoop netting at Indian Rock at Catalina Island, and recreational gear data from the California Lost Fishing Gear Recovery Project. CDFW also relies on information provided by its enforcement officers as well as anecdotal information provided through online fishing reports posted on recreational fishing websites.

Offshore - All oceanic waters outside state waters or deeper than 100 fathoms
Finfish - Fishes with fins with vertebrates, as opposed to shellfish, which lack vertebrates
Total allowable catch (TAC) - A specified numerical catch objective for each fishing season, the attainment (or expected attainment) of which may cause closure of the fishery.

2.3.3 Legality of the Bycatch

Commercial and recreational fishermen are not allowed to retain sublegal-size lobsters under current California law (FGC § 8252). However, fishermen may retain legal-size crabs and octopi provided that they have the valid permits (14 CCR § 125; 14 CCR § 29.85; FGC § 8250). Commercial fishermen may also retain Kellet's whelk until the whelk's annual **total allowable catch** (TAC) is reached (14 CCR § 127; FGC § 8250). Cormorant and otter bycatch is not thought to be occurring within the CA lobster fisheries. However, if bycatch of these species occurs, compliance with the Marine Mammal Protection Act and the Migratory Bird Treaty Act would be required and further monitoring may necessary (16 USC §§ 1361 *et seq*.; 16 USC §§ 703 *et seq*.).

2.4 History of Conservation and Management Measures Affecting the Fishery

California has regulated the CA lobster fishery for over a hundred years. Current management measures include commercial fishing permits, recreational harvest report cards, gear restrictions, **size limits**, time and area closures, and a recreational possession limit (Table 2-3). The Commission has complete management authority over the sport lobster fishery (14 CCR § 29.90) and significant management authority over the commercial lobster fishery (14 CCR § 121-122; FGC §§ 8254, 8259).

Size limit - The minimum size a fish or other organism must be for it to be possessed.
Fishing Effort - A measure of some expenditure in pursuing a fishing activity. The measure in lobster fishing effort is usually in terms of number of traps fished (in commercial fishery), number of fishing trips, or time spent fishing.
Limited entry program - Regulatory program that restricts the total number of permitted

California regulations control the commercial fishery's overall **fishery effort** with a **limited entry program** (FGC § 8259; 14 CCR § 122). Since 2005, fishermen with transferable permits are allowed to sell their permits under strict conditions. Individuals wishing to enter the fishery have to purchase a permit from an existing permittee. The number of permittees actively fishing has been stable since 2008. During the 2013-14 fishing season, 141 transferable permits and 51 non-transferable permits were renewed, and 157 of those permits were actually fished.

On the recreational side, all fishermen are required to purchase a lobster report card regardless of their age, and all sport fishermen over the age of 16 must purchase a sport fishing license unless they are

Table 2-3: Regulatory history of the California spiny lobster fishery

Year	Regulatory Change Affecting the Commercial CA Lobster Fishery	Type of Change
1894	1 pound minimum size in Los Angeles, San Diego, and Ventura Counties	Size limit
1901	Berried Females Protected (repealed)	Management
1901	First minimum length implemented (9½" total length)	Size limit
1913	First slot limit introduced (9" – 13½")	Size limit
1917	Slot limit modified (10½" – 16")	Size limit
1955	3.25 inch carapace length minimum size implemented	Size limit
1957	2x4 inch wire mesh required or 2 inch high openings along two sides of traps to allow escape of undersized lobsters	Gear restriction
1961	Implementation of the modern day open season: The first Wednesday in October through the first Wednesday after March 15	Season
1961	Fish and Game Commission given authority to manage the fishery	Management
1961	Lobster permits required. New permits issued by lottery with a capacity goal of 225 fishermen	Management/ Permitting
1973	Logbooks required by law to record essential fishery information. Also, permit applications require estimate of number of traps to be fished	Reporting
1976	Escape ports are required for commercial traps	Gear restriction
1986	Fish and Game Commission given authority to limit the number of permits	Management/ Permitting
1992	The recreational season opener is moved to the Saturday preceding the first Wednesday in October to provide the sport fishery with four days of fishing prior to the commercial opener	Season
1994	Fish and Game Commission places a moratorium on new permits for 2 years in preparation for a switch to a limited entry permit fishery	Management/ Permitting
1996	Limited entry permit program begins	Management/ Permitting
2003	Lobster permit lottery repealed	Management/ Permitting
2011	CDFW initiates a spiny lobster Fishery Management Plan as mandated by the 1998 Marine Life Management Act	Management
2012	A network of new marine protected areas go into effect in Southern California as mandated by the 1999 Marine Life Protection Act	Fishing area restriction

fishing during free fishing days or on public fishing piers. All recreational fishermen are restricted by a daily bag and possession limit of 7 lobsters and a 3.25 inch (82.6 mm) minimum carapace size. Hoop nets are restricted to 5 hoop nets per person (2 if fishing from a public pier) and 10 hoop nets per vessel. Fishermen are also required to pull and inspect the contents of their hoop nets every 2 hours.

In 1998, the MLMA was passed and required the state to manage all fisheries sustainably, in part through the use of FMPs. In 1999, the Marine Life Protection Act (MLPA) was passed in California, which led to the establishment of a comprehensive new network of **marine protected areas** (MPAs) in the SCB (Section 4.8).

2.5 Economic and Social Factors of the CA Lobster Fisheries

The economic status of the CA lobster fishery was evaluated by an independent panel of experts in April 2013. The report (Appendix VI: Economic Report) analyzes the expenditures of the commercial fishery and recreational fishery, as well as the economic significance of the commercial fishery based on the 2009-10 to the 2011-12 fishing seasons. The report provides a statewide perspective on the economic significance of the fishery and establishes a foundation for future economic analysis.

Ten commercial lobster fishermen were surveyed with questions relating to the cost of participating in the fishery based on methodologies established in a 2009 study (Hackett et al., 2009). The commercial lobster fishery's total 2011 operational cost is estimated to be around $10.5 million. Of this, over half (> $6 million) comes from a combination of bait (~$1.6 million), fuel (~$1.3 million), crew wages (~$1.8 million), and federal taxes (~$1.1 million) (see Appendix VI: Economic Report).

The economic impacts (**total economic value added, total economic output)** of the commercial fishery were calculated based on factors such as expenditures (e.g., trap costs, fuel cost) and revenue (e.g., fishing income, export and domestic sales). The gross ex-vessel value of the fishery from the 2011-12 season was $12.9 million, and the statewide total economic output was over $22 million, contributing a total of 323 full-time equivalent jobs. The total economic value added to the economy during this same period was just under $12 million, with $695,893 contributing towards employee compensation (wages and salaries plus benefits for deckhands, crew members). Licensed lobster fishermen took in an estimated income of $3.8 million (see Appendix VI: Economic Report, Table 3).

> **Total economic value added – Total economic output** less the goods and services used up to create that output; for lobster fishery, it means the net value of the lobsters after costs like trap purchases are accounted for. Also known as Net Economic Output.
> **Total economic output –** The total amount of economic output that does not take into account the amount of intermediate goods consumed during the harvest/production process; for lobsters, this means the amount of money sales generate before costs such as trap cost are considered. Also known as Gross Economic Output.

The amount of economic impact the commercial fishery has on coastal communities differs across the southern California region, but the amount of added value is on a similar order of magnitude for each region. The fishery adds roughly $2.1 million dollars of net economic output to the economy of Santa Barbara County, $1.4 million to Ventura County, $2 million to Los Angeles County, $1.6 million to Orange County, and $3.5 million to San Diego County (see Appendix VI: Economic Report, Table 4).

Appendix VI: Economic Report represents the most recent attempt at quantifying the economic impact of the commercial lobster fishery. However, several aspects of economic analysis are outdated. Based on information contained in the Lobster FMP Guideline used for the 06/12/14 LAC meeting, operational costs have most likely risen in part due to an increase in the number of trap pulls and a downward trend in catch-per-trap-pull. Other costs can include rising fuel prices, rising operation costs, and the greater

distances fishermen have to travel due to MPAs. Future trap limit regulations will also influence the economic characteristics of this fishery. The economic analysis also do not reflect the recent changes in CA lobster ex-vessel value (Section 2.1), which may continue to rise.

State-wide expenditures on recreational lobster fishing were calculated based on a telephone survey conducted by CDFW in 2012. The survey targeted a random sample from all individuals who returned a calendar year 2011 lobster report card. The survey found that Californians spent between $33 - $40 million dollars on recreational lobster fishing in 2011 (see Appendix VI: Economic Report). Of this, roughly $7 million is attributed to residents who live in zip codes that border the coastline, $20 million is attributed to other residents living in zip codes that are at least partially within 50 miles of the coastline, while roughly $10 million is attributed to residents living further inland. The largest sources of expenditures were non-coastal residents who live within 50 miles of the coast who fished spiny lobster along the coast, and those who live more than 50 miles from the coast who dove for spiny lobster offshore.

3. Natural History and Population Dynamics of the California Spiny Lobster

The California spiny lobster (*Panulirus interruptus*) is one of approximately 55 spiny lobster species found in tropical and temperate oceans worldwide, most of which are fished commercially and/or recreationally (Booth, 2011; Phillips and Kattaka, 2000). Spiny lobsters are named after the forward-pointing spiny projections that cover their bodies. The species lack the pincers found on clawed lobsters.

The body of *P. interruptus* has two readily identifiable parts: (1) a fused head and thorax (cephalothorax) enclosed in a carapace, and; (2) the abdomen, or tail (Figure 3-1). The carapace protects most major organs and serves as the attachment points for the legs. In sexually mature males, the gonad pores (sperm ducts) are found at the base of the fifth pair of the legs. Females have enlarged swimmerettes, or pleopods, along each side of the tail and a small claw on the fifth legs.

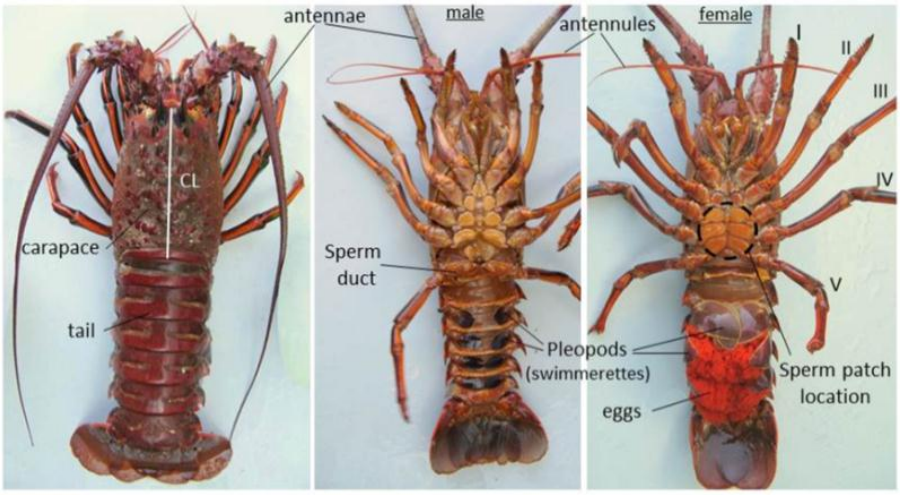

Figure 3-1: External anatomy of *P. interruptus*. CL = carapace length.

3.1 Critical Habitat and Known Threats to the Habitat

> **Life history -** The history of changes an organism passes through in its development from egg, spore, or other primary stage until its natural death.

One of the primary objectives of the MLMA is to ensure that "the health of marine fishery habitat is maintained" (7056(b)). In order to accomplish this, an understanding of the spatial extent of habitats that support CA lobster throughout their **life history** is needed. The CA lobster is endemic to the North American west coast from Monterey, California southward to at least as far as Magdelena Bay, Baja California (Wilson, 1948; Schmitt, 1921), with a small isolated population in the northwestern corner of the Gulf of California (Kerstitch, 1989). Johnson and Snook (1927) reported its occurrence as far south as Manzanillo, Mexico. The core range, however, lies between Pt. Conception, USA, and

Magdalena Bay (Figure 2-1). The physical center of the range is within Mexico. Population density and fishery **productivity** within Mexico's border is the highest around Cedros Island and Vizcaino Peninsula in Baja California (Vega, 2003).

Productivity - Describes the birth, growth, and death rates of a stock. A highly productive stock is characterized by high birth, growth and mortality rates, and as a consequence has a high turnover. Such stocks can usually sustain higher exploitation rates and, if depleted, could recover more rapidly than comparatively less productive stocks.
Settlement - In marine ecology, it means the process by which organisms change from an open ocean life history phase to assume a new mode of life as a member of a sea-floor community. In lobster, it is the stage at which juveniles move into the adult habitat where they become resident.
Substrate - The surface or medium on or in which an organism lives (i.e., mud, sand, rocks)

Sub-adults and adult CA lobsters are commonly found on the seafloor at depths ranging from **intertidal** to 64 m (210 ft.) (Mitchell et al., 1969; Robles et al., 1987; Allen, 1916; Lindberg, 1955), while the **planktonic** larvae have been found offshore as far as 530 km (329 mi.) and at depths to 137 m (449 ft.) (Johnson, 1960a; CDFG, 2001). Rocky structures/reefs are important **habitat** for CA lobster, and high quality rocky habitat is often characterized by the presence of brown algae such as giant kelp *Macrocystis pyrifera*, feather boa kelp *Egregia menzesii*, and stalked kelp *Pterygophora californica* , as well as surfgrass *Phyllospadix* spp. (Lindberg, 1955; Engle, 1979). CA lobster habitats are generally described in relation to their juvenile (approx. <3 years old) and adult (approx. >3 years old) life stages.

Juveniles range from individuals that have recently settled from the planktonic stage (carapace length (CL) 7-8 mm) to individuals in the range of 44-56 mm CL (Mitchell et al., 1969; Parker, 1972; Serfling, 1972; Engle, 1979). CA lobster larvae prefer to settle on common surfgrass and red algae that are abundant in rubble habitats (Parker 1972, Engle 1979, Castañeda-Fernández de Lara et al., 2005). These shallow rubble habitats are crucial for the CA lobster (Winget, 1968; Blecha, 1972; Parker, 1972; Serfling, 1972; Engle, 1979, Castañeda-Fernández de Lara et al., 2005). These structurally complex habitats also protect and conceal juveniles from predators (Parker, 1972; Engle, 1979), and CA lobsters typically remain in these habitats for 2-3 years post-**settlement** until they become sub-adults (Parker, 1972; Engle, 1979; Castañeda-Fernández de Lara et al., 2005).

Adult and sub-adult CA lobster commonly occupy natural hollow spaces within rocky **substrate**. They may also occupy hollowed-out holdfasts of *giant kelp* created by sea urchin grazing (Mai and Hovel, 1997) or burrows excavated (either by lobsters or sand scouring processes) near the base of colonies of the sandcastle tube worm *Phragmatopoma californica* (Zimmer-Faust and Spanier, 1987). Human structures such as pier pilings (Stull 1991), industrial debris (Lindberg, 1955), harbor jetties (Neilson et al., 2009), and artificial reefs (Barilotti et al., 2005; Reed et al., 2006) can also serve as habitats.

CDFW, working with outside researchers, has compiled all readily available data detailing the spatial coverage of surfgrass (*Phyllospadix spp.*), eelgrass (*Zostera spp.*), giant kelp (*M. pyrifera*), hard rocky reef (natural), and artificial reefs . For areas where the bottom substrate habitats have not been previously mapped, aerial multispectral survey data were used to estimate the locations of hard substrate based on the presence of giant kelp coverage recorded in 1989, 1999, 2002-2006, and 2008-2009. Since kelp requires hard rocky substrate to settle and establish, the presence of kelp was determined to serve as an appropriate proxy to estimate reef areas that may act as lobster habitat. Figure 3-2 provides a snap shot of known area that each of these habitats occupies within the historical range of the CA lobster fishery. For a detailed, known account of these habitats at a regional level, see Appendix III: Habitat Maps by Areas. It is important to note that any artificial or natural hard substrate associated with the sea floor can serve as CA lobster habitat, not all of which are depicted on the map.

Activities such as beach nourishment and urban runoff can adversely affect these habitats (Peterson and Bishop, 2005). Coastal development can also pose a threat to estuarine habitats (Kennish, 2002). Lastly, global climate will lead to sea level rise and may intensify the impact of El Niño and its associated storm events (Shaughnessy et al., 2012; Section 3.9). Rising sea level coupled with more intense storm can further erode and destroy existing sea grass beds and kelp beds.

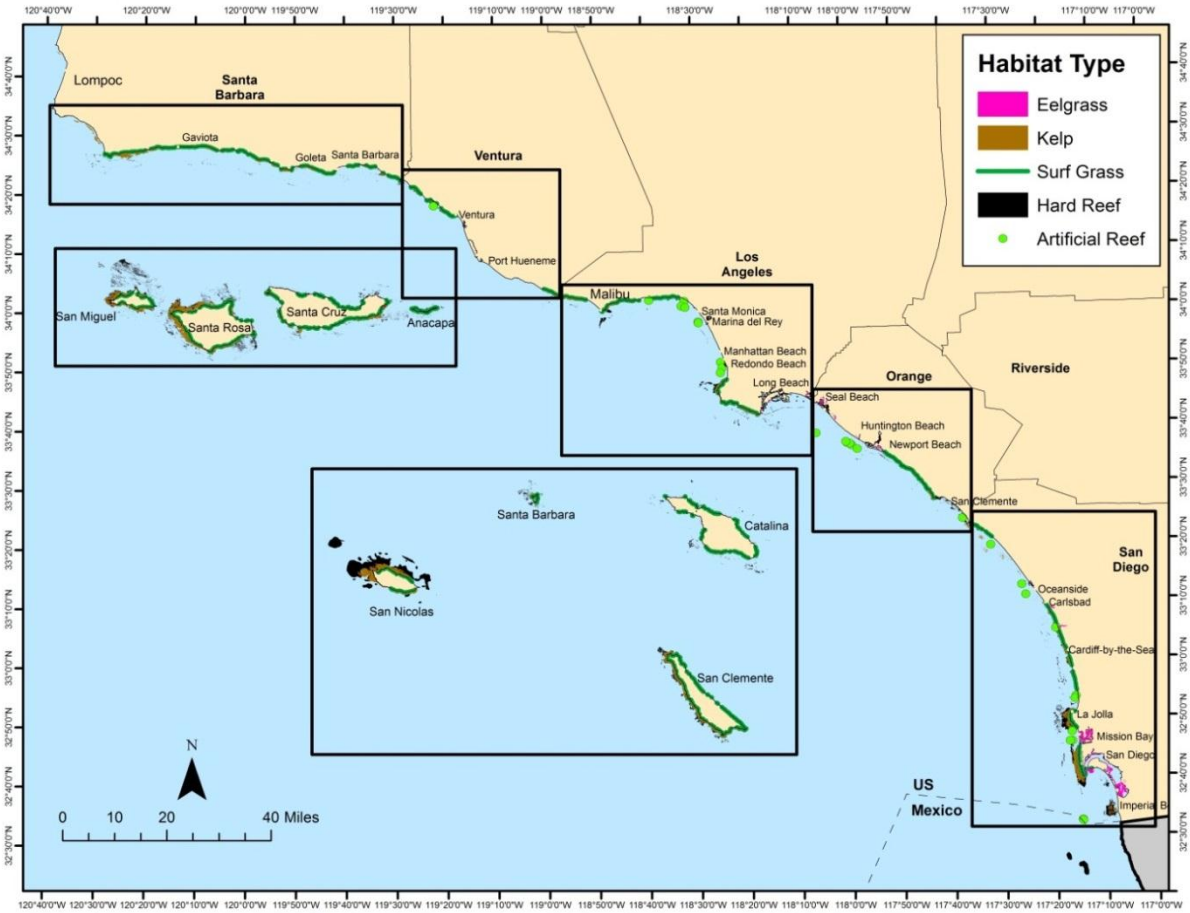

Figure 3-2: Locations of critical CA spiny lobster habitat in the southern California Bight.

3.2 Growth

Like all crustaceans, CA lobsters have a rigid exoskeleton that covers the outer surface of their bodies. Once formed, this exoskeleton does not shrink or expand. In order to increase its body size, a CA lobster must shed its exoskeleton and replace it with a larger one (Mykles, 1980). The molt frequency and molt increment (size increase during each molt) of a CA lobster determines its growth rate. Rapidly growing young lobsters molt many times per year, but molt frequency decreases with age (Engle, 1979). Existing studies suggest that *P. interruptus* can usually reach a sexually mature size before reaching the minimum legal size of 82.6 mm CL (Table 3-1). However, how quickly individual CA lobsters can reach the **size at maturity** (SAM) is a complex scientific question. To obtain a growth curve, CDFW currently uses the widely-accepted Von Bertalanffy growth equation:

> **Size at maturity (SAM) -** The size at which 50% of animals in a population have reached sexual maturity and are capable of reproduction.

$$l_t = L\infty\left(1 - e^{-K(t-t_0)}\right). \qquad \textit{(Equation 3.1)}$$

Estimates for a CA lobster's lifespan, which is crucial for the calculation of the growth constant K (Chavez and Gorosteita, 2010), range from 30-50 years (Neilson, 2011). The species' asymptotic size,

$L\infty$, can also vary based on the methodology adopted and the species in question (Mathews and Samuel, 1990).

Table 3-1: Size at which 50% of females in various population samples were sexually mature (size at maturity: SAM).

♀ SAM (mm CL)	Location	Source	Method*
72.5	Baja (Sebastian Vizcaino bay	Ayala 1983	Ovary
72.6	Baja (Vizcaino Peninsula)	Vega 2003	Sperm/Egg
70.0	California (Palos Verdes)	Lindberg 1955 (in Engle 1979. Converted using CL=0.31*TL)	Ovary
66.6 (215 mm TL)**	California (Palos Verdes)	Lindberg 1955 (215 TL converted here using: CL=0.31*TL)	Ovary
78.2 (215 mm TL)**	California (Palos Verdes)	Lindberg 1955 (215 TL converted here using: CL=0.3798*TL-0.342)	Ovary
63.5 (205 mm TL)**	California (La Jolla)	Fry 1928 (in Wilson 1948) (205 TL converted here using: CL=0.31*TL)	Not specified
74.4 (205 mm TL)**	California (La Jolla)	Fry 1928 (in Wilson 1948) (205 TL converted here using: CL=0.3798*TL-0.342)	Not specified
77.2	California (Palos Verdes, La Jolla)	Kay 2011 (Kay converted TL data of Fry 1928 and Lindberg 1955 using: CL=0.3798*TL-0.342)	Egg

Legal Size in California: 82.5 mm CL
***Methods used to measure SAM include analysis of dissected ovaries ("Ovary"), or the proportion of females with a spermatophore and/or eggs ("Sperm/Egg" or "Egg").**
**** SAM reported as total length (TL) by original researchers; TL's were converted to CL in preparation of this document or in other reports, as indicated in the "Source" column. Estimates 3a vs 3b and 4a vs 4b are from same data and differ only in the conversion factor from TL to CL. Although the large range of values for California (63.6-78.3 mm CL) may reflect some degree of natural variation, it may also be caused by differences in how total lengths (TL) were measured in early studies (i.e, Wilson 1948, Lindberg 1955, Backus 1960) and different methods used to convert these total lengths to carapace length (CL) by Engle (1979) and Kay (2011). Due to these inconsistencies, and the time elapsed since initial SAM observations, renewed estimates of SAM in California may be prudent. (Note: 3 ¼ inch legal size = 82.5 mm).**

Choosing the appropriate parameters is important for the management of the fisheries, since the resulting growth curve will directly inform CDFW of the ability of the stock to replenish itself (Section 4.3.1.3). Most of the growth curves that CDFW has analyzed for CA lobster project very similar growth rates up until individual lobsters have reached 8 years old. The growth rate for CA lobster for that age and beyond does not carry significant management implications, since most individuals are harvested relatively soon after they reach legal size (Orange Line), and most individuals become sexually mature at an age where different growth curves currently converge.

3.3 Reproduction and Larval Biology

Parrish Model - A simplified and efficient fishery stock model developed for the California spiny lobster by Dr. Richard Parrish. CDFW currently uses this model to calculate the SPR of the stock.

Mating in *P. interruptus* occurs when a male places a putty-like spermatophore on the sternum of a female (Figure 3-1). The spermatophore is durable and can remain in place for months, which allows females to store sperm until eggs in their gonads are fully developed and ready to be fertilized (Ayala, 1983). Females that bear spermatophores are common from January-May, but are most abundant from February-April (Figure 3-3; Mitchell et al., 1969; Bodkin and Browne, 1992). Females use their hind walking legs to scratch open the spermatophore, which fertilizes eggs as they are extruded. These females then attach the eggs under the pleopods.

Females with eggs on their tails are referred to as "berried", and are commonly found in California from late April-August and are most abundant in June-July (Figure 3-3; Mitchell et al., 1969; Bodkin and

Browne, 1992). The time of year at which CA lobster can be found berried depends on factors such as latitude (Pineda-Barrera et al., 1981) and temperature (Vega, 2003). Females produce one brood of

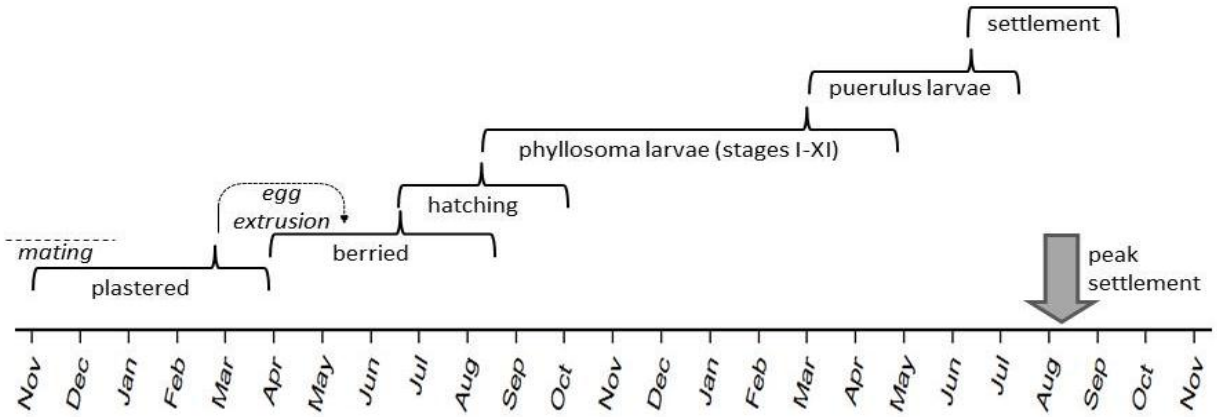

Figure 3-3: Timing of reproduction, larval development, and settlement for *P. interruptus*.

eggs per year (Mitchell et al., 1969; Ayala, 1983 George, 2005).

The total number of eggs carried by individual females (fecundity) has been examined in separate studies (e.g., Lindberg, 1955; Allen, 1916) throughout the range of *P. interruptus*, and all studies indicate that the number of eggs increases with female carapace length. Lobsters in California carry fewer eggs than individuals in Baja, and this north-south increase in the number of eggs carried was also observed within Baja (Pineda-Barrera et al. 1981). The size at which 50% of female *P. interruptus* in a population are capable of reproduction has been estimated at a number of sites throughout Baja and California. In California, SAM estimates range from 63.5 – 78.2mm CL, and Baja range from 72.5 mm - 72.6 mm (Figure 3-4; Table 3-1; Table 3-2). Egg-bearing females in the 55 - 60mm CL size range have been encountered (although not common) during the current CDFW MPA Baseline study in southern California, with the smallest observed size being 53mm CL.

Table 3-2: Age at sexual maturity and legal size for P. interruptus

Age at maturity*		Age at legal size		Source	Region	Method
M	F	M	F			
4-5	5-6	7-8		Lindberg 1955	California	lab, LF, molt
5	7	11	10	Mitchell et al. 1969	California	LF
3-4	5-6			Serfling 1972	California	lab, LF
5-6	8-9	11	13	Odemar et al. 1975	California	Tag
		8		Ford and Ferris 1977	California	lab, tag
		8-10		Bodkin and Browne 1992	California	Molt
3	5	4	7	Ayala 1976	Baja	unknown
4.5	6	6.5	8.5	Guzman del Proo and Pineda 1992	Baja	unknown

As reported from previous studies and adapted from Engle (1979). Methods used to determine ages include: laboratory study of captive individuals (lab), analysis of length-frequency data (LF), tag-recapture studies (tag), and molting frequency x molt increment (molt).
***sexual maturity for CA studies = 58 mm CL (M), and 70 mm CL (F); (Lindberg 1955, in Engel 1979); sexual maturity for Ayala (1976) = 65 mm CL**

After an incubation period of approximately 8-9 weeks, developing embryos hatch from the eggs on the female's tail and enter the water column as free swimming (**pelagic**)

Pelagic - Of or relating to aquatic organisms that live in the ocean without direct dependence on the shore or bottom.

larvae called phyllosoma (Johnson, 1956). Phyllosoma are flattened, transparent, and 1-2mm long (4-5mm including appendages) when they hatch. They then pass through 11 different stages of

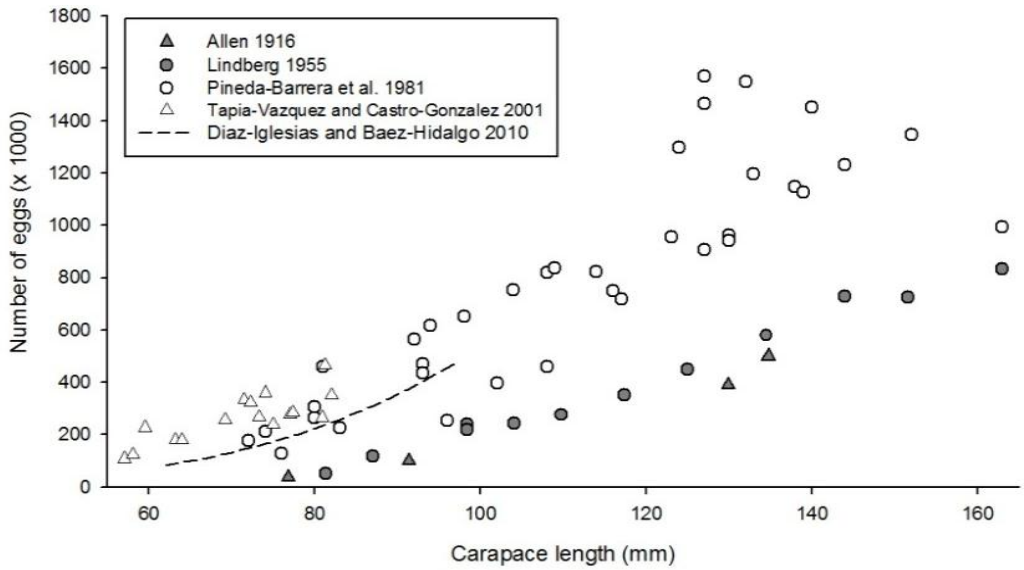

Figure 3-4: Fecundity of *P. interruptus* from a number of studies throughout its range. Taken from Kay, 2011. * Observations of Lindberg (1955) and Allen (1916) are from California. Pineda-Barrera et al. (1981) and Tapia-Vazquez and Castro-Gonzalez (2001) sampled sites in Baja. Diaz-Iglesias and Baez-Hidalgo (2010) report an equation (but no raw data) of the relative fecundity, which is the number of eggs that produce healthy swimming larvae, for ovigerous females collected from multiple sites in Baja. (Note: legal size = 82.5mm (3 ¼ inch)).

development and attain a body length of 26-32mm (Johnson, 1956; Mitchell, 1971). Phyllosoma spend many months drifting with ocean currents and feeding on **plankton** (Mitchell, 1971; Dexter, 1972).

The strong southward California Current usually prevents a large number of larvae from being transported north of Point Conception (Pringle, 1986). Other features within the SCB such as the Southern California Eddy and the deep Davidson current can help retain the larvae within the U.S. border (Johnson, 1960a; Mitarai et al., 2009; Figure 3-5). These features, coupled with record of phyllasoma being found hundreds of kilometers offshore (Koslow et al., 2012), suggest that recruits are kept within the SCB and are well mixed between different parts of the SCB.

Approximately 7-8 months after hatching, phyllosoma transform into a puerulus stage that closely resemble adults (Johnson, 1960a). These pueruli then return to **nearshore** reefs and

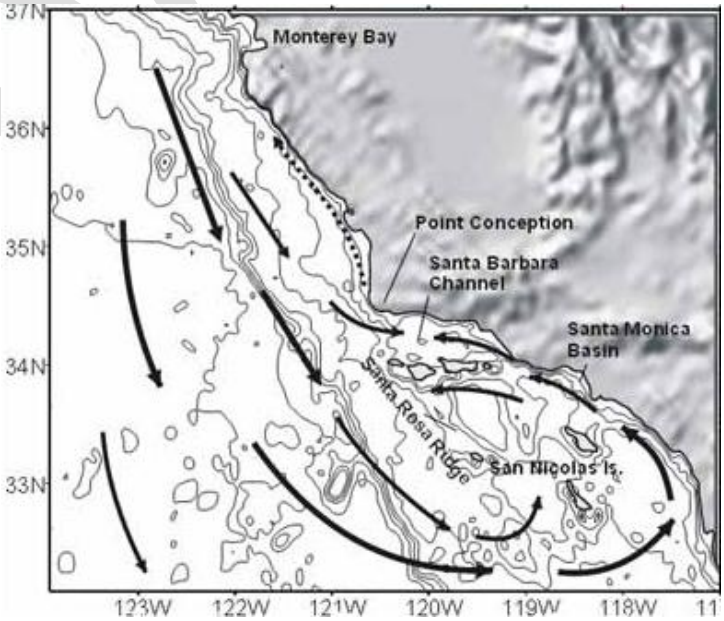

Figure 3-5: A simplified diagram of the North-South California Current, the South-North Seasonal Counter Current, and the resulting Southern California Eddy that help retain planktonic larvae of various marine species within the SCB. Credit: UCLA Nazlin lab.

Plankton - Very small organisms that passively drift with tide and current.
Nearshore - All oceanic state waters within 0-3 miles from shore or less than 100 fathoms deep, whichever is greater.

molt into juvenile lobsters on the seafloor (Parker, 1972). The duration of the puerulus stage is estimated at 2-3 months, and settlement in California occurs from June-October with a strong peak in August (Figure 3-3; Parker, 1972; Serfling, 1972; Serfling and Ford, 1975a). The same general timing has been observed in Baja (Guzman Del Proo et al., 1996). The arrival and "landing" of a puerulus upon a potential habitat surface is referred to as settlement. Because peak hatching and settlement in California both occur in August, newly settled lobsters are assumed to be 1 year old upon settlement (Parker, 1972; Engle, 1979).

3.4 Pathology

Spiny lobsters in the family Palinuridae do not harbor many naturally occurring diseases (Shields, 2011). However, a large diversity of disease-causing agents have been isolated from tissues of spiny lobsters held at artificially high densities (e.g., market pens) or from individuals subject to excessive handling or poor environmental conditions (Evans, 2004). Causative agents of these diseases include bacteria, viruses, fungi, and protozoans (Evans, 2004; Shields, 2011). The *Panulirus argus* virus 1 (PaV1) is one notable disease that is lethal to juvenile *P. argus* throughout the Caribbean (Behringer et al., 2010). Presently no disease epidemic, such as the withering foot syndrome found in abalones, is known to affect wild *P. interruptus*.

Lobsters are known to accumulate the toxin domoic acid, which is produced by the diatom *Pseudo-nitzschia*. This microscopic alga is common and seasonally abundant in coastal waters. Domoic acid accumulates in the bodies of animals that filter diatoms and other food particles from seawater (e.g., mussels, scallops, etc.), which are preyed upon by CA lobster. Domoic acid can be concentrated in lobster organs, but does not occur in muscle tissue (e.g., meat of the tail, legs, and antennae). For this reason, domoic acid poses no threat to humans that consume only the meat.

Nocturnal - Relating to, or occurring at night.
Physiological - Of or relating to the normal functioning of an organism.

3.5 Movement

CA lobsters exhibit two general types of movement: **nocturnal** foraging and seasonal inshore-offshore movements. Foraging involves nightly movements across spatial scales that range from 1-1000 m (3.3 – 3333 feet), with the average distances being closer to 10-250 m (33-820 feet) (Stull, 1991; Hovel and Lowe, 2007; Withy-Allen and Hovel, 2013). One study recorded an average nightly forage distance (±1 SE) of 143±10 m (469 ±32 ft) for an individual, with a maximum distance of 475 m and a minimum distance of 48 m per night (Withy-Allen & Hovel, 2013). Many recreational divers, hoop netters, and commercial fishermen target spiny lobster during these nightly forays because they are often easier to find and capture.

In the La Jolla Ecological Reserve, individuals were found to maintain small home ranges (651 m^2 and 5912 m^2 per week, based on the area in which the lobster had 50% and 95% chances of being found, respectively; Hovel & Lowe, 2007). Further study in San Diego suggests that lobsters tend to move in linear fashion, as opposed to more circular patterns. Furthermore, individuals tend to retain site-fidelity after each forage trip; individuals generally return to the same general geographic feature (i.e., a particular rock formation or kelp bed) as opposed to the same exact shelter (Hovel & Lowe, 2007).

Seasonal inshore-offshore movement is characterized by occupancy of shallow reefs in summer and fall months, when surface waters are relatively warm and storm activity is low, followed by movement into deeper water with the arrival of winter swells, storms, or colder surface waters (Mitchell et al, 1969). The **physiological** advantages of moving into warm shallow water include faster growth (Engle, 1979) and accelerated egg development (Mitchell, 1971). The timing and intensity of cues that initiate

movement out of shallow water have not been rigorously studied, and no scientific reports address this issue directly (Allen, 1916; Lindberg, 1955; Mitchell et al., 1969; Engle, 1979). Studies suggest that female CA lobsters tend to exhibit more seasonal movements, potentially due to the need to seek optimal spawning locations (Withy-Allen and Hovel, 2013; Kelly,2001).

3.6 Predation and Defense

Many predators prey on juvenile CA lobster (Table 3-3), the most common of which are California sheephead (*Semicossyphus pulcher*), cabezon (*Scorpaenichthys marmoratus*), rockfishes (*Sebastes* spp.), kelp bass (*Paralabrax clathratus*), giant sea bass (*Stereolepis gigas*), and octopus (especially the two-spot octopus, *Octopus bimaculata*). Fish predators of adult lobsters tend to be the larger individuals such as male California sheephead and giant sea bass. Southern sea otter *Enhydra lutris nereis* may also become an important predator in the future, and continued range expansion of sea otters could have serious effects on the recreational and commercial fisheries for this species (Odemar et al., 1975; USFW, 2005). As of 2014, the southern limit of the species' range has not expanded, and the most recent survey suggests that the southern boundary of the species' range may have retracted slightly (USGS, 2014).

Table 3-3: Predators of California spiny lobster.

Predator	Predation event observed/studied	*P. interruptus* in gut contents of predator	Anecdotal
CA Sheephead	1^{T}, 4	1, 4,6*	3, 4, 5, 6
Moral eel	1^{T}	4*	1, 4, 3, 6
Black sea bass		1*	3, 4
Octopus	2, 6, 7^{T}		1, 3, 4, 6
P. interruptus			3
Sea otter			8, 9
Horned shark			5
Leopard shark		4*	4
Cabezon	6^{j}, 7*	4, 7*	4, 6
Rock fish (Sebastes)		4, $6^{j,}$*	4
Sculpin	6^{j}	4	4
Kelp bass		4, 6*	6
Black surfperch		6^{p}	
Spotted kelpfish	6^{j}		
Smoothhound shark	7*		

Studies are divided into three categories: those in which predation was observed or studied in the field ("Predation event observed/studied"), those in which stomach contents of predators were examined ("*P. interruptus* in gut contents of predator"), and studies in which predation was mentioned from second-hand or anecdotal accounts ("Anecdotal")
X*= observations reported but were not first-hand
X^{T} = lobsters in traps mutilated when these predators co-occur in trap
6^{j} = very small juvenile lobsters preyed upon **6^{p} = newly settled pueruli preyed upon**
([1]Allen 1916; [2]Maddox 1933; [3]Wilson 1948; [4]Lindberg 1955; [5]Mitchell et al. 1969; [6]Engle 1979; [7]Winget 1968; [8]Odemar 1975; [9]USFW 2005)

Lobsters encountered in open areas (e.g., while feeding at night) often attempt to flee by repeatedly flapping their tails, which propels them backward and away from perceived threats (Nauen and Shadwick, 1999; Nauen and Shadwick, 2001). Lobsters encountered in their shelters often withdraw to the interior of the shelter, or flee through exit holes at the rear of shelters. If escape is not possible,

lobsters may attempt to defend themselves by orienting their bodies and antennae directly towards the predator (Herrnkind et al., 1975; Zimmer-Faust and Spanier, 1987; Spanier and Zimmer-Faust, 1988, Loflen and Hovel, 2010; Figure 3-6). This is especially common at the entrance of shelters, where many individuals can block the entrance by forming a phalanx with this posture. Right after a molting event, a lobster's antennae and exoskeleton remain soft for about one week. During this time lobsters are especially susceptible to predation and tend to limit movements that increase the risk of being eaten (Mitchell et al., 1969).

Figure 3-6: Lobsters inhabiting dens in the natural environment, displaying typical posture with antennae directed outwards and in gregarious groupings (left panel)

3.7 Prey

CA lobsters typically forage at night, when they exit the relative safety of their shelters and actively search for food (Allen, 1916; Lindberg, 1955; Roth, 1972; Engle, 1979; Zimmer-Faust et al., 1985; Stull, 1991). CA lobsters are often described as **scavengers**, but they also function as predators and grazers (Table 3-4). CA lobsters routinely attack live prey such as mussels (Robles 1987, 1997), snails (Engle, 1979; Schmitt, 1982; Schmitt, 1987), and sea urchins (Tegner and Dayton, 1981, Tegner and Levin, 1983, Eurich et al., 2014). Common food items routinely observed during field observations and laboratory experiments in gut/fecal contents include bivalves, echinoderms, small crustaceans, gastropods, and corraline algae (Table 3-4).

A CA lobster's diet depends strongly on its age and size. Juvenile lobsters spend their early years in surfgrass while adult lobsters frequent habitats associated with hard-bottom. Habitats and food types can vary by locations, even for sites that are close to each other (Winget, 1968). Foraging distance increases as an individual grows (Tegner and Levin 1983; Ling and Johnson, 2009). Foraging distance therefore can also affect what prey items are available to a given lobster. A CA lobster's size is itself a limitation of what it can eat. For example, Eurich et al. (2014) found that smaller individuals had difficulty breaking through the test of large urchins, whereas larger CA lobsters are more capable of consuming these prey. The interaction further depends on the population density (lobster and urchin) and the prey quality, as lobsters prefer healthy urchins from kelp-beds over urchins with limited gonad tissue found urchin barrens (Tegner and Levin 1983, Ling and Johnson 2009, Eurich et al. 2014).

Scavengers – Animals that feed on dead or decaying organisms

Table 3-4: Prey items eaten by P. interruptus, categorized by three study types

Prey Item	Gut/Fecal			Field			Lab		
Mollusca	C[4,5]								
Bivalves	C[7,8]								
mussels (*Mytilus)*	C[3,9]			C[2,9-12,14]		E[13]			E[20]
Gastropods	C[3,7,8,9]			C[6,14]		E[13]			E[17,18]
Echinoderms	C[4]	R[5,7]							
Sea urchins	C[3]			C[15]		E[13]	C[16]		E[21]
Sea cucumber									E[19]
Crustaceans	C[4,5,7,8,9]								
P. interruptus	C[3]		E[1]						
Crabs	C[3,9]								
Bryozoans		R[3,4,5,7,8]							
Polychaetes	C[3]	R[5,7,8]				E[13]			
Hydroids		R[3]							
Sponges		R[3,4,5,7]	E[1]						
Eggs	C[4,5]								
Fish	C[4,8]	R[3,4]	E[1]						
Squid									E[20]
Foraminiferans		R[5,8]							
Coralline algae	C[3,4,5,7]	R[8]							
Surf grass	C[4,7,8]	R[4,5]							
Other algae	C[4,9]	R[3,4,7,8]	E[1]						

("Gut/Fecal" = gut and/or fecal content analysis; "Field" = field observations; "Lab" = lab observations). For Gut/Fecal studies, prey are reported as common (C) or rare (R) in samples. For field observations, prey were indicated as commonly attacked (C) or rarely attacked (R). For lab experiments, prey that were preferred in choice experiments are noted as commonly (C) preferred or rarely eaten (R). Also reported are prey that were observed to be eaten (E) in situations for which there was no measure of preference.
([1]Allen 1916; [3]Lindberg 1955; [4]Winget 1968; [5]Engle 1979; [7]Castaneda-Fernandez de Lara et al. 2005; [8]Diaz-Arredondo and Guzman-del-Proo 1995; [2]Fry 1928 (in Wilson 1948); [6]MacGinite and MacGinite 1949; [9]Robles 1987, 1997; [10]Robles and Robb 1993; [11]Robles et al. 1990;[12]Robles et al. 2001; [13]Zimmer-Faust and Case 1982; [14]Schmitt 1982, 1987; [15]Tegner and Dayton 1981; [16]Tegner and Levin 1983; [17]Shabani et al. 2007; [18]Kicklighter et al. 2005; [19]Eckert 2007; [20]Diaz-Iglesias et al. 2011; [21]Eurich et al. 2014)

3.8 Ecosystem Role of CA Lobster

The interactions between CA lobsters and their prey are considered as direct effects because the action of one species (i.e., predator) directly affects another species (i.e., prey). Through direct predation, CA lobsters have been found to limit the **abundance** of the top snails *Tegula aureotincta* and *T. eisinia* in cobble and rocky reef habitats (Schmitt, 1982; Schmitt, 1987). CA lobsters have also been found to limit the density and size of mussels (*Mytilus californianus*, *M. galloprovincialis, Septifer bifurcatus*) and gastropods (snails) in rocky intertidal habitats at Catalina Island (Robles, 1987; Robles et al., 1990; Robles, 1997; Robles et al., 2001). In addition, CA lobsters are thought to limit the local abundance of red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) on reefs in southern California (Lafferty, 2004; Tegner and Levin, 1983).

Abundance - The total number of animals in a population. This is rarely known, but usually estimated from relative abundance although other methods may be used.

CA lobster predation can also trigger indirect effects in marine ecosystems. The most clearly demonstrated indirect effect of lobster predation in marine ecosystems involved predation upon

intertidal mussels. Robles and Robb (1993) observed that as CA lobsters preyed upon intertidal mussels, red algae were able to colonize and grow in the empty spaces previously occupied by the mussels. In this case, lobster predation upon mussels indirectly influenced the abundance of algae.

As previously stated, lobsters are thought to limit the local abundance of red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) on reefs in southern California. Urchins are herbivores that consume algae and kelp. In southern California, the **biomass** of giant kelp *M. pyrifera* can be inversely related to urchin abundance (Ebeling et al., 1985; Arkema et al., 2009) or the intensity of urchin grazing (Harrold and Reed, 1985). Therefore, CA lobster can impact giant kelp indirectly by releasing it from urchin grazing and thus enhancing the persistence and extent of kelp forests (Dayton and Tegner 1998; Jackson et al., 2001; Dayton, 2003; Graham, 2004; Lafferty, 2004; Halpern et al., 2006; Eurich et al., 2014).

3.9 Climate Change Impacts on CA Lobsters

Climate Change (CC) is a shift in global climate pattern characterized by increasing global air and ocean temperatures in most regions, widespread melting of snow and ice, and rising global average sea level (IPCC, 2013). These widespread environmental changes have been attributed to the emission of greenhouse gases (GHG) - CO_2, methane, and nitrous oxide brought on by industrialization. While atmospheric methane and nitrous oxide are significant contributors to climate change, CO_2 is currently considered to be the most important contributor. A more detailed discussion on CC background mechanisms are presented in Appendix V: Climate Change Vulnerability of the CA Spiny Lobster.

Various CC effects will likely impact the CA lobster fishery. Sea surface temperature (SST) in the SCB is predicted to rise (NOAA, 2012). Warmer atmospheric temperature may also change the **upwelling** and circulation pattern of the region (Bakun, 1990; Bakun et al., 2010; Rykaczewski and Dunne, 2010; Pisias et al., 2001; Snyder et al., 2003). CC can also lead to more intense storms and increased runoff along the southern California coast (IPCC, 2013). Lastly, it is widely believed that increasing atmospheric CO_2 concentration will continue to acidify the ocean (Caldeira and Wickett, 2003; Royal Society, 2005; Pecl et al, 2009). Figure 3-7 illustrates the various factors (A-F) and pathways that CC can impact the CA lobster fishery. It is important to note that CC is an incredibly complex phenomenon. While scientists can make reasonably accurate predictions on big picture changes, predicting on a smaller geographic scale (e.g., SCB) is still challenging (IPCC, 2013) (See also Appendix V: Climate Change Vulnerability of the CA Spiny Lobster).

Biomass (B) - The total weight of organisms at a given point in time in a defined stock, area, population, or catch.
Upwelling - On the California coast, upwelling is the upward movement of deep waters into the nearshore ecosystem due to springtime winds moving the topmost layers of water away from land.
El Niño - A periodic warming of the ocean surface waters in the eastern Pacific Ocean. It is characterized by a lack of upwelling of cold, nutrient-rich waters nearshore.

Warmer SST in the pelagic environment may lead to better survivorship, and growth in the SCB ("Pelagic Habitat," Figure 3-7). As for fishery effects of CC, warmer coastal environments may make adult lobsters more active and easier to capture ("Coastal Habitat," Figure 3-7) (Pringle, 1986; Koslow et al., 2012). Furthermore, since California is at the northern edge of the lobster's current domain range, higher SST could extend the lobster population northward. Conditions such as **El Niño** (see Appendix V: Climate Change Vulnerability of the CA Spiny Lobster) leading to warm water along the California coast could provide episodic transport of larvae north from Mexico which could also increase harvest (Pringle, 1986).

As SST increases, species typically found off Baja California could begin to occur with greater frequency within the southern California kelp forests. Such changes have already been observed in some kelp forests (Field et al., 1999). Kelp itself may be impacted by increasing SST and reduced nutrients. It is unclear at this point exactly how kelp forests will respond to warming SST, but the effect is likely negative (Steneck et al., 2002). Likewise, CA lobster, being more tropical, may or may not be directly (i.e., physiologically) affected by increasing SST. However, there may be an increased likelihood of disease with higher water temperatures. For example, the bacterial epizootic shell disease found in east coast lobster stocks has been linked to higher water temperature (Glenn and Pugh, 2006).

Whether CC would intensify upwelling in southern California or suppress it is still subject to ongoing scientific debate (B and E, Figure 3-7) (Bakun et al., 2010; Rykaczewski and Dunne, 2010). Weaker upwelling leads to declines in **zooplankton** abundance (Roemmich and McGowan, 1995) and a decrease

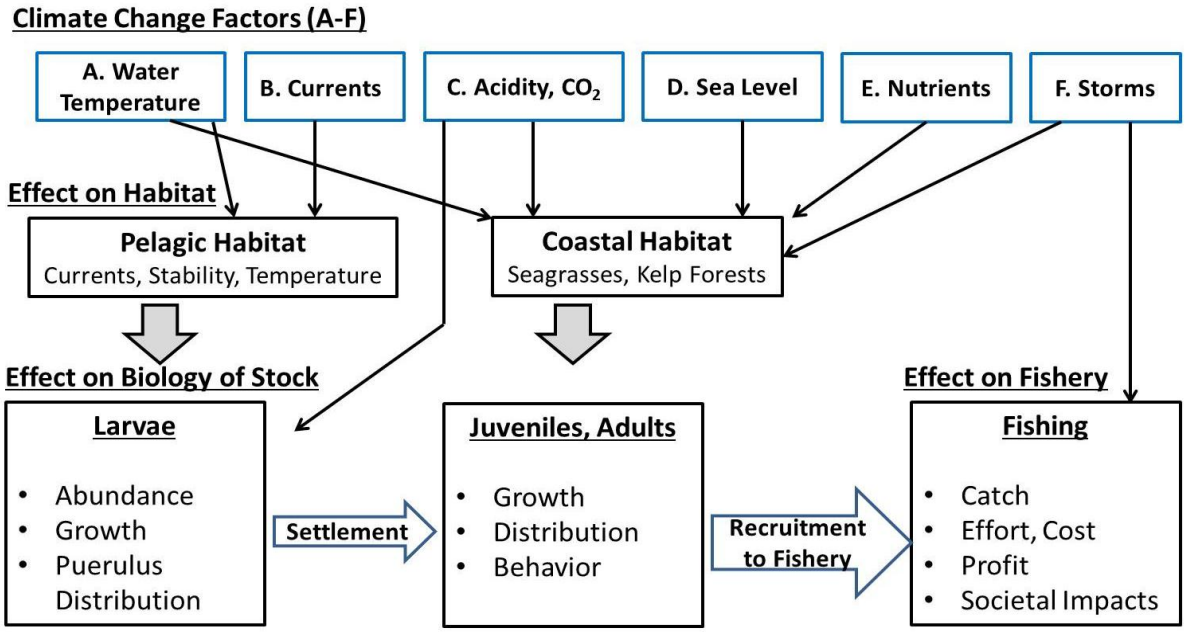

Figure 3-7: Schematic showing relationships between Climate Change variables (labeled A-F), habitat, lobster biology, and the fishery. Further topics listed within the individual boxes are specific variables that are expected to change under CC. Credit: Dr. K. Hovel, San Diego State University

in CA lobster larvae food sources. Stronger upwelling can increase the CA lobster larvae food sources, but it can also change the dispersal and recruitment pattern of the stock in the open ocean (Gaylord and Gaines, 2000; Connolly et al., 2001) (B, Figure 3-7). Harley et al. (2006) suggested that increased upwelling may decrease the populations of some **benthic** species such as lobsters by moving potential recruits offshore and away from suitable habitats. This is probably more applicable to regions north of Pt. Conception and would thus act to inhibit northward settlement of the lobster.

Zooplankton - Small animals passively carried along with water currents and other water movement.
Benthic - On or relating to the region at the bottom of a sea or ocean.

Sea level rise will lead to coastal inundation and increased coastal erosion, especially during more intense storms and high tidal periods (D, Figure 3-7). Coastal erosion can lead to silting of coastal habitats, in particular seagrass beds used for settlement and adult foraging. Even in areas that will not experience intense silting, seagrass beds would still be sensitive to changing light wavelengths brought about by increased turbidity and changing water depth (Moore et al., 1997).

More intense storms combined with increased nutrient runoff (E and F, Figure 3-7) can also damage or completely destroy seagrass beds. This would reduce the amount of suitable habitat for lobster puerulus settlement, resulting in fewer successful recruits. Similarly, kelp beds could be damaged or destroyed at more frequent intervals, thereby disrupting adult lobster habitat and its immediate ecosystems (Pecl et al., 2009). In addition, more intense storms could also hinder fishing activities and damage deployed lobster traps.

Lastly, CC will also lead to a more acidic ocean (C, Figure 3-7). Water corrosive enough to dissolve seashells has been observed off California and is expected to become more frequent (Feely, 2008). The types of organisms potentially affected include snails and mussels, corals, and many phytoplankton species. It is unclear if there will be any direct adverse effects on lobster (Pecl et al., 2009). Many crustaceans, including the American Lobsters on the east coast, are able to resist acidifying ocean water (Ries et al., 2009). However, even if spiny lobsters can maintain their protective shells in a more acidic environment, there would still be adverse impacts. Compensating for the corrosive effect of carbonates requires significant energy that would otherwise be used for reproduction and growth (Long, 2013).

4. Measures for Conservation and Management of the CA Lobster Fishery

The primary goal of fishery management under the MLMA is sustainability (FGC § 7050(b), § 7056). The MLMA and the Master Plan define sustainability as:

a) Continuous replacement of resources, taking into account fluctuations in abundance and environmental variability.

b) Securing the fullest possible range of present and long-term economic, social, and ecological benefits, maintaining biological diversity, and, in the case of fishery management based on maximum sustainable yield, taking in a fishery that does not exceed optimum yield (FGC § 99.5).

CDFW will maintain the sustainability of the CA lobster fishery through a set of **harvest control rules** (HCR) that consists of 3 reference points, an HCR matrix, and a toolbox of 8 regulatory options.

Harvest control rules (HCR) -Harvest control rules are plans of action that prescribe adjustments in harvest regulations (e.g. fishing effort, total allowable catch, minimum legal size) and are activated ("triggered") when the calculated amount of a resource that can be taken (the defined upper limit, also known as "threshold reference point") is reached or surpassed.
Yield per recruit (YPR) - A theoretical value that describes the yield to a fishery that is contributed by a given number of recruits (usually a single recruit).

4.1 Overfishing, Sustainable Yield, and Overfished

The MLMA's mandates for sustainability are closely tied to the concept of **overfishing** as defined by the Fish and Game Code. Fish and Game Code section 98 defines overfishing as "a rate or level of taking that the best available scientific information, and other relevant information that the commission or department possess or receives, indicates is not *sustainable* or that jeopardize the capacity of a marine fishery to produce the maximum sustainable yield on a continuing basis [emphasis added]." There are four types of overfishing:

Recruitment overfishing: Fishing that depletes the mature adult population (spawning stock) to a level at which reproduction is inadequate to replenish the population (Sissenwine et al., 1987).

Growth overfishing: Fishing in which **yield per recruit** is lower than theoretical maximum values due to the harvesting of small and rapidly growing fish (Diekert, 2012).

Economic overfishing: Level of fishing effort that exceeds **maximum economic yield (MEY)** (Flaaten, 2010).

Ecosystem overfishing: Level of fishing that creates significant adverse impact to the species diversity, trophic composition, and productivity of an ecosystem (Murawski, 2000).

These different types of overfishing each present their own threats to sustainability. **Recruitment overfishing** is a threat to the biological sustainability of a fishery, and is the fishing activity most commonly linked to collapse of fish stocks. In contrast, economic and **growth overfishing** can be biologically sustainable but reduces the economic and social sustainability of a fishery. Finally, ecosystem overfishing threatens the integrity of the larger ecosystem, which is ultimately essential for the conservation of the stock as well.

Maximum economic yield (MEY) - The total amount of profit that could be earned from a fishery if it were owned by one individual. An open entry policy usually results in too many fishermen so profits are barely higher than opportunity costs.
Instantaneous Fishing mortality (F) - The rate at which organisms are harvested or killed due to fishing; F is an instantaneous rate that reflects the rate at which a proportion of a population is being lost, whereas the harvest rate (u) is an annual rate that reflects the rate at which a number of fish from a population is being lost.
Maximum sustainable yield (MSY) - In a marine fishery, means the largest catch that can be taken from a stock continuously over time that does not result in a continuing reduction in stock abundance, assuming constant environmental conditions. MSY is generally presented as a maximum annual catch that can be maintained indefinitely; however, MSY can change with fluctuations in abundance and environmental variability (e.g. shifts in ocean regimes), requiring adjustments in allowable harvest.

Each type of overfishing is associated with a particular harvest rate. Fishery scientists usually describe the rates at which fish are removed from a stock with two types of measurements. The first and more intuitive measurement is the *harvest rate* (*u*), which is the proportion of all legally harvestable fish that are taken in a fishing season. Values for harvest rates can range from 0-1. For example, harvest rates of 0, 0.5, and 1 indicate that none, half, and all of the harvestable fish are taken every season, respectively. The second measurement is the **instantaneous fishing mortality rate** (*F*), which can be calculated directly from the harvest rates (and vice-versa). Unlike *u*, *F* is described in the less intuitive log space and comports better with complex scientific calculations used in fisheries models.

The total harvest each season is considered the fishery yield, and together with harvest rates and sustainability objectives form interrelated metrics for evaluating the fishery (Figure 4-1). An extremely low harvest rate will result in a low fishery yield which may not satisfy the economic and social sustainability objectives of the fishery. As harvest rates increase, fishery yield also increases. But once the harvest rates increase beyond a stock's ability to regenerate itself, it would lead to growth and recruitment overfishing and actually drives down the yield of the fishery. For a fishery under equilibrium conditions, the total harvest that equals the stock's ability to regenerate is called the **maximum sustainable yield** (MSY), and the fishing mortality rate associated with this yield is referred to as F_{MSY}.

Any fishery would also have an MEY. Any amount of fishing effort (e.g., # of traps fished, days at sea) has costs associated with a number of factors (e.g., additional fishing gear, bait, fuel, crew days). Consequently, the cost of fishing increases as effort and harvest rate increase (diagonal dashed line in Figure 4-1). Due to this increase and the dome-shaped relationship between harvest rate and fishery yield, there is usually a mortality rate (*F*) at which a fishery achieves MEY, or F_{MEY}. A fishing mortality rate that exceeds F_{MEY} represents economic overfishing. F_{MEY} is almost always lower than F_{MSY} (Flaaten, 2010). Thus, a harvest rate that is biologically sustainable may still lead to economic overfishing and undermine the economic objectives of a fishery (FGC § 7050).

A high harvest rate can also undermine the environmental objectives set forth by MLMA if fishing leads to habitat damage, unacceptable bycatch levels, and trophic disturbance. For example, if CA lobsters are fished to an extent that they are no longer able to control the urchin population, overgrazing of kelp forests by the urchins may occur. The loss of kelp may then negatively impact the resilience of the CA lobster stock (Section 0). Academic researchers have begun to tackle the task of quantifying ecosystem overfishing over the past several years (Murawski, 2000; Methot et al., 2013).

In addition to overfishing, the MLMA also requires CDFW to define the criteria for when a fishery is considered "**overfished**" (FGC § 7086). Under the MLMA, "[i]f a fish population is depressed, and the principle mean for rebuilding the population is reduction of take, then the fishery is to be classified as overfished" (FGC §97.5). A fishery is "**depressed"** when "a declining population trend has occurred over a period of time appropriate to that fishery" (FGC § 90.7).

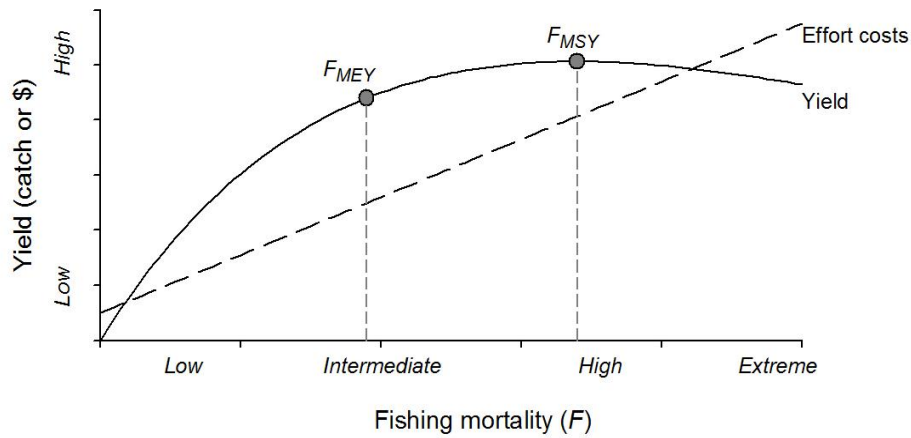

Figure 4-1: The general relationship between fishing mortality (or, harvest rate) and fishery yield (solid curved line). Also shown is hypothetical effort cost (diagonal dashed line). The fishing mortality that produces maximum economic yield (F_{MEY}) can be visualized as the fishing mortality at which the distance between the yield curve and the effort cost line is greatest.

It is important to note that the term overfished refers to the status of a fish stock, while overfishing refers to the activity of fishing and describes fishing practices in which too many fish are removed. When only a relatively small proportion of an available stock is being harvested (low harvest rates), overfishing is unlikely and **stock size** typically remains high (not overfished). When a relatively high proportion of an available stock is being harvested (high harvest rates), the risk of overfishing increases, and the stock is more likely to drop below a level that would classify it as being overfished.

Furthermore, an overfished stock is not always being subjected to overfishing, and vice-versa. Consider, for example, a **depleted** stock that is closed to fishing. After fishing stops, the harvest rate falls to zero, but until stock biomass rebuilds, the stock remains overfished. This condition would be represented by the lower left-hand region of Figure 4-2 (low harvest rate and low biomass). Similarly, a newly emerging fishery may experience overfishing (unsustainably high harvest rates), but the stock would not be considered as "overfished" until the stock size suffers a dramatic decline (upper right-hand portion of Figure 4-2). The designations of overfishing and overfished ultimately

Overfished - A stock that is at unacceptably low levels because it has experienced overfishing and has not been rebuilt.
Depressed fisheries - The condition of a fishery for which the best available scientific information and other relevant information that the Commission or Department possesses or receives, indicates that a declining population trend has occurred over a period of time appropriate to that fishery. With regard to fisheries for which management is based on maximum sustainable yield, or in which a natural mortality rate is available, "depressed" means the condition of a fishery that exhibits declining fish population abundance levels below those consistent with maximum sustainable yield.
Stock Size – Total estimated number or biomass of fish within a stock

depend on the sustainability objectives of the society.

4.2 Introduction to Harvest Control Rules

Many fishery managers around the world are moving towards adopting dynamic HCRs as their means of achieving MEY and MSY as well as avoiding overfishing and facing overfished stocks. HRCs are a type of management framework that "formulate[s] a procedure for making harvest policy decision[s]." It does so by "identify[ing] a pre-agreed course of management action as a function of identified stock status and other economic environmental conditions" (WCPFC, 2013). The HCR framework here is comprised of five fundamental components (Figure 4-3):

1) Harvest regulations
2) Data collection
3) Data Analysis
4) Reference point(s)
5) HCR matrix

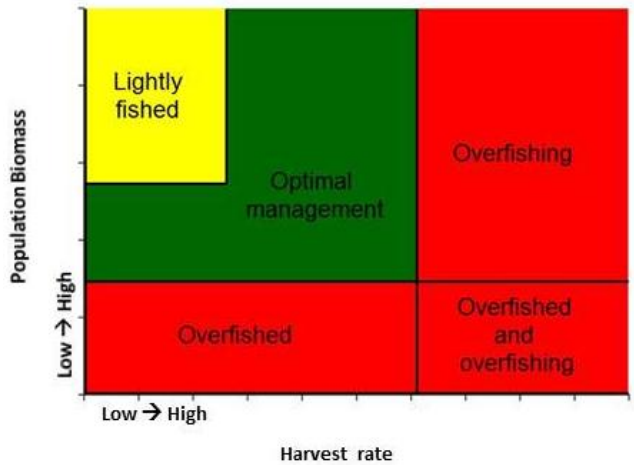

Figure 4-2: The general relationship between harvest rate and stock size

4.2.1 Harvest regulations

Harvest regulations are the rules that define how fishermen are allowed to harvest fish. These regulations typically take one of three specific approaches for ensuring sustainability: (I) managed escapement (used exclusively in salmon fisheries); (II) use of a dynamic time scenario (e.g., common when a stock is tied to extremely variable environmental conditions or when high bycatch is a problem), and; (III) manage for a sustainable harvest rate (Figure 4-4, modified from NRC 1998). The goals of these approaches are the same: to ensure fishery sustainability by avoiding overfishing and to achieve recovery when a stock is overfished.

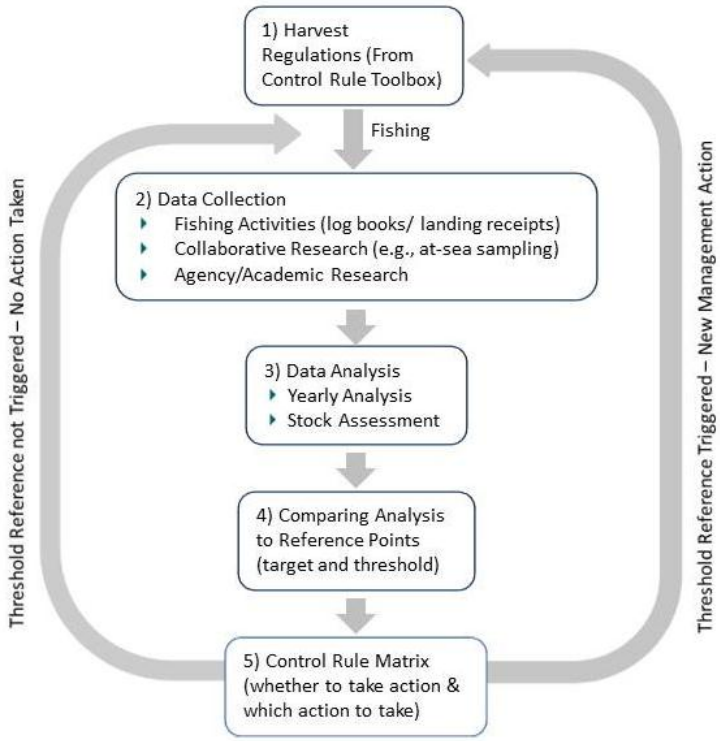

Figure 4-3: The relationship among the five elements of a general fishery management framework.

Harvest regulations - The rules that define how fishermen are allowed to harvest fish. Harvest regulations are diverse and include restrictions on size of animals harvested, effort, total catch, gear types, season, or location where fishing is permitted.

For most fisheries, management with escapement goals or a dynamic time scenario is inappropriate or logistically impossible (NRC, 1998). The more practical alternative is to manage for a harvest rate that maintains relatively high fishery yield without causing overfishing. Broadly speaking, there are three types of harvest regulations: biological

regulations, effort-based harvest regulations, and catch-based harvest regulations (items IIIa-c in Figure 4-4).

4.2.1.1 Biological harvest regulations

Biological harvest regulations directly protect some portion of a stock and buffer it against recruitment overfishing and growth overfishing. Common biological regulations include legal size limits (minimum and maximum), sex-based regulations, seasonal closures, and spatial restrictions (e.g., MPAs) (Figure 4-4, item IIIa).

Minimum legal size (Min LS) protects rapidly growing young fish, some of which may be reproductive. A Min LS can prevent recruitment overfishing only if it is larger than the size at which fish first start reproducing. A Min LS can prevent growth overfishing only if it protects rapidly growing young animals.

Maximum legal size (Max LS) is intended to protect large animals that have high fecundity and buffers against recruitment overfishing. MaxLS may also have ecological and/or market benefits. A management framework that employs both a Min LS and Max LS is often referred to as having a "slot" or "over/under" size limit.

Sex-based regulations are designed to safeguard the reproductive output of females with the assumption that remaining males present in a fished population can successfully fertilize all the available eggs. Fishermen may only be allowed to harvest male animals (male only fishery) larger than the size at sexual maturity, as is the case for the US west coast Dungeness crab fishery. Alternatively, a fishery can prohibit the landing of berried females (females that are carrying eggs), as in the Atlantic USA/Canada fishery for American lobster *Homarus americanus*.

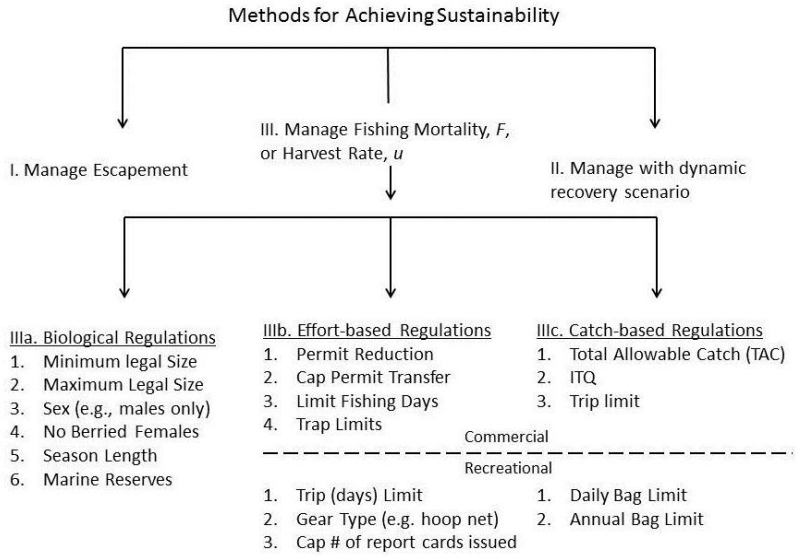

Figure 4-4: Methods for achieving fishery sustainability, including the three types of harvest regulations for harvest rates.

Area closures (MPAs, marine reserves) prohibit all or some fishing activities in prescribed areas. Heavily fished lobster populations around the world tend to show rapid increases in biomass, average size of individuals, and abundance inside closed areas (Diaz et al., 2011; Moland et al., 2012).

Seasonal closures act as biological regulations when they protect animals during the reproductive phase of their life cycle – such as the closure of the CA lobster fishery during summer in California. Seasonal closures also reduce total annual effort (see *Effort-based regulations*).

4.2.1.2 Effort-based harvest regulations

Whereas biological regulations serve to protect a portion of a stock, effort-based regulations protect the portion of the stock that is vulnerable to harvest (legally harvestable). This can help prevent recruitment overfishing and growth overfishing, but can also prevent economic overfishing when increases in effort

(and harvest rate) begin to provide diminishing return in terms of yield (i.e., the flattened part of a yield curve, Figure 4-1).

Limited Entry programs limit the total number of participants in a fishery.

Capping permit transfers (e.g., an annual limit) can limit the activation of latent **capacity** in a fishery, thereby avoiding abrupt increases in effort.

Seasonal closure does not have to correspond to a targeted species' life cycle; instead, it can serve to only control fishing effort by defining a maximum number of days/year that an individual can fish.

Trap limits (e.g., hoop net limit) define a maximum allowable number of traps per fisherman.

Gear type regulations generally restrict the use of gears that destroy habitat or catch portions of the stock protected with biological harvest regulations. These regulations can also control the harvest rate by prohibiting new gear types that increase harvest efficiency. However, it is important to note that gear type restriction can impose economic inefficiency on fishermen.

Capacity - The potential ability of a vessel or a fleet of vessels to capture organisms. This ability is based on the number of fishing vessels in the fleet, the size and technical efficiency of each vessel, time spent fishing, and management regulations.
Bag limits - The total amount of fish or other species that may be captured per person per day by law.
Individual transferable quota (ITQ) - A program which limits the catch allowed per license or individual as well as the number of individuals who participate.

4.2.1.3 Catch-based regulations

As with effort-based regulations, catch-based harvest regulations serve to protect the portion of the stock that is vulnerable to harvest (legally harvestable).

Daily **bag limit** is a daily limit on the number or weight of fish that a recreational fisherman may legally retain.

Annual bag limit is an annual limit on the number or weight of fish that a recreational fisherman may legally retain.

Total allowable catch (TAC) is the total catch that can be taken during each fishing season. A TAC works by protecting a fraction of the stock that is large enough to ensure sustainable reproduction, which stabilizes catches and associated economic output of the fishery from year to year. In TAC fisheries, catch is monitored during the season, and managers usually close the fishery once the TAC is reached, although in-season catch projections may allow the use of less disruptive regulatory measures if taken before reaching the TAC. In some fisheries, the TAC for an upcoming season is adjusted in response to recent trends in some reference indicator such as catch per unit effort (CPUE) or recruitment. Adjustment can also occur in response to going over or under the TAC in the previous season. Federal fishery management plans are required to establish a mechanism for specifying a TAC, which is known as an "annual catch limit" (16 USC § 1853(a)(15)). Federal managers are required to take actions whenever an annual catch limit is exceeded (50 CFR §§ 600.310(f)(2)(iv), (g)(3)).

Individual transferrable quota (ITQ) is a dedicated portion of a TAC. One limitation of TAC is that it does not prevent the "race to fish", a dynamic in which fishermen competitively attempt to catch fish before other fishermen catch them. In fact, a TAC can accelerate the race to fish because it shrinks the portion of fish available for harvest. In response, fishermen often invest in tools that provide a competitive advantage such as faster boats, more traps, and better technology – an effect known as "capital stuffing" (Copes, 1986).

In TAC fisheries, the race to fish and capital stuffing can be addressed with a quota system like ITQ (Costello et al., 2008). Quotas grant fishermen exclusive access to some fraction of a TAC. A quota system can also lead to additional economic benefits by allowing fishermen to focus fishing during periods of peak market price or spread fishing activities out over a longer period of time to avoid market gluts. The key incentive with quota management is that fishermen can wait to harvest their "share" of the catch. Individual transferable quotas (ITQs) are a common form of quota that may be transferred among fishermen. Transferable quota systems balance fleet dynamics by allowing for more flexible fishing operations.

Essential fishery information (EFI) - With regard to a marine fishery, means information about fish life history and habitat requirements; the status and trends of fish populations, fishing effort, and catch levels; fishery effects on fish age structure and on other marine living resources and users; and any other information related to the biology of a fish species or to taking in the fishery that is necessary to permit fisheries to be managed according to the requirement of this code.

Thresholds (threshold reference points) – For the purpose of this FMP, the levels of stock size, reproductive potential, or fishing mortality rates that managers attempt to avoid. When threshold reference points are crossed, they would lead to adjustment via a control rule.

4.2.2 Data collection

Data collection gathers information that directly informs the stock assessments and management decisions (Figure 4-3). The MLMA stipulates that FMPs employ the best available scientific information (FGC § 7050(b)(5)). This is referred to as **essential fishery information** (EFI), which includes information about species life history, habitat requirements, status and trend of the population, fishing effort, catch level, fishery's effect on the fish population, and "any other information related to the biology of a fish species […] in the fishery that is necessary to permit fisheries to be managed [sustainably]" (FGC § 93; Section 5.2, 5.3).

EFI is gathered by CDFW from a number of traditional fishery-related sources, including commercial logbooks and recreational report cards, as well as research programs conducted by agency staff or academic scientists. Information from logbooks, landing receipts, and report cards are confidential (FGC §§ 1050.6, 8022(a)). CDFW is increasingly interested in developing collaborative programs with academics, fishermen, NGOs, and other constituents through collaborative research in which scientists work with fishermen to increase the quality and quantity of data collected (NRC, 2004; Section 5.3).

4.2.3 Data Analysis

Raw data have limited management value until it is analyzed, which may be a formal stock assessment or a less formal analysis. A stock assessment integrates a diverse range of EFI to evaluate the status of a fish stock, including past and current stock levels and includes information to help guide future harvest rate. A stock assessment can provide a clear picture of the present condition of a stock (i.e., is it *overfished*?) and the impacts of current harvest practices (i.e., is *overfishing* occurring?). CDFW will determine how often, or when, to perform stock assessments for the CA lobster based on availability of new data or updates, response time of the fishery to changes in the environment or the fishery.

4.2.4 Fishery Management Reference Points

Analyzed data must be placed into the context of policy/value judgment. For example, a 10% drop in catch level should trigger management actions only if a relevant statutory/regulatory mandate or a manager deems it important. This is where a **threshold reference point** comes in. Threshold reference points are proxies that signal when a stock would require management attention (e.g., stock is overfished or too small to support fishery). Whenever a stock reaches the threshold reference point (e.g., $CPUE_{CURRENT}$ falls below $CPUE_{THRESHOLD}$), resource managers must investigate the cause and potentially provide a response. Reference points are calculated based on parameters related to the overall health of a fishery such as Catch, CPUE, Economic Yield, Recruitment, and Spawning Potential Ratio (SPR). A number of specific reference points are used in spiny lobster fisheries around the world

and are described below: i) stock size; ii) total catch each season; iii) CPUE; iv) harvest rate (fishing mortality); v) YPR/SPR; and vi) recruitment indices.

i) Stock size

Estimates of stock size measure how a stock has been impacted through fishing and whether or not the stock is overfished or is at risk of becoming overfished. A common metric for stock size is B/B_0, which is the current biomass (B) divided by the virgin stock biomass (B_0). Other measures of stock size in existence may refer to the number of fish present, the total spawning biomass, or the biomass that is available to the fishery.

ii) Catch (total catch per season)

Since stock assessments are costly to conduct, catch trend over time can instead serve as a proxy for stock size. A significant change in catch can always be susceptible to multiple interpretations. However, the fact that a significant change in catch appears is itself a clear indicator that, at a minimum, an impact at a biological, ecological, or anthropogenic level is occurring.

Using total catch as a proxy for stock size can be misleading when factors other than stock size influence the number of fish captured. For example, changes in water temperature in southern California may influence the activity level of lobsters on the seafloor, and in turn alter their catchability (the probability that an individual will be captured in fishing gear). Such behavioral changes are not necessarily accompanied by changes in stock size, but they may influence total catch and therefore the perception of stock size. Regulatory changes that alter the access or efficiency of fishermen (and therefore catch rates) can similarly impact total catch.

iii) Catch per unit effort (CPUE)

CPUE is used by fishery managers in two important ways. First, it serves as a proxy for the abundance of fish in an area. This proxy assumes that there is a relationship, though not necessarily a linear one, between the condition of a stock and the rate at which they are captured under any given unit of effort (e.g., time spent fishing, amount of gear deployed). As with total catch, long-term trends in CPUE can provide insight into changes in the stock, which will influence management decisions.

In addition, CPUE is also very useful for tracking the optimal effort level and detecting economic overfishing. An example of this is found in management zone "CRA8" of the New Zealand fishery for *J. edwarsii* (Bentley et al., 2005). Lobster stock in this zone was classified as being overfished, and a CPUE-based rebuilding plan was proposed. The objectives of this CPUE-based plan were (among others) the restoration of spawning biomass as well as the maintenance of high catch rates that ensure economic viability (Bentley et al., 2005).

CPUE data are relatively inexpensive and easy to collect, but they can be influenced by factors other than fish abundance (e.g., new regulations, environmental variability, catchability, and selectivity). CPUE-based reference points can also be misleading when advances in technology (e.g., gear construction, vessel electronics) make the fishermen more efficient and the gain in efficiency is not reflected in the reported unit of effort (e.g., trap pulls, number of traps fished). In such a scenario, fishermen may be perceived to have maintained the same level of effort while in reality their effective effort may have increased substantially. This phenomenon is known as **effort creep**, and is thought to have been an important contributor to the catch/stock

Effort Creep - A phenomenon where technology advancements in a fishery are able to mask the declining efficiency of a fishery caused by stock declines

declines in fisheries for *Panulirus cygnus* in Western Australia and *J. edwarsii* in South Australia (Bentley et al. 2005; Section 4.4).

iv) Harvest rate/ fishing mortality

Estimates of current harvest rates (or, fishing mortality) provide information that helps managers maintain fishery yield while avoiding recruitment overfishing and economic overfishing (Figure 4-1).

v) Yield per recruit (YPR)

The yield that a fishery can achieve (i.e., pounds of fish caught; monetary value of fish sold) changes as a function of the harvest rate, and is often expressed in terms of YPR. YPR is the theoretical yield that is produced from a single recruit (or some fixed number of recruits) that is subjected to different harvest rates. Yield curves (e.g., Figure 4-1) that report actual values or YPR have the same shape and are generally interpreted in the same manner.

vi) Spawning potential ratio (SPR)

In addition to yield, harvest rate also affects the ability of a stock to replace itself. Because fishing tends to reduce the number and the size of individuals, it has the potential to negatively impact the reproductive output of a population. The reproductive output (# of eggs) of a population is often referred to as the *spawning potential*. The SPR is usually a ratio of the number of eggs produced by a fished population divided by the number of eggs produced by an unfished population. SPR values range from 1-0. For example, SPR values of 1, 0.5, and 0 correspond to harvest rates at which a population can produce all, half, or none of the eggs produced when the stock is unfished, respectively (Figure 4-5). At low harvest rates SPR values are high because many large animals remain in the population (Figure 4-5). At higher harvest rates, SPR declines and may ultimately reach zero if no size limit is in place to protect at least some portion of the breeding stock. It is important to note that SPR assumes that an unfished population would produce a relatively constant amount of eggs or maintain a relatively constant spawning stock biomass (Rochet, 2000).

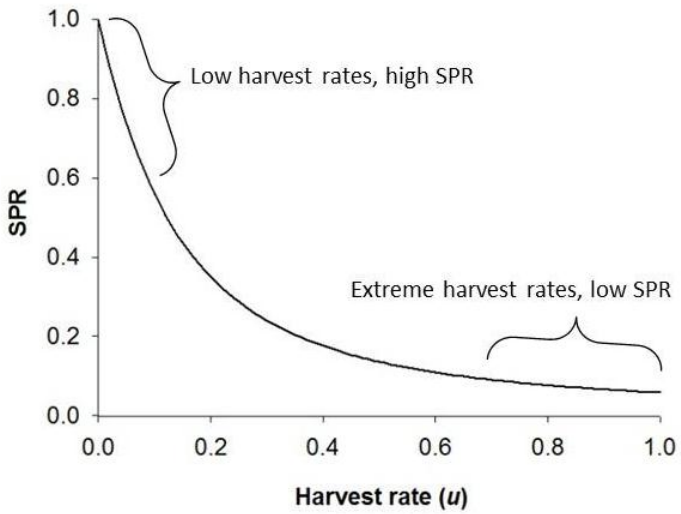

Figure 4-5: The general relationship between fishing mortality (or, harvest rate) and spawning potential ratio (SPR).

Depending on the amount of scientific information available to resource managers, various methods can be used to calculate SPR (Table 4-1). Methods for calculating the egg production or yield of an unfished population in particular vary greatly. For example, the SPR of a hypothetically unfished stock for the Cuban spiny lobster fishery was calculated based on egg production with the assumption that growth rate and fecundity are the same whether the individual is in a fished or unfished population (Puga et al., 2005). On the other hand, the SPR of a hypothetically unfished Western Australia lobster stock was calculated based on spawning stock biomass with density dependent variables (Hall and Chubb, 2001). Although the methods for calculating SPR can vary from region to region, the underlying purpose is generally the same: to gauge a fished stock's ability to replenish itself.

Table 4-1: SPR used around the world

Species	Location	$SPR_{THRESHOLD}$	Source	Rationale / derivation
Panulirus argus	Cuba	0.143	Puga et al. 2005	Replacement line analysis
	USA: Atlantic and Gulf of Mexico	0.20	FMP	Theoretical (Goodyear 1993); empirical (Mace and Sissenwine 1993)
	USA: Atlantic and Gulf of Mexico	0.05	Addison 1997	Not specified; proposed for use in conjunction with recruitment (to the fishery) observations
	USA: Florida	0.05	Bohnsack et al. 1990	Historical levels associated with catch: proposed in FMP
	USA: Caribbean	0.20	Bohnsack et al. 1990	Theoretical (Goodyear 1993)
	USA: Caribbean	0.20	FMP	Not specified, "committee recommendation"
Panulirus Cygnus	Western Australia	0.20	Hall and Chubb 2001	Historical performance of fishery
Jasus edwarsii	Victoria, Australia	0.20	FMP	Not specified
	New Zealand	0.20	NRLMG Report 2010	Not specified
Homarus americanus	USA – NE Atlantic	0.10	Addison 1997 Rosenberg et al. 1994	Historical performance of fishery

vii) Abundance of larvae or recruits

When measured over many years, trends in the abundance of larvae (or very young recruits) returning to a fishing ground can provide indirect evidence of a stock's relative spawning biomass. The abundance of larvae/recruits often varies year-to-year due to environmental conditions, and therefore may not be related to fishing mortality. However, long term trends (e.g., increasing, decreasing, or stable abundance) can inform managers about the reproductive potential of a stock. In some cases, levels of recruitment can be used to forecast future catches.

4.2.5 Harvest Control Rule Matrix

An HCR prescribes management actions (e.g., continue monitoring or implement regulatory changes to the fishery) when a certain reference point is triggered. Responses are required when threshold reference points are reached or surpassed (Section 4.3). An HCR can consist of a simple relationship between one trigger and one response (e.g., fishery closes when catch drops below a certain level). However, having a single trigger and a single response for a fishery generally cannot lead to adequate management actions. An HCR comprised of multiple reference points (e.g., Catch, CPUE, SPR, YPR, Fishing Mortality) and multiple harvest regulatory options (e.g., Seasonal Closure, Size Limit, Gear Restriction, TAC) can provide the necessary management flexibility to address specific fishery issues. In these types of complex HCRs, the relationship between triggers and responses (i.e., Harvest Regulations) is complex and interconnected.

A clearly detailed decision matrix is a formal mechanism that guides the appropriate management responses based on the triggering of different reference points. This mechanism provides managers with a pre-determined and transparent decision-making process that preserves CDFW's scientific and policy decision-making prerogatives.

4.3 HCR for the California Spiny Lobster Fishery

An HCR was developed by CDFW with substantial input from the LAC and independent scientific experts. It applies adaptive management by gauging the status of the fishery with specific reference points and tailoring responses when management actions are needed to ensure sustainability and prevent overfishing. The HCR also fulfills the MLMA mandate that requires "each fishery management plan or plan amendment prepared by CDFW shall specify criteria for identifying when the fishery is overfished" (e.g. FGC § 7086(a)).

The HCR is composed of 3 components. Three specific reference points serve as the metrics to assess the state of the CA lobster fishery and the lobster stock. A Control Rule Matrix details how the reference points will work together to identify any emerging issue within the fishery and its underlying causes. Lastly, a tool box of eight regulatory options gives managers the flexibility to address emerging and ongoing issues. The HCR is not guaranteed to capture every possible issue the fishery will face, and like any other management tool, resource managers will need to exercise independent judgment when using the HCR. In the future, CDFW will explore ways to improve the HCR, such as modifying reference points to more accurately reflect the status of the fishery and meet the MLMA management objectives. Future improvements will be adopted according to this FMP's amendment process (Section 6.2.2).

4.3.1 Reference Points for CA Lobster Fishery

Three quantitative measurements are identified to track/monitor the status of the CA lobster fishery:

1) Catch (the total catch in a single season)
2) CPUE (the number of legal lobsters caught per trap pull)
3) SPR (# eggs produced by current fished population / # eggs produced by unfished population)

Landing receipt - A document provided by the Department to commercial fish markets for recording landing information. Information required includes date, port of landing, species or market category of fish, pounds landed, and price paid.

Multiple reference points are necessary because change in a single reference point can be misleading or ambiguous. Having other reference points would help identify the underlying causes behind a specific change. For example, decline in catch alone can be caused by decline in stock size, but they can also be caused by unrelated factors (e.g., policy change, lower catchability of animals). However, an increase in catch accompanied by a decrease in CPUE may suggest that economic overfishing is occurring.

CDFW will use the trend of these reference points to help determine the status of the CA lobster fishery. Total catch ($CATCH_{CURRENT}$) and CPUE ($CPUE_{CURRENT}$) can be calculated directly from **landing receipts** and commercial logbooks without any change to current CDFW data collection. SPR can be can be calculated by inputting data from landing receipts and logbooks through computer models such as the Parrish Model. Each indicator can convey important information about the stock's status.

4.3.1.1 Catch-based reference point

The catch-based reference point for a particular season is calculated as follows:

$$CATCH_{CURRENT} = \frac{average\ catch\ for\ 3\ most\ recent\ seasons}{average\ catch\ for\ 10\ most\ recent\ seasons} \qquad (Equation\ 5.1)$$

The catch-based threshold reference point is 0.8: $CATCH_{THRESHOLD} = CATCH_{CURRENT} \leq 0.8$, (*Equation 5.2)*

It is important to note that this threshold reference point is primarily designed to detect trend. Catch can fluctuate drastically from year to year due to socioeconomic, environmental, and biological factors. These fluctuations often do not reflect problems that warrant management responses (Figure 4-6). The

multi-year running averages incorporated into the $CATCH_{THRESHOLD}$ of 0.8 serves to identify when a trend is significant enough to warrant management considerations.

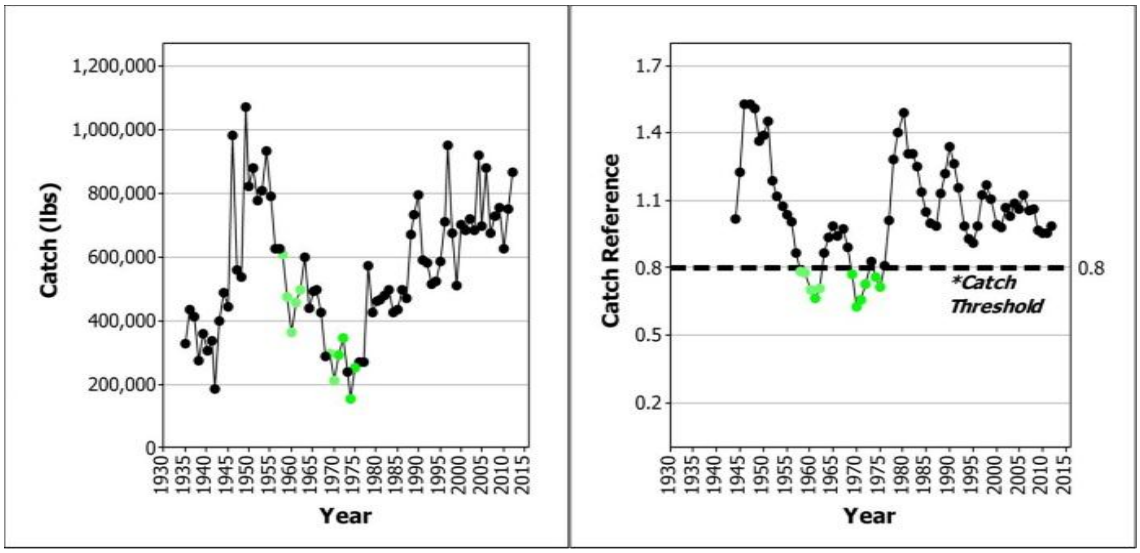

Figure 4-6: Annual catch (left panel) and catch reference values based upon *Equation 5.1*. With a threshold reference point ($CATCH_{THRESHOLD}$) of $CATCH_{CURRENT}$ = 0.8, $CATCH_{THRESHOLD}$ is exceeded (i.e., catch is conisdered to be low and triggers management consideration) in years where values the right-hand panel fall below the 0.8 value line (represented by green dots). Values at or near 1.0 in the right-hand panel indicate stable catches. Individual years listed (x-axis) are the year in which an individual lobster season began (e.g., 1935 = 1935-36 season).

CDFW obtained the $CATCH_{THRESHOLD}$ of 0.8 through consultation with several lobster fishery experts during the LAC process (Dr. Douglas Neilson, Dr. Ray Hilborn, Dr. Matthew Kay, Dr. Hunter Lenihan, Dr. Richard Parrish, and Dr. Jeremy Prince). Based on available studies and data, it was decided that the prescribed threshold value (0.8) should be calculated using the average catch of the 3 most recent seasons divided by the average catch of the 10 most recent seasons. The threshold is designed to detect significant changes within the fishery, which has been biologically stable since 2001, without overweighing natural year-to-year fluctuations. A $CATCH_{CURRENT}$ value below or equal to a 0.8 suggests a declining trend in catch that warrants consideration (Hilborn, 2010). A $CATCH_{CURRENT}$ value above 0.8 indicates that the catch is stable or increasing. An examination of California's catch history also indicates that a $CATCH_{THRESHOLD}$ of 0.8 would have detected the two major declines in catch performance in the modern era of this fishery (Figure 4-6).

Averaging catch to calculate $CATCH_{CURRENT}$ and $CATCH_{THRESHOLD}$ will ensure that management decisions are influenced by actual changes in the fishery, the larger socio-economic context, or the environment rather than fluctuations that occur naturally from year-to-year. A moving average for calculating $CATCH_{CURRENT}$ and $CATCH_{THRESHOLD}$ is preferable to a static number for $CATCH_{THRESHOLD}$ (e.g., 400,000 lbs) because a sustainable level of catch will always fluctuate (Hilborn, 2010).

4.3.1.2 CPUE-based reference point

The CPUE-based reference point for any season ($CPUE_{CURRENT}$) is calculated in the same manner as $CATCH_{CURRENT}$:

$$CPUE_{CURRENT} = \frac{average\ CPUE\ for\ 3\ most\ recent\ seasons}{average\ CPUE\ for\ 10\ most\ recent\ seasons} = 0.8 \qquad (Equation\ 5.3)$$

The CPUE-based threshold reference point is any value for $CPUE_{CURRENT}$ that is equal to or less than 0.8:

$$CPUE_{THRESHOLD} = CPUE_{CURRENT} \leq 0.8 \qquad \text{(Equation 5.4)}$$

The rationale for using the value of 0.8 and estimating a moving average is also based on expert input and scientific literature (Hilborn, 2010). Additional support was provided through the collaborative LAC stakeholder process, which determined that an average CPUE of the 3 most recent seasons that is lower than 80% of the average CPUE of the 10 most recent seasons would signal important adverse change (e.g., economic overfishing) within the fishery that warrant management consideration. However, since available CPUE data did not exist before 1973 (Figure 4-7), it cannot be determined if this reference point would have signaled the fishery declines in the late 1950s and 1960s. Retrospective analysis of $CPUE_{CURRENT}$ (Figure 4-7) indicates that the fishery has not exceeded $CPUE_{THRESHOLD}$ as of early 2014. However, the number has been approaching the $CPUE_{THRESHOLD}$, and is on the verge of crossing the 0.8 threshold. The slight CPUE increase in the 2012-13 season may have been the only reason that $CPUE_{CURRENT}$ has not crossed $CPUE_{THRESHOLD}$.

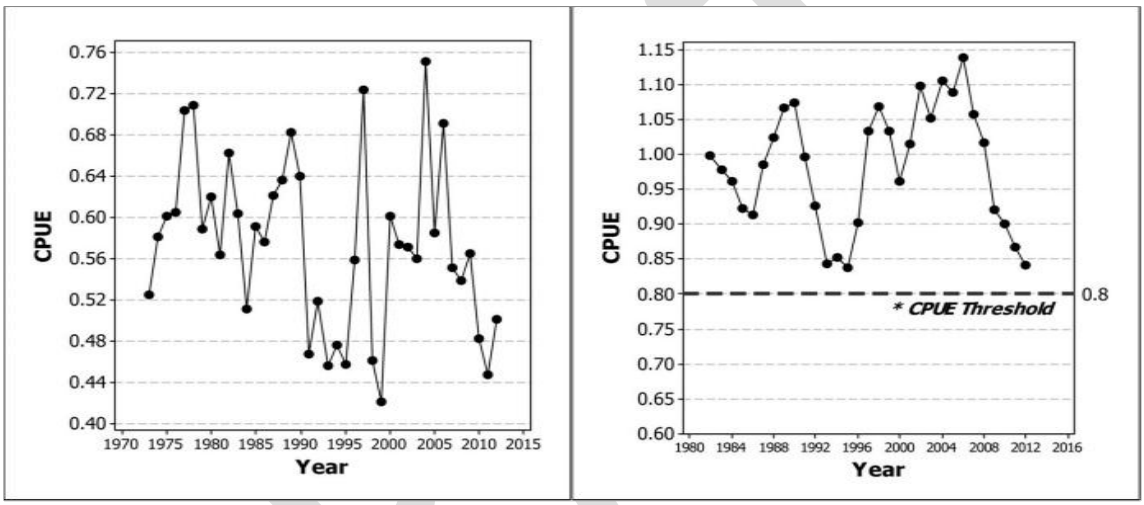

Figure 4-7: CPUE for individual fishing seasons (left panel) and CPUE reference values based upon *Equation 5.3*. With a threshold reference point ($CPUE_{THRESHOLD}$) of $CPUE_{CURRENT}$ = 0.8, $CPUE_{THRESHOLD}$ is exceeded (i.e., catch is conisdered to be low and triggers management consideration) in years where values the right-hand panel fall below the 0.8 value line. Values at or near 1.0 in the right-hand panel indicate stable catches. Individual years listed (x-axis) are the year in which an individual lobster season began (e.g., 1970 = 1970-71 season).

4.3.1.3 SPR Reference Point

SPR-based thresholds are used widely in fisheries around the world (See Table 4-1). Most $SPR_{THRESHOLD}$ used for lobster fishery management are based on the calculated value of 0.20 (i.e., 20% of unfished spawning biomass or egg production) commonly used for finfish fisheries (Table 4-1; Mace and Sissenwine, 1993; DiNardo, 1999; SAFMC, 1998; CFMC, 1990). However, some lobster fisheries have calculated the $SPR_{THRESHOLD}$ for their specific fishery. For example, the $SPR_{THRESHOLD}$ for the *Homarus americanus* fishery off the northeast coast of the United States is estimated to be 10% (Zhang et al., 2012). The $SPR_{THRESHOLD}$ for *P. argus* in Cuba is calculated to be 14% (Puga et al., 2005). Furthermore crustaceans such as lobster are thought to be able to persist at much lower levels. In Canada, the $SPR_{THRESHOLD}$ of *H. americanus* has been estimated to be approximately 5%, however the population was able to persist with a calculated SPR of 1-2% in the late 1990s (Ennis and Fogarty, 1997).

SPR can be calculated in several ways. The method currently employed by CDFW utilizes data from commercial logbooks and commercial landing receipts to calculate the average weight of lobsters caught in a given year. CDFW then relates the average weight to a corresponding fishing mortality (*F*) and calculates an SPR value using the resulting *F*. This calculation is currently accomplished using the Parrish

Model. The Parrish Model calculates the SPR as an **output** based on 46 user-specified inputs, each responsible for the calculation of various biological, economical, and operational characteristics of the fishery. The age-length relationship, for example, incorporates three inputs: $L\infty$, K, and t_0 (the maximum length a CA lobster can biologically attain, the growth rate, and a number that adjusts the initial size of a lobster for the calculation, respectively; Section 3.2).

SPR is also the component in the HCR where the effects of MPAs are factored into the management of CA lobster fisheries. Through the Parrish Model, CDFW accounts for MPA effects on SPR through 7 different inputs. These are: 1) the total fraction of the species' habitat covered by the MPA, 2) migration rate into the MPAs, 3) migration rate out of the MPAs, 4) a reduced fishing mortality rate experienced by individuals that cross the MPA boundaries, 5) average length of MPAs, 6) average distance between MPAs, and 7) effort correction due to fishing effort displacement.

Estimating the percentage of lobster habitat that is covered by MPAs is a complex and data-intensive task. Bottom-type data are not available for all the areas that comprise lobster habitat, so proxy information must be used. For example, detailed data on the coverage of kelp canopy can be used as an indication of hard bottom. However, these proxies contain sources of uncertainties. The coverage of the canopy can be different from the extent of the reefs that kelps are attached to. On the otherhand, the lack of kelp canopy in an area does not necessarily indicate the absence of reefs.

Based on available hard-bottom habitat data, CDFW currently estimates 14.6% of all available lobster habitat to be protected by MPAs. Only areas that prohibit both recreational and commercial take are considered as MPAs. Although recreational-only areas do protect lobster from commerical traps, they receive disproportionately higher fishing effort from the recreational sector (Figure 2-10). Lobster report card data indicates that the majority of recreational fishing effort for lobster is taking place in recreational only areas. The high recreational fishing pressure experienced by these areas makes it inappropriate for CDFW to consider them as true MPAs. CDFW will continue to incorporate better habitat information as they become available.

The CA lobster stock was deemed stable throughout the early 2000s according to the 2011 CDFW stock assessment. If the stock's SPR can be kept at the same level as this period of time, the risk of recruitment overfishing is low. Obtaining an accurate estimation of the SPR level for that period of stability is a challenging process. The Parrish Model treats all MPAs as if they have reached full maturity. However, this was not the case in the early 2000s when there were only a small number of no-take MPAs (e.g., northern Channel Islands, La Jolla). Furthermore, it will likely take several years for the MPAs implemented during the south coast MLPA in 2011 to reach full conservation potential.

Using best available information, CDFW estimates that in the early 2000s around 4.5% of lobster habitat was closed to both commercial and recreational fishing. With an average landed weight of 712 g (1.57 lb), which is the average landed weight from the 2000-01 fishing season to the 2007-08 fishing season, the SPR of that period is calculated to be 18%. Until better estimations are available, 18% will provide the baseline SPR of the early 2000s as well as the $SPR_{THRESHOLD}$. Under current conditions with 14.6% MPA coverage and an average weight of 694 g (1.53 lb), SPR for the 2011-12 fishing season is estimated to be 20% (Figure 4-8).

Considering the current legal size limit and an estimate of 14.6% habitat coverage from MPAs, the SPR of the stock would drop below the 18% threshold only if over 92% of every cohort gets harvested in the first year of becoming legal, an unlikely scenario. The low likelihood of this threshold being crossed is in line with current CDFW expectation and policy preference. The projection reflects the importance of

the MPAs to the reproductive potential of the species as well as the insurance they provide against recruitment overfishing. The metric used to measure a stock's reproductive potential should reflect the effects of a management tool designed in part to protect that very stock's reproductive potential. If a trap limit is implemented, it would be expected to further reduce fishing effort which could lead to a further increase in SPR.

Available CDFW data from logs and landing receipts show that individuals in the northern Channel Islands are notably larger than the minimum legal size (MinLs), while lobsters in the south are generally caught very close to the legal size. If growth rate is similar across the bight, northern lobsters would most likely participate in more spawning seasons than southern lobsters before capture.

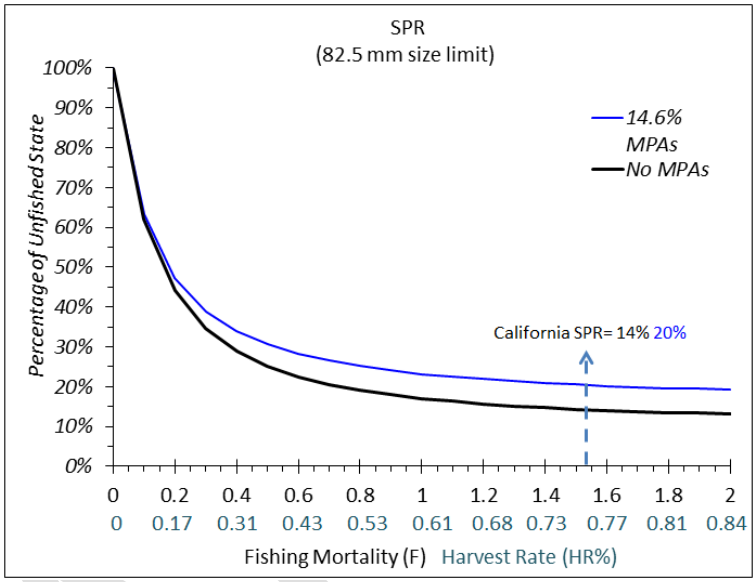

Figure 4-8: SPR curve output from the Parrish Model. Black line represents the SPR curve the current CA lobster population would have without any MPA protection, and blue line represents the SPR curve with the current estimated level of MPA protection. The bight-wide CA lobster SPR is currently estimated at 12.5% SPR.

Considering these factors, treating the entire CA lobster stock within the U.S. border with one SPR value is appropriate based on complete population mixing due to the species' protracted larval phase. Information related to regional differences in the species' biological parameters and fishery dynamics will need to be improved to better assess the adequacy of using a single SCB-wide SPR value (Section 5.2).

4.3.2 Implementation: HCR Matrix

The three reference points selected to monitor and manage the CA lobster fishery (Catch, CPUE, and SPR) are incorporated into an HCR Matrix. This matrix provides a "dashboard" approach to assist managers in interpreting the status of Catch, CPUE, and SPR reference points in relation to their respective thresholds (Table 4-2). Based on these interpretations, the matrix would prescribe particular courses of action (e.g., increase monitoring), to address the current condition of the fishery. Depending on the respective trend of each reference point (i.e., has any of the threshold reference point been exceeded), the matrix identifies various management strategies ranging from easing harvest regulations, to no regulatory action, to further restricting the fishery.

The HCR is discretionary and not every triggering event will necessarily lead to an immediate regulatory response. Additional evaluation is needed before taking action to determine if external factors (i.e. new regulations, market dynamics, environmental changes) have cause or contributed to the reference point(s) being exceeded. This process will include consultations with the fishing communities and other stakeholders. For example, if the triggering of the catch-based reference point coincides with a new effort-based regulation, the first task would be to determine if the triggering event is caused by the new regulation. If it is determined that the triggering event is caused by the new regulation and not biological processes, no further management action would be necessary. In the event that the management actions are warranted, the HCR calls for the implementation of one or more of the eight regulatory options provided in the control rule toolbox (Section 4.3.3).

Table 4-2: HCR Matrix

Scenario	Reference Point			Interpretation/possible causes	Suggested management response sequence
	$CATCH_{THRESHOLD}$	$CPUE_{THRESHOLD}$	$SPR\ (F_{18\%})$		
1	↑	↑	↑	○ Stock productivity and fishery performance stable and/or increasing	*No response required, but optionally:* Monitor reference point (SPR) trends a) Make no change (if SPR trends are stable or just above thresholds) b) Ease harvest rate regulation (if SPR trends high/increasing)
2	↓	↑	↑	○ Fishery lightly harvested (i.e., fishing effort and harvest rates are low, could be caused by drop in price or other economic factors)	*No response required, but optionally:* Monitor reference CPUE and SPR trends a) Make no change (if CPUE/SPR trends stable/just above threshold) b) Ease harvest rate regulation (if CPUE/SPR trends increasing)
3	↑	↓	↑	○ Catchability down (e.g. cold water) ○ Potential economic overfishing ○ Potential early warning of recruitment overfishing	*No response required, but optionally:* Confirm/monitor SPR values with multiple models/approaches a) No change (if SPR trends are stable/above threshold) b) Harvest rate reduction (if SPR trends declining), regulator options c) No change, or ease harvest rate restriction (if catchability is proven to be lower than usual and is causing CPUE decline)
4	↓	↓	↑	○ Catchability down (e.g. cold water) ○ Potential economic overfishing ○ Potential early warning of recruitment overfishing (fewer recruits surviving to adulthood)	*No response required, but optionally:* Confirm/monitor SPR values with multiple models/approaches a) No change (if SPR trends are stable/above threshold) b) Harvest rate reduction (if SPR trends declining), regulatory options c) No change, or ease harvest rate restriction (if catchability is proven to be lower than usual and is causing CPUE decline)

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Scenario	Reference Point			Interpretation/possible causes	Suggested management response sequence
	$CATCH_{THRESHOLD}$	*$CPUE_{THRESHOLD}$*	*SPR ($F_{18\%}$)*		
5	↑	↑	↓	○ Stock overfished, and/or ○ CPUE or SPR estimate(s) in error?	*Response required:* a) Investigate underlying causes b) Confirm/monitor SPR with multiple models/approaches *If action is required:* Tailor management response to prevailing conditions
6	↓	↑	↓	○ Stock overfished, and ○ Possible catchability increase (effort creep due to technology, etc.) ○ Disease in stock?	*Response required:* a) Investigate underlying causes b) Confirm/monitor CPUE (misreporting?) c) Confirm/monitor SPR with multiple models/approaches *If action is required:* If action is required tailor management response to prevailing conditions
7	↑	↓	↓	○ Stock overfished ○ Probable overfishing	*Response required:* a) Investigate underlying causes b) Confirm/monitor SPR with multiple models/approaches *If action is required:* If action is required tailor management response to prevailing conditions
8	↓	↓	↓	○ Stock overfished ○ Probable overfishing ○ Disease?	*Response required:* a) Investigate underlying causes b) Confirm/monitor SPR with multiple models/approaches *If action is required:* If action is required tailor management response to prevailing conditions

Interpretation of different scenarios in which threshold reference points are exceeded, and recommended management responses. Symbols for each reference point are: ↑("safe", does not exceed threshold), and ↓ (exceeds threshold). Note that once *$CATCH_{THRESHOLD}$* or *$CPUE_{THRESHOLD}$* are exceeded, monitoring CPUE and Catch trends provides valuable information that managers can use to "fine tune" the fishery or to detect overfishing early (i.e., before the stock becomes overfished).

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4.3.3 Regulatory options linked to the control rule

This FMP prescribes a control rule toolbox of eight regulatory options (not in order of rank) that are available to decision makers (Table 4-3) when threshold reference points are triggered. The specific actions in the toolbox are:

1) Change in commercial **trap limit**
2) Change in recreational bag limit
3) TAC
4) District Closures
5) Change in season length
6) Change minimum size limit
7) Impose a maximum size limit
8) Sex selective fishery (Male-only fishery or female-specific size restriction)

> **Trap limit –** A type of regulatory measure that restricts the amount of traps a fisherman may have within a given season.
> **Allocation -** In the LFMP allocation means a certain amount of lobster set aside for recreational, commercial, and ecosystem needs.

Each of the eight regulatory options in the control rule toolbox carries specific benefits and limitations (Table 4-3) that managers will need to carefully evaluate, including impacts to constituents, level of regulatory change, and duration of regulatory change (i.e., how long it will remain in place). CDFW will consult with the fishing communities and other stakeholders in order to better inform any management recommendation to the Commission on the proper regulatory response.

<u>1) Implementation and subsequent adjustments to commercial trap limit</u>

Relative to fisheries for finfish and other invertebrates, crustacean (crab and lobster) fisheries can sustain more intense harvest rates without rapidly collapsing (Zhang et al., 2012; Ennis and Fogarty, 1997). This resilience against fishing pressure often allows commercial lobster fisheries to remain at high effort levels that can be economically inefficient and unnecessary for maintaining high yield. Over time, such effort level can lead to economic overfishing, and if left unregulated, lead to recruitment overfishing. Therefore, reducing effort when fishery performance (e.g., CPUE) or stock status (e.g., SPR) is in decline would likely address the root cause of such declines. As specified in Table 4-3, effort adjustment also allows for increases when reference indicators (e.g., Catch, CPUE, SPR) indicate that the fishery is underutilized. A trap limit would directly reduce the number of traps fishermen put in the water.

The CA lobster fishery is not currently regulated by a trap limit. However, recent rise in fishing effort has led to possible economic inefficiency within the fishing sector (Sections 2.1, 4.3.1.2). Furthermore, pollution from an excess of lost traps may create further environmental and social concerns. CDFW has worked closely with its constituents to resolve these issues, and as part of the implementing regulations for this FMP, the CDFW will propose a formal trap limit program that allows the Commission to adjust commercial sector fishing effort (Section 4.5). Once the limit is in place the Commission will be able to adjust it as needed based on the HCR.

<u>2) Change in recreational bag limit</u>

An adjustment to the recreational bag limit would serve to control effort in the recreational sector. Adjustment options may consist of daily, weekly, monthly, or annual limits. A bag limit would change the amount of lobsters a recreational fisherman can keep. MLMA requires any type of **allocation** within an FMP to be equitably shared between the recreational and commercial sectors (FGC § 7072(c)). Any proposed change to the recreational bag limit is allocative by nature, and should be considered in conjunction with possible adjustments for the commercial sector.

3) TAC

A TAC or a TAC/ITQ management framework can prevent a stock from being overfished. However, management challenges in quota fisheries include, but are not limited to, allocation of catch among fishermen, consolidation of capacity when quota is transferable, accounting for natural fluctuations in stock size that may render the TAC too restrictive or aggressive from year to year (e.g., Johnston and Butterworth, 2005), and access to the fishery if/when quota shares increase in price. Advocates of quota systems argue that the high cost of quota shares should lead to increased stewardship among current fishermen because they have an incentive to protect their asset. This and other aspects of TAC/quota management are complex (e.g., Branch, 2009) and often contentious. While some studies emphasize the successes of TAC and quota approaches to management (Costello et al., 2008; Bonzon et al., 2010), others suggest that they should be considered cautiously on a per-case basis (del Valle and Astorkiza, 2007; Bromley, 2009; Ecotrust, 2009; Gardner et al., 2013).

If the SPR-based threshold reference point ($F_{18\%}$) is exceeded, a TAC could be established for California. Creating a TAC for the CA lobster fishery would likely require CDFW to estimate the total biomass of the stock, a relatively conservative catch level, or an ideal CPUE (see Bentley et al., 2005). Derivation of these parameters is technically difficult, time intensive, and relatively expensive for a fishery this size. In addition, an equitable distribution of the TAC between the commercial and recreational sectors will be necessary (FGC § 7072(c)). If a quota system is adopted, allocation between and within sectors (commercial and recreational) will need to be considered. Quota allocation is likely to be highly contentious.

4) District Closures

Some areas may be closed only to certain types of fishing, and areas closed to fishing tend to experience very low fishing mortality (although some fishing mortality can occur due to spillover and poaching). Population increase inside closed areas can increase the spawning output of the entire stock. However, closing areas off to fishing can also displace fishing effort to other areas, placing more pressure on the unprotected portion of the stock (Section 4.2.1.1). Furthermore, existing CDFW records show that most of the recreational take in the state occurs in locations where commercial fishing is prohibited (Santa Monica Bay, Long Beach Harbor, San Diego Bay, and the front side of Catalina; Figure 2-10).

A number of areas (Districts) are presently closed to commercial harvest. Prominent examples include the north side of Catalina Island, Santa Monica Bay, and harbor jetties. If the SPR-based threshold reference point is exceeded, these areas could be additionally closed to recreational harvest. Doing so would enhance the spawning output of populations in these areas. The FMP accounts for the effect of area closures on SPR using the Parish Model (Section 4.3.1.3).

5) Change in season length

Seasonal closures reduce fishing mortality by reducing the number of days that fishing is allowed each year. Closed seasons can protect stocks during important life events, such as spawning. A longer closed season could also improve survival of individuals that would have succumbed to fishing, which in turn increases SPR. The current closed season in California protects reproduction, and any extension of current seasonal closures is unlikely to provide substantial protection for reproductive behaviors or activities. If the SPR-based threshold reference point is exceeded, fishing season length could be shortened, either by delaying the opening date or by closing the season early. That said, most catch occurs during the first part of each season, so reducing the duration of the season would have a disproportionately small effect on fishing mortality.

6) Change minimum legal size

Increasing the Min LS would ensure that animals will, on average, reproduce more times before they are caught. Furthermore, females will be slightly larger and produce more eggs. Increasing the Min LS is a simple, effective, and direct way to increase SPR. However, it will lead to extra cost for the fishermen as they make adjustments to their gears (e.g., enlarge escape ports). If the SPR-based threshold reference point is exceeded, the Min LS could be increased to a size that ensures a target SPR within a specified time frame. A reduction in Min LS would have the opposite effect, if future conditions suggest that SPR could be reduced.

7) Establish maximum legal size

If the SPR-based threshold reference point is exceeded, a Max LS could be implemented to protect larger spawning females. As the communities inside MPAs mature, they will likely comprise more of these adults with higher fecundity, and a Max LS would be expected to protect these important spawners as they move outside of the boundaries of the MPAs.

8) Sex selective fishery

A sex-selective restriction allowing the harvesting of male lobsters could be implemented for the CA lobster fishery. If the SPR-based threshold reference point is exceeded, changing sex regulation for females could be an efficient mean to increase SPR. As stated in Table 4-3, there are advantages and disadvantages to this system that should be carefully considered. Prohibition on the take of berried females is another sex selective provision that could considered.

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Table 4-3: Control rule toolbox

Regulatory options	Benefits	Challenges/Limitations
1) Change commercial trap limit to adjust harvest rate (i.e., fishing mortality, *F*)	• Restores economic performance (CPUE) and stock status (SPR) • Directly addresses most common management problem in lobster fisheries (high harvest rates due to high effort) • Among options here, highest degree of stakeholder support • Applicable when performance/stock increases (i.e., harvest rates can be scaled upwards in absence of crisis, or after recovery) • Accentuates the multiple benefits of trap limit for other MLMA objectives (i.e., Table 5.1)	• Mechanisms only applicable to commercial • Requires implementing a trap limit program
2) Change recreational bag limit to adjust harvest rate (i.e., fishing mortality, *F*)	• Restores stock status (SPR) • Directly addresses most common management problem in lobster fisheries (high harvest rates due to high effort) • Among options here, highest degree of stakeholder support • Applicable when performance/stock increases (i.e., harvest rates can be scaled upwards in absence of crisis, or after recovery)	• Mechanism only applicable to recreational
3) TAC	<u>Without individual quota system (e.g., ITQ)</u> • Can provide long term stability to catch • Adjustments and rebuilding measures are simple and efficient <u>With individual quota system (e.g., ITQ)</u> • Can provide long term stability to catch • Can ease "race to fish" • Can encourage fishing during high market value periods (unless cost of fishing is higher then), this is often later in the season for CA lobster – can have economic benefits • Can lead to effort reduction (but not guaranteed) • TAC/ITQ can be tuned to other fishery performance measures (e.g., CPUE); maximize efficiency	<u>Without individual quota system (e.g., ITQ)</u> • Insufficient data to establish TAC • Encourages "derby" fishery, exacerbates high effort level, and compromise safety ("race to fish") • Allocation across sectors difficult (commercial vs. recreational) • Hard to monitor recreational catch against a TAC (current system is not sufficient) • Recruitment/stock size variability problematic for setting optimal/appropriate TAC • Benefits to broader MLMA objectives not clear <u>With individual quota system (e.g., ITQ)</u> • Insufficient data to establish TAC • Difficult to monitor recreational catch against a TAC (current system is not sufficient) • Allocation both across and <u>within</u> sectors difficult • Recruitment/stock size variability problematic for setting optimal/appropriate TAC/quota

Regulatory options	Benefits	Challenges/Limitations
4) District closures (e.g., Santa Monica Bay, jetties, Catalina)	• Directly protects stock and increases SPR • Protected areas can be directly incorporated into stock assessment • Streamlining management by prohibiting all lobster fishing in certain CDFW fishing districts	• If implemented alone, does not reduce high effort in fished areas (potential root of problem), thus does not improve economic performance • Increased congestion in open areas • Likely to reduced yield, reduce public access • How to estimate value of jetties for including the protected stock in stock assessment?
5) Change season length	• Ease and immediacy of implementation and enforcement (applies both sectors in same manner) • Relatively easy to estimate benefits from historical catch records	• If implemented alone, does not reduce high overall effort harvest rates (potential root of problem), thus does not improve economic performance • The timing of catches made within season varies regionally (high early season in south, more prolonged in north), thus impact will bear regional disadvantages. Not likely to be uniformly effective throughout range of fishery • Shortens and temporally eliminates access to market – could have long term repercussions?
6) Change minimum size limit	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Larger size limit directly protects stock and increases SPR • Impact easily incorporated into stock assessment	• Disproportional economic impacts in southern portions of range where most animals in catch are barely legal • Does not directly address high harvest rates • Does not improve economic performance • No benefit to other MLMA objectives
7) Impose a Maximum Size Limit	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Directly protects stock and increases SPR • Impact easily incorporated into stock assessment • Enhances other MLMA objectives: (1) Ecological benefits of large animals in food chain, (2) non consumptive users	• Benefits (increases in SPR) are minimal at high harvest rates because few animals survive to large size • Does not directly address likely root cause of problem: high harvest rates • Does not improve economic performance • Reduced yield to fishery • May disproportionally impact recreational sector
8) Sex Selective Fishery (male only or female-specific size restriction or condition)	• Ease and immediacy of implementation and enforcement (applies to both sectors in same manner) • Directly protects stock and increases SPR; similar method works in *H. americanus* fishery (V-notch program) and crab fisheries (i.e., dungeness) • Enhances other MLMA objectives: (1) Ecological benefits of large animals in food chain, (2) non consumptive users	• If implemented alone, does not reduce high harvest rates in fished areas (potential root of problem), thus does not improve economic performance • Reduced yield to fishery, likely large effect • Mating dynamics unknown, possible that small males might not fertilize eggs of larger protected females due to (1) sperm limitation and (2) antagonistic interaction between large females and small males during mating

The eight regulatory options available to decision makers if threshold reference points are triggered, and the relative benefits vs. limitations of each potential regulatory change.

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4.4 Management of Other Lobster Fisheries

Commercial lobster fisheries exist in many parts of the world. The lessons learned from these global lobster fisheries have played an important role in shaping this FMP. The following review of four select lobster fisheries from other parts of the world highlights the various tools used in other lobster fishery management. A comprehensive list of fisheries is listed at the end of this section (Table 4-4).

4.4.1 South Australia *Jasus edwarsii* Fishery

The South Australian lobster fishery has been regulated with limited entry, seasonal closure, minimum harvestable size, trap limit, trap design restrictions, and a prohibition against keeping berried females (SAFMR, 2006; SAFMR, 2007). A trap limitation was implemented in the 1980s when fishing capacity began to expand due to technological advances (Sloan and Crosthwaite, 2007). Each fishing license is restricted to fishing between 20-100 traps (SAFMR, 2006), but a fisherman or a holding company may own more than 1 fishing license (FAO, 2001). The recreational part of the fishery accounts for less than 5% of the fishery's annual harvest, and is further managed through daily limits and gear restrictions. In addition, recreational fishermen are required to clip the tails of each lobster they catch; the clipping helps identify recreationally caught lobsters and prevent them from entering the commercial markets.

In the early 2000s, landing and CPUE for the fishery dropped due to unfavorable environmental conditions (Linnane et al., 2013a). State managers then implemented a TAC of 625 mt (1.38 million lb) for the fishery in 2003 and a system of limited permit entry in 2007 (Sloan and Crosthwaite, 2007; Linnane et al., 2013a). The stock has since improved but has not fully recovered (Linnane et al., 2013a). The improvement may have been due to a more stringent TAC of 470mt (1 million lb) that was implemented in 2008 (Linnane et al., 2013a; Linnane et al, 2013b). The lower TAC may have prevented growth overfishing, but it could take years before recruitment improves (Phillips and McWilliam, 2009; McGarvey et al., 1999).

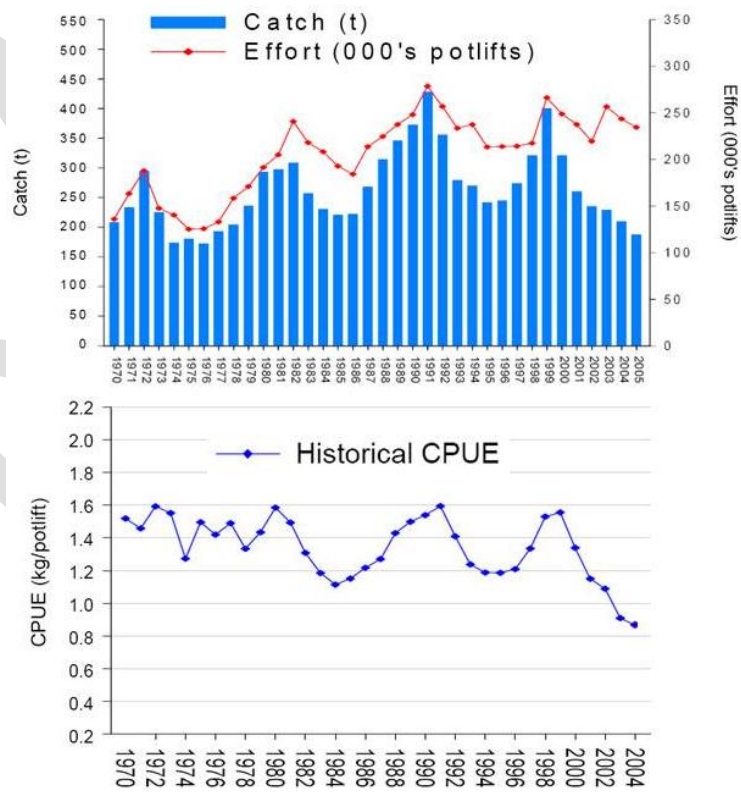

Figure 4-9: Catch, effort, and CPUE in the South Australia lobster fishery for *Jasus edwarsii*. (Data shown here are for Region D of the Northern Zone). The steep declines in CPUE were perceived as stock decline and partially triggered management changes (see Chapter 3, this document). This figure modified from Sloan and Crosthwaite (2009).

The fishery currently uses a formal HCR based on CPUE, measured as the weight of legal-sized lobster per trap lift, and recruitment abundance, measured as the number of sublegal-sized lobster per trap lift (Sloan and Crosthwaite, 2007). When both CPUE and recruitment decrease below specific reference points, managers must either decrease the TAC by 10%, introduce spatial

management measures, or both. When CPUE and recruitment increase beyond specific reference points, managers are required to increase the TAC by 10%.

4.4.2 Florida *Panulirus argus* Fishery

The Florida lobster fishery contains a large recreational component (Sharp et al., 2005). The recreational fishery was estimated to account for 24% of the total lobster landings in the state during the 2009-10 fishing season (SAFMC, 2012). The fishery is managed in part through seasonal closure, minimum size restriction, trap/bag limit, trap design restrictions, TAC, and prohibition against keeping berried females for both recreational and commercial fishermen (FAC § 68B-24.001 *et seq.*).

The fishery first experienced decline in the early 1990s in part from overfishing (Milon, 1999; Matthews, 2004). The state then implemented a tag-based trap limitation during the 1993-94 season, which would decrease the number of traps within the state through attrition until a target goal of 400,000 traps is reached (FAC § 68B-24.009). Fishermen may transfer their trap limits to immediate family or other lobster permitted fishermen, but transfer outside family would incur a fee of $2 per trap transferred as well as a 10% reduction on the number of tags transferred (FAC § 68B-24.009; FSA § 379.3671(2)(a)1.). The trap limitation and other conservation measures have likely improved both the health of the stock and the efficiency of the fishery (Milon et al., 1999).

4.4.3 Western Australia *Panulirus cygnus* Fishery

The Western Australia lobster fishery has maintained a high sustainable yield for decades. Management measures for the commercial fishery include management by zones, seasonal closure, minimum size, limited entry, trap limit, trap design restrictions, TAC, a maximum size for females, and prohibition on keeping berried females (GWADF, 2014). Recreational fishermen are allowed to use traps or to dive for lobsters, but they are subject to daily bag limit, and may take lobsters only during the day (GWADF, 2013). The recreational fishery is small, accounting for only 2.6% of the total fishery landing in the 2010/11 season (GWADF, 2012).

Harvest from this fishery increased substantially in the 1980s and 90s due to technological advances and resulted in depressed recruitment, but a combination of biological (e.g., maximum female size limit) and effort-based measures (e.g., trap limit) reversed the trend (Hall, 2001). Recruitment again dropped in the mid-2000s. This recent decline was most likely caused by unfavorable oceanographic conditions (Brown, 2009). In response to the drop in recruitment, the fishery managers decided to implement a fishery-wide TAC (GWADF, 2014). The managers are currently implementing an ITQ system to divide the TAC into transferable components (Fletcher and Santoro, 2012).

4.4.4 Maine *Homarus americanus* Fishery

In Maine, a combination of good management practice and favorable environmental conditions has resulted in historically high landings (Steneck, 2006). Both commercial and recreational fishermen are regulated with minimum and maximum size, trap limit, trap design restriction, and prohibition against taking of berried females (13-188 CMR §§ 25.01 *et seq.*). The commercial sector is further restricted with an area-based limited entry program (12 MRS §§ 6446-6447). Each management area may also further reduce the 800-per-fisherman trap limit required by the state through a voting process within the fishing community (12 MRS §§ 6446, 6447(5)(A); 13-188 CMR 25.10(2)). The stock is not considered to be overexploited, but concerns related to suboptimal economic performance, increases in territorial conflicts, trap entanglements (i.e. excess gear in the water), and harbor congestion have surfaced (Acheson and Acheson, 2010).

Table 4-4: Global Lobster Fishery Overview

Lobster Species (Jurisdiction)	Biology-based Management Tools							Catch-based Tools			Effort-based Management Tools							Co-Management by Regions	Main Source of Reference
	Minimum Size	Maximum size	Taking of Berried Females Restricted	Taking of Moulting Lobsters Restricted	MPAs and Other Area Closures	Seasonal /Temporary Closure	Minimum Trap Service Interval	Bag/ Daily Limit	TAC	ITQ	Limited Entry	TAE (Total Allowable Effort)	Trap Limit	Gear Design Restrictions	Gear Type Restrictions	Tail Clipping for Recreational Fishery	No Fishing at Night		
Panulirus interruptus (California)	C R				C R	C R	C	R			C			C	C R				
Panulirus interruptus (Baja California, Mexico)	C		C		C	C					C			C	C			C	SCS, 2004
Panulirus argus (Cuba)[1]									C	C[2]					C			C	Muñoz-Núñez, 2009
Panulirus argus (Florida)	C R		C R			C R		C R	C				C	C	C[3] R				FAC § 68B-24.001
Panulirus cygnus (Western Australia)	C R	C R	C R		R	C R		R	C	C			C R	C R		R	R	C	GWADF, 2012
Panulirus japonicus (Japan)													C[4]	C	C			C	Nonaka et al., 2000; Phillips et al., 2000
Palinurus elephas (Spain)	C		C			C							C	C	C				Quetglas et al., 2004; Goñi and Latrouite, 2005
Palinurus gilchristi (South Africa)			C						C			C[5]							Reg. in Terms of the Marine Living Resources Act, 1998 C. 44
Jasus edwarsii (New Zealand)	C R		C R	C R	R			R	C	C			R	R				C	NZMPI, 2009; NZMPI, 2014
Jasus edwarsii (South Australia)	C R		C R			C		R	C		C		C	C		R		C	SAFMR, 2006; SAFMR, 2007
Jasus lalandii (South Africa)	C R		C		C	C			C	C				C	C R		R		Reg. in Terms of the Marine Living Resources Act, 1998 C. 44
Homarus americanus (Maine, USA)	C R	C R	C[6] R[7]					R			C[8] R[9]		C	C				C	13-188 CMR §§ 25.01 *et seq.*; 12 MRS §§ 6446 *et seq.*

[1] Recreational fishery introduced in 1996, but no creational sector exists (Regulaciones Pesqueras de Cuba 164/1996d; but see Phillips et al., 2000)
[2] Total catch quota shared between 10 management regions
[3] Fishermen may dive or trap for lobsters, but not both
[4] Fishery uses nets instead of traps; number of nets limited per boat
[5] Days at sea limited
[6] A V-shaped notch is fixed on a female before release
[7] A V-shaped notch is fixed on a female before release
[8] Not all management areas are limited entry, but Maine residency always required for license
[9] Maine residency always required for license
C = Commercial and R = Recreational

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4.5 The LAC Process and the Resulting Regulatory proposals

CDFW convened the LAC to facilitate communication and build consensus between various constituent groups and CDFW. The LAC is composed of representatives for the recreational fishermen, commercial fishermen, non-consumptive recreational users, conservation interests, and the various levels of government through. The process included nine regular meetings between June 2012 and September 2013. The process also involved specific communications such as the 2013 Commercial Trap Survey, which allowed members of the commercial fishing community to provide anonymous input detailing their beliefs and concerns regarding their fishery.

During the LAC process, constituent representatives were able to reach substantial consensus pertaining to the CA lobster fisheries, such as recognizing the current distribution of catch between the commercial and recreation fisheries as acceptable. The LAC has also reached consensus on five objectives to guide future allocation considerations for the lobster fishery:

- Identify current effort levels for each sector and establish controls to prevent unrestricted growth.
- Identify the proportion of overall catch and/or effort from each sector, and if necessary, take corrective action to maintain those proportions if the percent of total catch and/or effort by sector deviates significantly from a pre-determined base period.
- Recognize the current differences between sectors in traditional fishing grounds and time-of-day fished, and seek to maintain those differences.
- If increases or decreases to the fishery are required due to application of the control rule, those changes should seek to maintain equitability and not give an advantage to either sector unless biological triggers require a change to allocation.
- End illegal commercialization.

Most importantly, the LAC also formed consensus on several regulatory amendments that would benefit the fisheries and/or the natural resources. These proposals were compiled into a finalized consensus recommendation on September 11, 2013. These proposals will be submitted to the Commission as part of this FMP's implementing regulations.

<u>Commercial trap limit recommendation</u>

In 2013 CDFW mailed a focused commercial lobster trap survey to all lobster operator permit holders (141 transferable and 53 non-transferable permit holders). The survey asked specific questions on individual trap fishing effort and to assess the level of support for a commercial trap limit. A total of 111 permit holders responded with the majority of survey responses (62%) submitted by fishermen who target lobster south of Santa Monica Bay (including Santa Barbara Island, Santa Catalina Island, San Clemente Island, and Cortez Bank). Over 76% of all respondents replied "yes" to the question "do you think there needs to be a trap limit?" Of the respondents who favored a trap limit, 48% wanted a trap limit of 300 traps or less, and 34% wanted a trap limit of 350-400 traps. Other notable responses include a 78% "no" for regional trap limits (northern vs. southern parts of the fishery), 52% responding "yes" to being able to stack two permits to increase their trap numbers under a trap limit, and 67% responded "no" to stacking more than two permits.

The result of this survey was presented to the LAC during the development of the LAC Commercial Trap Limit Proposal. Through consensus, the LAC recommended a trap limit of 300 attached to each fishing permit. The LAC formalized this proposal in part to cap and potentially reduce current effort level. However, the proposal also aims to eventually cap the long-term effort capacity of the commercial fishing fleet at 42,300 traps (141 permits x 300 traps each). Furthermore, each fisherman may stack a maximum of 2 permits. The proposed mechanism will give fishermen the flexibility to fish up to 600 traps each.

Fishermen may receive more tags during a season to replace tags lost during rare and unforeseen catastrophes. The LAC also proposes to allow each fisherman to purchase a one-year temporary permit for 300 more traps while the trap limit fist goes into effect. The permits are designed to give fishermen time to adjust their fishing practices during the initial implementation of the trap limit; they must be repurchased each year from CDFW and will phase out of existence after three years.

The LAC process acknowledged that even with stacking, some existing fishermen, especially those fishing between 600-1,200 traps, will still need to modify their respective fishing practices. However, the interest of these fishermen must be balanced with the risk of pollution due to lost gears, the externalized economic inefficiency impacting the rest of the commercial fleet, and the desire of other fishermen wishing to see fewer traps in the water. The CDFW considers the LAC proposal as an appropriate balance and will recommend it as part of the implementing regulations for this FMP. CDFW also considers the trap limit as an important substantive regulatory proposal from the FMP/LAC process. Unlike the other regulatory proposals listed in this section, the commercial trap limit is an integral part of the HCR. It is also a pro-active initiative aimed to improve the biological, social, and economic sustainability of the CA lobster fisheries.

Permission to carry SCUBA gear on commercial vessels

Existing regulations do not explicitly prohibit SCUBA equipment on commercial lobster vessels. However, regulations do prohibit fishermen from using SCBUA equipment "to assist in the take of lobsters" (14 CCR 122(g)). SCUBA gear is an important tool for recovery of lost traps that otherwise might remain in the marine environment. It can also be used for disentanglement in instances such as when trap lines are caught on a vessel's propeller. Commercial fishermen may use SCUBA for the sole purpose of retrieving lost gear or to unfoul a line form a vessel and it will be illegal to use it for the take of lobster.

More than one permittee may operate from the same vessel

Neither the FGC nor the CCR prohibits two or more holders of lobster operator permits from operating from the same vessel. However, how liabilities are shared between these fishermen in the event of a violation is unclear. As such, the LAC and CDFW propose to explicitly prescribe joint liability for operator permit holders operating from the same vessel in the event of a FGC or CCR violation.

Extended soak time for traps

FGC currently requires all fishermen to service their traps every 4 days (FGC § 9004). The federal counterpart, on the other hand, requires a minimal service interval of 7 days (50 CFR § 660.230(b)(3)). The desire to conform to federal regulation and to provide fishermen with more flexibility in servicing their gear led the LAC to propose a longer soak time for lobster traps. Any potential negative environmental impact brought on by the extended soak time would potentially be mitigated with the proposed trap limit.

Formalize the use of notes in the commercial fishery

Lobster fishermen are allowed to authorize another lobster operator permit holder to pull his or her trap by assigning that permit holder a note. This system was designed to allow one permit holder to pull the traps of another in the event of an emergency, such as sudden illness of vessel breakdown. LAC proposes to formalize the note system with more stringent CDFW oversight in order to minimize potential abuse.

Additional grace periods

The LAC also proposes to extend the grace period for trap deployment before the commercial season opens and grace period for trap retrieval after the commercial season closes. Commercial fishermen are currently allowed to deploy traps in the water 6 days before the season opens. They are also given 6 days to remove their traps from the water after the season closes. However, any trap left in the water during the grace

periods must be unbaited with doors wired open. Fishermen may not bait the traps until 24 hours prior to the season opening, and traps must still be emptied of baits and wired open when season closes.

The LAC considers the current grace period length to be too short. Commercial fishermen tend to over-stack their decks with traps and create hazardous conditions. To decrease the chance of accidents and navigational hazards, the LAC proposes to extend the grace period for deploying and retrieving traps to 9 days. Fishermen are still prohibited from baiting the traps until 24 hours before the season opens, and traps must still be emptied and wired open when the season closes.

Branding of commercial buoys

Existing regulation requires lobster fishermen to have their respective fishing license numbers on their buoys in contrasting colors (14 CCR § 122(k)). Feedbacks from commercial sector representatives suggest that numbers that are branded onto the buoys are just as legible as the ones that are painted. Furthermore, branding does not erode as quickly as paint, which translates to less effort on the part of the fishermen to maintain legibility. For these reasons, LAC is proposing to explicitly allow fishermen to paint their license numbers in contrasting colors or to brand the numbers in a clearly legible form.

Tail clipping/hole-punching

Tail-clipping/hole-punching have been practiced in areas like Australia (which allows for either or), where enforcement officers can use clipping or hole punching to distinguish recreationally-caught lobsters from commercially-caught lobsters. The same can be accomplished in California. This tool is relatively simple to implement and enforce and can help prevent recreationally-caught lobsters from entering the black market.

Prohibition on mechanical hoop net pullers

A prohibition on mechanical hoop net pullers has been proposed to deter poachers from using the pullers to poach commercial traps. However, CDFW is aware of only one recorded incident when a mechanical puller was illegally used to poach a commercial trap, and it is unclear whether this prohibition will in fact reducing poaching. LAC has also proposed to incorporate an exemption for fishermen with disabilities.

Changing the Opening Time for Recreational Season

The midnight opening time for recreational season has led to confusion amongst the recreational fishing community. Concerns over safety were also discussed by the LAC, due to fatalities routinely occurring on opening nights. Furthermore, a midnight opening is more difficult for CDFW to enforce than a day time opening. Because the safety and enforcement issues associated with a midnight opener, the LAC proposes to move the recreational season opener to an alternate time. However, the LAC has expressed concerns over potential economic impact on Commercial Passenger Fishing Vessels.

Marking recreational hoop net floats

The LAC has also reached a consensus on supporting a rule requiring all recreational fishermen to mark all hoop net floats with unique identifications (e.g., individual license numbers, GO ID numbers). This would allow enforcement officers to better identify violations and lost gear.

Clarifying regulatory language on diving for lobsters

A current regulation prohibits the possession of “hooked devices” when diving for lobsters. This has led to different interpretations of the language as well as citation for spearfishermen who were in possession of spear guns while attempting to take lobsters by hand. LAC proposes to clarify the language, remove the reference to “hooked device,” and focus the regulatory language on how lobsters may only be taken by hand when diving. Merely carrying spears while taking lobsters should be legal, while use of them to aid in lobster fishing should remain illegal.

4.6 Management Strategy Evaluation Model (MSE)

An important step that CDFW is taking to further improve the CA lobster fisheries management is the refinement of the **management strategy evaluation model** (MSE). MSE is a sophisticated model that integrates traditional fishery stock models with management measures to predict the effects of those measures. This model incorporates the effects of both the recreational sector and the commercial sector and to provide an estimate of future performance of the CA lobster stock under different sets of management activities.

Management strategy evaluation (MSE) – For the purposes of the spiny lobster FMP, the MSE is a computer model that simulates lobster population dynamics, designed by a team led by Dr. Yong Chen, University of Maine. The MSE will allow CDFW to monitor and evaluate the effects of vetted management measures and the lobster fisheries on the lobster population.

4.6.1 Capability of the MSE

As in most fishery stock models, the MSE incorporates known characteristics of a fish population and its associated fisheries to simulate a virtual population. MSE can be used in that capacity to determine important characteristics, such as abundance, of the CA lobster stock (i.e., perform a stock assessment). The MSE, for example, approaches lobster growth by treating individual growth at molt as an event with a specific probability of occurring, and the probability of growing decreases as individual lobsters age. It does not explicitly adopt a von Bertalanffy growth function, but the resulting growth curve still appears very similar to the ones illustrated in **Error! Reference source not found.**. Likewise, the model uses total MPA coverage to calculate the encounter rate between individual lobsters and lobster fishermen. The encounter rate is then used to determine the fishing mortality of the stock.

However, MSE's capability extends beyond the ability to conduct stock assessments. Once an MSE run has determined the status of the CA lobster stock, it could then apply different hypothetical HCRs to the virtual population and predict the performance of each HCR (e.g., comparing the 10-year yield of an HCR using a $CATCH_{THRESHOLD}$ of 0.8 with an HCR using a $CATCH_{THRESHOLD}$ of 0.7). The model would determine whether any threshold reference point has been reached during each virtual fishing season and apply changes to the stock's fishing mortality accordingly to simulate management actions. The model then records the status of the stock, such as total yield, over multiple fishing seasons (Figure 4-10). CDFW would then be able to assess the merit of different management options using these results.

One notable advantage of the MSE is its ability to refine the catch-based reference point in the future. The model can incorporate a historical-based (*ad-hoc*) reference point generated by user-specified **inputs** (e.g., median catch of year 2001-2008) in accordance with the existing HCR, however, by running simulations of the fisheries based on different level of fishing mortality, MSE can also generate a $CATCH_{THRESHOLD}$ that corresponds to the highest cumulative yield. The MSE currently does not take changing environmental trends into its calculation, though CDFW scientists are attempting to incorporate such considerations into the MSE model.

4.6.2 Incorporating the MSE

The core components of the model were completed in the fall of 2013. However, the model is not yet ready for deployment. Current model outputs exhibit unresolved patterns in residuals and questionable population trends for MPAs, suggesting that it requires further development. While the current version of MSE is able to incorporate all the management measures within the control rule toolbox (Section 4.3.3), it cannot incorporate CPUE and SPR as reference points. The three reference points prescribed in Section 4.3.1 have been vetted with the Commission as well as various fishery scientists and constituent representatives during the LAC process.

As in the refinement of $CATCH_{THRESHOLD}$, MSE can potentially use and refine $SPR_{THRESHOLD,}$ after the program code is modified to provide SPR estimates. In the meantime, CDFW will continue to improve these inputs

with various monitoring efforts, including the effects of new management actions (e.g., at-sea sampling, lobster report cards, landing receipts; Section 5.1.1). If the MSE model is adapted to calculate SPR, CDFW would use the model to calculate a more robust $SPR_{THRESHOLD}$. Alternatively, if one of the reference points used by MSE is found to be a better indicator of the CA lobster stock's ability to replenish itself, the FMP will be amended appropriately to incorporate the new metric.

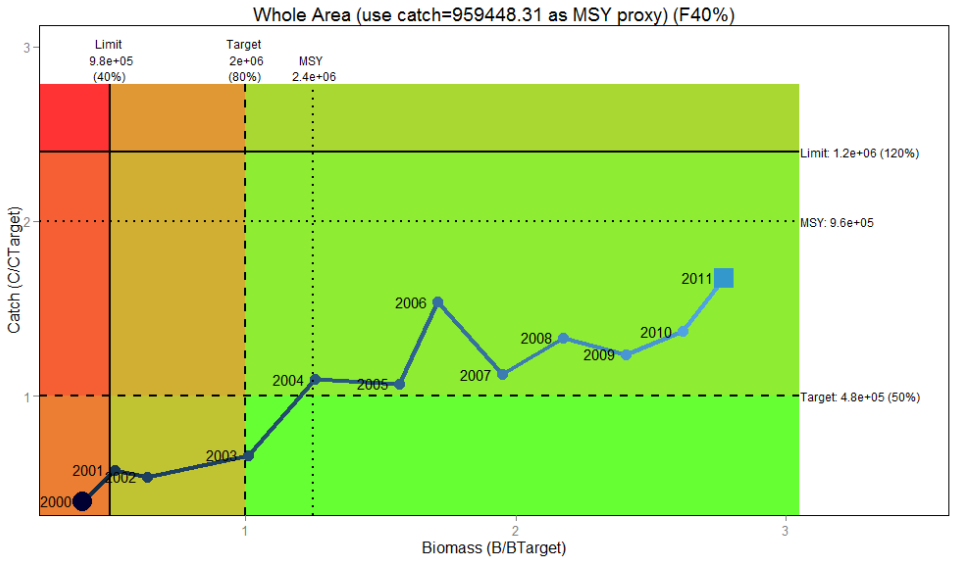

Figure 4-10: An example of an MSE model run using an HCR that bases its reference points on a fishing-season MSY of 959,448.31 lb

Eventually, the MSE has the potential to streamline future management actions for the CA lobster fisheries and reduce administrative uncertainties. More importantly, the model offers CDFW the potential to assimilate and analyze biological and regulatory information much more quickly, which would ultimately serve to enhance the fisheries. Once the model is fully developed, CDFW will make the appropriate recommendations to the Commission.

4.7 Additional Initiatives

This FMP does not preclude future improvement to the HCR or better management alternatives, and the stakeholder community should encourage initiatives that further sustainability and fisheries performance as long as they adhere to the MLMA Master Plan objectives. An example of such measures is a collaborative research partnership (Section 5.3). Members of the commercial fishery and the recreational fishery have the opportunity to form organizations to exchange information and perspectives as well as to represent them during government processes. Fishermen are encouraged to collaborate on their own initiatives and to form community organizations to help inform management. An example of this type of arrangement is the California Sea Urchin Commission. Furthermore, interested parties may wish to work with CDFW and the Commission to develop innovations not explicitly mentioned in this FMP. These can include, but not limited to gear innovations, monitoring tools, regional management, and other technological advances.

4.8 Fitting the FMP into the Big-picture Ecosystem Management

This FMP adopts an ecosystem approach to management. In this context, consideration for factors such as population structure, habitat, trophic interactions, cumulative impacts of the fisheries, and climate change is crucial (COS, 2012). The first part of this FMP is dedicated to the incorporation of information on both the environmental impact of the fisheries (Chapter 2) as well as the ecosystem role of the CA lobster (Sections, 0, 3.7, 0) into the FMP in addition to the information related to the CA lobster's own natural history (Sections 3.1, 3.2, 3.3, 3.5). Next, management measures were considered in the context of other existing state regulatory structure. One of the most notable existing measures is the system of interconnected MPAs that have been established in the SCB since 2012.

On January 1, 2012, the south coast regional network of 50 MPAs, covering 355 square miles or about 15% of state waters, went into effect (including 13 previously established in 2003 at the northern Channel Islands that were retained without change). These MPAs were established to achieve a set of six ecosystem-based conservation goals, most of which are not strictly related to fisheries (FGC §§ 2851, 2853). However, properly managed MPAs have been shown to enhance fisheries under the right circumstances by protecting critical habitats (http://www.dfg.ca.gov/marine/mpa/statistics.asp; Grafton et al., 2006). The MPAs, especially the state marine reserves, makes it unlawful to "injure, damage, take, or possess any living, geological, or cultural resource" unless the activities is part of a permitted research, restoration, or monitoring process (PRC § 36710(a)). Protection of critic al habitat can, for the case of CA lobster, translate to increased spawning potential (Kay, 2011).

Spillover - The emigration of adults from a protected area to the fishing grounds, and/or larval export from the protected area to surrounding areas.

It is current estimated that between 14.6% of all SCB lobster habitats are protected by MPAs (Section 4.3.1.3; assuming that lobster fisheries occur out to 100 m (~300 ft) depth). Refinement of the data, such as analyzing the difference between habitats inside MPAs and habitats outside MPAs, is an ongoing information need (MPA Monitoring Enterprise, 2014). CDFW incorporates this number as well as other MPA specific data (e.g., MPA size, adult spillover, fishing effort adjustment due to MPA) into the calculations of the SPR reference point through the Parrish Model.

A significant number of studies have been dedicated to the effects of MPAs over the past several decades (e.g., Grafton et al., 2006; Roberts et al., 2003). However, information detailing their effects on the CA California lobster fisheries has been sparse. It is known that MPAs can eliminate fishing mortality inside their boundaries, but displace fishing effort and intensify fishing in the non-MPA areas (Beverton and Holt 1957; Guenette et al., 1998; Goñi et al., 2010; Alcala et al., 2005; Shester, 2008). Existing research shows that under the right conditions, MPAs can allow lobsters to reach a larger reproductive size before being caught (Diaz et al., 2011). Past research on a related species of spiny lobster, *J. edwardsii*, further shows that larger females carry more eggs and produce stronger larvae (Smith and Ritar, 2007). If CA lobsters exhibit the same type of improvement in fecundity as they age, and if the southern California MPAs are allowing individuals to grow to a bigger size until being caught, then the MPAs will contribute to the fisheries through enhanced recruitment.

MPAs have also been shown to contribute to lobster fishery yield in outside unprotected areas through movement (adult "**spillover**"). Whether MPAs will contribute to spillover of a fishery depends on a variety of factors, such as the location and size of the MPAs in relationship to the mobility of individual lobsters (Bevacqua et al., 2010; Moland et al., 2013). Furthermore, in an era of global climate change, MPAs are havens where CA lobsters would not be impacted simultaneously from climate change (Section 3.9) and fishing.

MPAs can also almost completely eliminate other ecosystem impacts from commercial and recreational fishing within their boundaries. These include bycatch and trap-habitat interactions. The elimination of fishing pressure in certain areas can also ensure that a portion of the CA lobster stock will grow to a size large enough to enable them to assist with controlling the local urchin population (Section 0).

In addition to the MPAs and the new HCR, measures that have been proven to be effective at keeping the CA lobster stocks at a biologically sustainable level (Sections 2.4) will remain in place. Existing regulations for the recreational industry include the mandatory reporting requirement, minimum size limit, area closures, bag limit, gear restriction, and season restriction. Existing regulations for the commercial industry include the mandatory reporting requirement, minimum size limit, area closures, limited entry, gear restriction, trap specification, and season restriction. On top of the fishery-specific recreational and

commercial regulations, the CA lobster fisheries will also adhere to the Marine Protected Areas (MPAs) regulations.

The management measures and strategies this FMP adopts are thus not designed to independently solve every ecosystem-related issue attributed to the CA lobster fisheries. Instead, the FMP management strategies, the MPAs, and existing management measures all have their respective strengths and weaknesses, and they are meant to complement each other. For instance, while the MPAs can eliminate fishing, and thus all incidental bycatch, within their borders, they are not designed to curtail bycatch elsewhere. This is where existing rules such as trap design specifications and new rules like the proposed trap limit would complement the MPAs and reduce the overall ecosystem impact of the CA lobster fisheries. The HCR, in conjunction with the proposed trap limit, will help control fishing effort and further buffer against unsustainable harvest of CA lobsters. In addition, the HCR will help maintain the role of CA lobster within the nearshore ecosystem as well as the integrity of the associated benthic habitat and minimize impacts to non-targeted species.

While this FMP and existing management measures can complement each other very effectively for the CA lobster and its associated ecosystem, there remains a number of other agencies that have jurisdictions over various aspects of coastal and nearshore areas. For example, the authority to manage coastal development of the state is vested in the California Coastal Commission (PRC §§ 30000 *et seq.*). The Coastal Commission can use the information within this FMP (Section 3.1) to inform its permitting and other regulatory functions to minimize impact to important lobster habitats. The information will also serve as a starting point for intergovernmental collaborations in important future developments.

5. Fishery Research Protocol – Essential Fishery Information

The MLMA requires CDFW to manage fisheries with the best available science, which requires CDFW to collect and maintain the most up-to-date EFI (FGC 7072(b)). Certain categories of EFI relate to the socio-economic aspect of a fishery while others relate to the natural history and biology of the fished species. CDFW must outline how it would obtain missing or outdated EFI within an FMP (FGC § 7082).

5.1 Research and Monitoring Needs for Essential Fishery Information

CDFW has historically relied on its own **fishery-dependent data** to determine the status of the spiny lobster stock and associated fisheries. Improving existing data has shaped CDFW lobster-related research since 2007. Table 5-1 describes the future data needs for managing the CA lobster fishery, including the biological EFI category, their importance, current state of knowledge, and methods for improving them.

5.1.1 Existing CDFW Research Methods

The following methods are already employed by CDFW:

> **Fishery-dependent data -** Information collected directly from or during the process of fishing, or from fishery landing data. May be collected from commercial and/or recreational sources, and may include catch/effort reported by fishermen, size and age composition of the catch, and biological samples collected at port.

Logbooks

Commercial fishermen have been required to record specific information for each fishing trip in commercial logbooks since 1973. A logbook entry must contain the date, fisherman and crew ID, vessel ID, CDFW fishing block, a landmark (typically a shoreline feature or reef) corresponding to the area, the number of legal-size CA lobster retained, and the number of sublegal-size lobsters released. Effort is compiled based on the number of trap pulls or the length of the soak time. Associated landing receipt ID numbers can also be recorded. Each log has room to record 3 days of fishing with up to 5 sets of trap pulls per day.

Commercial landing receipts

Commercial landings have been recorded since the early 1900s on commercial landing receipts. Landing receipts record the date of sale, species(s) landed, port of landing, fisherman ID, vessel ID, CDFW fishing block from which the catch was taken, the price paid, and weight landed. Landing receipts are filled out by fish dealers or by fishermen permitted to sell their own catch.

Correlating commercial logbooks and landing receipts

Information such as the weight and number of lobsters landed by a fisherman on a given day is important for both the management and the enforcement of the CA lobster fisheries. CDFW uses this type of information to obtain the average size of a landed lobster, which is crucial for determining the SPR of the stock. In addition, CDFW can better determine the health of the commercial fishery if a fisherman's catch can be related to the effort expended to obtain those catch. To obtain such information, correlation between commercial logbooks and landing receipts is necessary.

In the mid-1990s, CDFW transitioned from daily logs to new logs that record up to three days of fishing. Unlike the daily logs, which recorded the weights landed on a daily basis, the new logs provide space for the number of legal-size lobsters retained, but not weight. Landing receipts between fishermen and buyers, on the other hand, only record weight (Appendix IV: Sample Logs and Landing Receipt). In order to determine the weight of the lobsters caught on an individual fishing date, CDFW must first identify the landing receipt ID numbers recorded on the log of that particular date. CDFW must then retrieve the specific landing receipt with the corresponding ID.

The current system makes correlating logs with receipts a complex process. For fishermen that sell all of their catch from a single day to one buyer, correlation is straight-forward. CDFW only needs to find the one log and locate the one landing receipt ID number. However, CDFW will not be able to determine the precise weight of the lobster caught on a single day for fishermen that sell multiple days catches to a buyer. CDFW can locate the landing receipt in question, but it has no way of attributing different portions of the landed weight to different days of fishing.

Currently single day trips that are tied to only one landing receipt account for approximately 60% of all logs returned, and CDFW currently bases its SPR calculation from only this portion of the landed lobsters. More sophisticated computer programs can also analyze the correlation between catch totals and landed weights from logs with multiple landing receipts per fishing day, but the process is much more complicated. CDFW proposes to amend the landing receipts to record the total number of lobster purchased as well as the ID number of the corresponding logs.

Recreational lobster report cards

Report cards were introduced during the 2008-09 recreational season and must be purchased by every person fishing for lobster in California, including children and people fishing from piers or people fishing on free-fishing days. Initially, the report cards were valid for a single calendar year and captured data for the last half of a given season and the first half of the subsequent season. Because of the mismatched timing, CDFW could not obtain results from a full season until approximately 15-17 months after the season ended. A new seasonal card introduced for the 2013-14 season can shorten the wait time to 3-5 months following season closure.

Report cards record the date, location, gear type, and number of lobster retained. The report cards can differentiate between 92 fishing areas as of the 2013-14 fishing season. The spatial resolution for coastal

areas south of Pt. Conception is relatively high. However, the Channel Islands are each represented by a single location code, and CDFW's ability to analyze recreational catch patterns is limited. Furthermore, all take north of Surf Beach in Santa Barbara County (up to the California-Oregon border) is represented by a single code (Figure 2-10). CDFW may modify the spatial resolution of the report cards in the future based on management needs.

Types of gear covered include conical hoop net, flat hoop net, skin diving, and scuba diving. However, the cards do not include the number of nets used nor the amount of time spent fishing. In addition, CDFW cannot practically compare the time recreational fishermen spent hoop net fishing directly with the time the community spent diving. Consequently, CDFW uses 'trips', or a single line from the report cards, as the unit of effort. Due to this, as well as low report card return rates, only limited effort comparisons are possible between hoop netting and diving using the report card. Refined data collection of effort could be achieved with two additional columns on the card: the number of nets used (zero if diving) and the total time spent fishing.

Fishery-independent data - Information collected during processes that do not involve fishing (e.g. scientific research) and separately or independent of fishery landing data; may be collected using fishing gear such as trawls or seine nets, or surveys done using acoustics, SCUBA, or video to observe fish. Fishery-independent studies are often difficult and sometimes not feasible to conduct during fishing, such as mark-and-recapture studies to estimate movement, migration, growth rates, and natural mortality.
California Recreational Fisheries Survey (CRFS) - The California Recreational Fisheries Survey (CRFS) is the method for estimating total marine recreational finfish catch and effort in California. The CRFS is a coordinated sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing.

At- sea fishery sampling

At-sea sampling refers to instances when fishermen gather data during normal fishing operation. Such a program has been integrated with other data collection efforts (e.g., observers, **fishery-independent** surveys, tagging studies) to manage the New Zealand rock lobster fishery (Starr and Bentley, 2002; Starr, 2010). California Sea Grant in collaboration with CDFW is currently conducting a pilot project for CA lobster based on a framework developed for the southern California rock crab fishery (Culver et al., 2010) and an earlier effort by CDFW.

The current project collects the same general information as the lobster logs but includes animal size, sex ratio, reproductive condition, shell condition, and trap density, and provides important corroboration for CDFW's logbook data (and vice versa). At-sea sampling programs can also provide more accurate estimates of CPUE. Since this program requires willing and capable fishery participants, and attracting the appropriate candidates requires sufficient incentives, the program's successful adoption would ultimately depend on acquiring the necessary funding in the future.

Creel Sampling

Two creel surveys were undertaken by CDFW targeting the recreational lobster fishery. The data collected included mode (type of fishing platform), gear, number of hours fished, fishing location, number of lobster released, number of lobster kept, carapace length, weight, and sex. The surveys involved intercepting fishermen leaving a site after fishing. Survey sites include launch ramps, piers, jetties, and beach access points.

The first survey occurred in 1992 and targeted lobster fishing during the first two weekends of the lobster season at four sites. The 2007 survey encompassed the entire SCB and was done in preparation for the launch of the recreational lobster report card and sampled three of the four sites sampled in 1992. The 2007 survey also operated at night over the first 12 weeks. The 2007 sites were based on CDFW's long running finfish-oriented **California Recreational Fisheries Survey** (CRFS), which has since incorporated lobsters into its survey program. It is important to note that while most recreational lobster fishermen fish

at night, CRFS sampling only occurs during daytime. CDFW has used the results from these creel surveys to compliment data from the recreational report cards as well as other assessment efforts.

Research trapping

Research trapping programs use lobster traps to sample populations. Research trapping is typically collaborative and takes place onboard commercial fishing vessels. In some instances, scientists trained to use commercial fishing gear can work from research vessels, which can reduce scheduling conflicts among partners, especially when commercial vessels are unavailable (Kay et al., 2010).

Research trapping is a powerful tool because data are collected in a manner that matches fishery-dependent methods, which makes data directly comparable in statistical analyses and stock assessment. Furthermore, traps allow researchers to sample a relatively large number of lobsters not typically possible with traditional research approaches (e.g., scuba). These programs have been employed in California to support MPA monitoring efforts as well as lobster tag recovering efforts in the northern Channel Islands (Kay et al., 2011) and in San Diego (Hovel and Neilson, 2011).

5.1.2 Potential Improvements and Expansions

These methods are currently not being led by CDFW to provide lobster EFI. However, CDFW is a research partner in a number of collaborative projects that include some of these methods led by other institutions.

Baseline scuba sampling

Scuba diving is an essential method for directly observing CA lobster in their natural habitat. A large number of research groups use scuba to monitor reefs in southern California. CDFW scientists are currently working with other academics on a baseline study for CA lobster within southern California MPAs; the study includes a tag/recapture component, scuba surveys, and a habitat mapping/lobster movement component. The scuba survey will be used to determine abundance, density, den occupancy, habitat type, and other ecological information at key locations inside and outside select MPAs.

Port sampling

Port sampling is a method by which samplers meet commercial vessels when they return from fishing and measure some fraction or all of the catch. This is a very efficient and cost-effective method for obtaining large sample sizes. During the 2008-09 fishing season, for example, a single researcher working with commercial lobstermen was able to sample 14 fishing trips from Santa Cruz Island and 17 trips from Santa Rosa Island. The catch sampled during these sampling sessions represented approximately 8.5% and 12.5% of the total 2008-09 catch from the CDFW fishing blocks encompassing Santa Cruz and Santa Rosa Islands, respectively (Kay et al., 2011). Port sampling is ideal for monitoring length frequencies, sex ratios, mean weight of animals in the catch, and condition of animals. CDFW is currently concentrating on the development of an at-sea sampling program to provide information independent of port sampling.

Larval collectors

Larval collectors are man-made devices upon which pueruli settle. They are typically constructed to resemble preferred settlement surface, and are usually deployed in nearshore waters. The utility of larval collection for CA lobster is still uncertain, and further research on larval sampling methodology is needed. The California Cooperative Oceanic Fisheries Investigations' (CalCOFI) zooplankton sampling time series has the potential to reveal more information regarding the abundance and distribution of CA lobster larvae across several decades (Koslow et al., 2012). The project is ongoing and may contribute to the management

of the CA lobster fishery in the future. CDFW is also working to develop collaborations that will model larval transport in the SCB and California Current, which can help determine the sources and the destinations of the lobster larvae across southern California.

Laboratory studies

Laboratory studies are useful for investigating aspects of lobster biology that cannot be studied in the field. Results of laboratory studies must be interpreted with caution because conditions in a controlled lab are inherently different from field conditions, and they are often designed to complement field studies.

Oceanography

Oceanography is a broad field within marine science that focuses on the physical properties and processes of the ocean (e.g., water temperature, salinity, depth, nutrient levels, storm activity, currents, and bottom types). This field of study can directly assess the effects of climate change, ocean acidification, and climate-driven hypoxia on future CA lobster population. Oceanography can also relate the physical characteristics of the ocean to biological processes such as productivity, trophic structure, population connectivity, distribution of larvae, growth rate and distribution of fish stocks, disease outbreak, and other management-relevant issues. Oceanographic data are typically collected with instruments deployed from boats and ships or with satellites; complex modeling is often the mainstay of data analysis.

Genetics

Genetics uses the hereditary material in an organism (e.g., genes coded for by DNA) to help understand a large number of biological processes. Because genes in DNA are passed from parents to offspring, and because certain genes are unique to individuals, populations, or species, they are a powerful tool for studying the relatedness of two or more organisms. This information can provide insight into topics like population connectivity, evolution, and disease susceptibility and resistance.

5.2 Biological EFI: Status, Application to Management, and Methods for Obtaining Data

Chapter 4 of the MLMA Master Plan designates this fishery as data rich for several EFI categories (e.g., growth rates and reproduction) and poor in others (e.g., stock distribution, recruitment). Furthermore, even in areas where the population-wide characteristics are well understood, important details can still be missing. For example, while the average growth rate of CA lobster has been well-studied for some time, regional differences have not been thoroughly explored (Table 5-1).

Age and growth

Accurate age and growth data are essential for CA lobster management. Growth rate can be used to determine the age of maturity or SAM and provide an estimation of the number of spawning seasons a lobster would experience before reaching legal size when coupled with observations of SAM. Published growth rate for *P. interruptus* are highly variable (Section 3.2), and it is unknown whether, or by how much, growth rates might vary through time or from region to region in California. Furthermore, decades of fishing have resulted in a scarcity of older lobster that complicates determination of the species' maximum size.

CDFW currently relies significantly on the information found in existing academic literature to derive lobster growth rates and longevity. CDFW has undertaken new fishery-independent tagging studies in San Diego Bay and South Coast Region MPAs to provide improved and region-specific estimates of growth. These studies rely not only on research trapping to recover tags but also recovery by recreational and commercial fishermen. Commercial fishermen participating in a CDFW at-sea sampling project were also instructed to

record tagged lobster on their data sheets. CDFW will continue to participate in tagging studies that address these critical knowledge gaps.

MPAs also provide researchers with an opportunity to correct for the maximum-size/age related biases associated with fished populations. Due to the recent establishment of reserves (established 2012) it is unlikely that lobster populations inside the reserves will reach pre-fishing conditions for many years (possibly 2-3 decades). CDFW is currently participating in the south coast region MPA Baseline Study in an effort to track the effects of MPAs on lobster populations. The current status of knowledge related to age and growth EFI ranges from poor to moderate. Obtaining better information related to age and growth is a high management priority (Table 5-1).

Stock distribution

The MLMA Master Plan defines stock distribution as "where a stock is found." It is necessary to define the stock distribution because of management implications related to potential biological differences between sub-populations and jurisdictional issues (CDFG, 2001). CDFW currently manages the entire population within the SCB as one population and one stock. The status of knowledge related to stock distribution of CA lobster is currently well-known, but the finer scale distribution is unknown (Section 3.1). The research priority for this EFI is low (Table 5-1).

Ecological interactions

The ecology of CA lobster is discussed in detail in Section 2.1. The species serves as an important scavenger and predator of the southern California kelp forest ecosystem. Predation on intertidal mussels can relief red algae from competition pressure for space and predation on urchins can relief giant kelp from grazing. CA lobster plays an important role in the ecology of rocky reefs, and it is associated with critical habitats such as surfgrass beds. Management should remain aware of information on the ecology and habitat preference of *P. interruptus*, and encourage related ecological research and monitoring.

A number of research programs both independently and in collaboration with CDFW are currently conducting long term monitoring of southern California reefs. These programs provide a valuable service monitoring the condition of *P. interruptus* habitats, prey abundance, predators, water quality, and oceanography. The long list of research groups collecting such data include: the National Park Service Kelp Forest Monitoring Program, the Partnership for the Interdisciplinary Study of Coastal Oceans, Santa Barbara Coastal Long Term Ecological Research Program, the California Current – LTER, individual research laboratories, Reef Check California, the Orange County MPA Committee, and Heal the Bay (Santa Monica). Research protocols and data collected for many of these organizations are available online. This FMP does not link ecological metrics directly to the reference points or the HCR, and future research and monitoring of ecological interactions are a medium level priority for CDFW at this time (Table 5-1).

Indices of abundance

Indices of Abundance - Measurements of the abundance of an organism made over time; used to make inferences about the abundance of an entire population.

Indices of abundance (Catch and CPUE) are used as reference points that link directly to the HCR in this FMP. Indices of abundance are perhaps the most common reference points used in fisheries management, and they are described in detail in Section 4.2.4 and 4.3. CPUE and catch are currently tracked by CDFW data and will be available after each fishing season for the foreseeable future. CDFW is also interested in developing new types of data making new control rules possible in the future. One example of this is CDFW collaboration on direct visual estimations of CA lobster density and abundance with various academic groups. The knowledge regarding Catch and CPUE is rich. Their status as reference points means that the

priority for continued monitoring of these parameters is high. CDFW has moderate information on visual surveys on the sea floor, and its priority is low (Table 5-1). Larval abundance from CalCOFI as well as settlement studies offers prospective abundance indices that may be linked to spawning biomass and/or recruitment. Ongoing research in these areas is a medium priority.

Movement patterns

Lobster movements can be divided into two general categories: 1) seasonal movements related to biological or environmental cues, and 2) more frequent foraging excursions (Section 3.5). Both are important to this FMP because they are mechanisms by which lobsters exit MPAs and become vulnerable to fishing. The spatial scale and frequency of these two movement types require different research approaches.

Lobster movement over longer time periods (i.e., seasonal) can be studied using traditional tag-recapture studies that use individually identifiable (non-signal-transmitting) tags. CDFW has been involved in such a movement study in San Diego Bay in collaboration with San Diego State University. CDFW is also currently involved in a study examining spillover rates as part of the South Coast MPA Baseline Study in collaboration with fishermen, San Diego Oceans Foundation, and Scripps Institution of Oceanography.

Unlike seasonal movements, foraging excursions are best studied using "active" (signal-transmitting) tags that are applied to animals and tracked by researchers. CDFW undertook a multi-year tracking study with San Diego State University to look at lobster movement around San Diego Bay and the Point Loma kelp bed (Hovel & Neilson, 2011). The level of knowledge on movement patterns is moderate, and their priority is medium (Table 5-1). CDFW will continue to engage in independent and collaborative tagging studies.

Recruitment

Larval recruitment and fishery recruitment are two measures that can be useful in projecting the future trend of the fishery. Data that track larval abundance and recruitment can provide powerful information for fisheries management such as: 1) long term trends that provide direct evidence of a stock's ability to replenish itself, 2) the state of the spawning biomass that produces the observed larval abundance (Jacobson and MacCall, 2011), and 3) annual levels of recruitment to predict future catches (e.g., Phillips, 1986; Caputi et al., 1995; Shanks et al., 2010). Spatial pattern of larval abundance also helps define reef areas that are sources or sinks for reproduction of the stock, which can be invaluable for understanding the role of MPAs as conservation tools. For these reasons, many lobster fisheries have data collection programs that track the abundance of larvae using artificial collectors. California has no collector program for CA lobster larvae, but samples collected on annual CalCOFI cruises have been used to explore patterns and processes related to CA lobster larval abundance (e.g., Johnson, 1960a, b; Pringle, 1986; Koslow et al., 2012).

Implementation of a formal CA lobster larval monitoring program can provide valuable information regarding the current and future conditions of the CA lobster stock. The workload would be significant because larval collectors must be sampled frequently (every 1-2 weeks) over the peak settlement period of 4^{+} months. This sampling includes recovery of the collecting devices and laboratory sorting of the contents to count larvae. Such programs are only valuable if they are run nearly every year and over long time spans. In addition, the most appropriate type(s) of collectors for CA lobster need to be identified. Thus, a larval recruitment monitoring program represents a significant long-term investment, and CDFW would need to identify the resources necessary to conduct this monitoring. Lastly, some lobster fisheries have experienced stock fluctuations that larval recruitment data did not predict (Linnane et al., 2013a; Koslow et al., 2012).

A larval monitoring program that has the resolution to define larval sources and sinks can aid management, but would require a large number of larval collectors throughout the SCB and the associated cost can be

significant. Such an approach would ideally be coupled with genetic studies that help identify the origins of settling larvae. An alternative to larval collection is to use oceanographic models of currents to estimate the locations of the population sources and sinks. Such a model was used to evaluate MPA network designs during the MLPA process in southern California. Development, refinement, and application of such models have not occurred within the context of CA lobster fishery, but CDFW will continue to explore this tool.

Monitoring fishery recruitment (growth of sublegal-size lobsters to legal size) allows for predictions of fishery yield for upcoming seasons, and provides assurance that reproduction has been successful in previous years (i.e., during the year(s) that current fishery recruits hatched and settled). Trends in sublegal-size abundance are used as reference points in some lobster fisheries (e.g., ASFMC, 2009). These data are inexpensive when collected in logbooks, but often do not reveal how many times individual lobsters are caught, released, and recaptured. Fisheries that use sublegal-size abundance to estimate fishery recruitment usually have dedicated survey programs for collecting these data. Current knowledge regarding recruitment is from poor to moderate. Obtaining better information on the stock's sublegal-size abundance is one of the highest priorities for management, while information regarding larvae has medium priority (Table 5-1).

Reproduction

Size and age at maturity are important parameters for both the Parrish model and the MSE model. Determining this parameter has primarily been based on observing berried females found in fishery harvests and research trapping. Recent CDFW measurements during tagging studies suggest that SAM is smaller than previously thought. How this parameter varies regionally is unknown. Fecundity of large female lobsters such as those inside MPAs has also not been thoroughly sampled. For these reasons, determining variability across regions is a future goal. State of knowledge on CA lobster reproduction is moderate, and the priority for obtaining better information is high (Table 5-1).

Total Mortality

Total mortality is the rate at which fish die, and it can be separated into two components: 1) **natural mortality** (causes include predation, disease, and old age), and; 2) **fishing mortality**. Natural mortality is a critical parameter in biological models used in stock assessment. Published estimates suggest that natural mortality for CA lobster is similar across individuals, and they are consistent with estimates for other temperate spiny lobster species. Little is known about the natural mortality associated with juveniles. Factors that affect natural mortality include ocean temperature, oceanographic regimes (e.g., PDO, El Niño), reef-specific ecology, habitat characteristics, and existence of MPAs (Kay and Wilson, 2012). Approaches for estimating natural mortality include tag-recapture and examination of populations in MPAs.

Total mortality - Natural mortality and Fishing mortality combined.
Natural mortality (M) - The rate at which organisms in a population die due to natural causes.
Fishing mortality (F) - The rate at which organisms in a population die due to fishing.

Fishing mortality (*F*) is an estimate of the rate at which fish are caught. A harvest rate (*u*) can be calculated directly from *F*, and it is the percentage of the legally harvestable fish stock that is caught in a fishing season (Section 4.1). Fishing mortality (and, harvest rates) lie at the core of this FMP. F directly links to the MLMA objectives (Table 5-1), reference points determined or used by the FMP models, and any control rule described by the FMP. A major emphasis of this FMP is focused upon the identification and management of harvest rates that avoid/minimize recruitment overfishing, economic overfishing, and ecological impacts. Available estimates for mortality range from poor to moderate and are adequate for modeling purposes.

However, accurate and region-specific estimations of fishing mortality rates are central to accurate model runs, and are thus the highest research priorities identified in this FMP (Table 5-1).

Other EFI –Stock Composition

The models proposed by the CA lobster FMP to produce reference point data would benefit from additional EFI not explicitly listed in the CDFW Master Plan. CDFW may include any biological information that is "necessary to permit fisheries to be managed [sustainably]" as part of a fishery's EFI (FGC § 93). Additional EFI to improve modeling includes **stock composition**. Stock composition generally refers to the size composition (**length frequency distribution**), abundance, and sex ratio of a stock. Better information on the spiny lobsters' stock composition can provide a useful and independent corroboration to CDFW's other assessment efforts.

Length frequency distribution gives CDFW a way to corroborate calculations of growth rate, fecundity, and mortality. However, the assumption that length frequency data derived from commercial landings would accurately represent the length frequencies of natural populations holds true only if lobsters of all sizes have an equal chance of entering and remaining in traps or other fishing/sampling gear. Otherwise, the true population size composition will be misrepresented in any data based on traps. To compensate for potential bias within the landings database, CDFW currently supplements its length-frequency data with samples from research traps, gill nets, and SCUBA that are part of the collaborative South Coast MPA baseline study. California Sea Grant's at-sea sampling pilot project and creel sampling would also provide more accurate length frequency distributions. At-sea sampling currently has several advantages over port-sampling: 1) higher spatial resolution; 2) sublegal-size lobsters are measured; and 3) bycatch can be recorded.

Abundance of the legal-sized individuals can help assess present harvest rate and future catches. CDFW has calculated legal-size lobster abundance based on CDFW-collected commercial catch data in the past, but these estimations have relatively coarse spatial resolution. Finer geographical-scale estimations have also been made (e.g., Hovel and Neilson 2011; Kay et al. 2011; Iacchei et al 2005). CDFW has participated in new local studies to help fill the gaps between the previous studies, especially those pertaining to the southern portion of the bight.

The number of sublegal-size lobsters captured by the commercial fishery is being recorded in logbooks, and with improved tagging studies, comparisons of sublegal-size abundance across space and time can be adjusted to more accurately reflect the abundance of sublegal-size lobsters. The sex ratio of the stock is also largely unknown. Better sex ratio information can be used to improve model runs. CDFW is not planning any new monitoring effort to directly obtain information on stock sex ratios, but future MPA surveys and Sea Grant's at-sea sampling program are expected to provide this information.

In addition, research that describes invertebrate population changes in California MPAs is also an ongoing priority within CDFW to inform adaptive management of the State MPA network. MPAs affect lobster stock composition by producing large and localized increases in lobster average size and abundance inside reserve borders (Diaz et al., 2011). New information on the cumulative biomass and reproductive potential of the lobsters inside reserves can then be incorporated into the estimates for *F*, SPR, or other measures of stock size used in this FMP. CDFW's information on these parameters ranges from poor to rich, and obtaining better information is of the highest priority. This effort will potentially span decades as various components of the coastal ecosystem rebuild to pre-exploitation level.

Stock Composition - Any description of the population attributes of a stock (age, size, sex), usually within a spatial context. This commonly refers to the spatial distribution of breeding groups or genetically-related organisms.
Length frequency distribution - A graphical representation of the number of organisms by length.

Other EFI – Habitat Coverage by Type

An accurate estimation for the total percentage of CA lobster habitat that is contained within MPAs is one of the most important inputs for the calculation of SPR (Section 4.3.1.3). CDFW obtained the current estimate by calculating the percentage of shallow hard-bottom habitats (0-100 m depth, 0-328 ft) that are protected by MPAs prohibiting both commercial and recreational take. This estimate utilizes the maximum extent of kelp canopy as a proxy for hard-bottom habitat in areas where seafloor mapping data are not available. Incorporation of other habitat types such as tidal flats and eelgrass beds is currently not appropriate either because it is unclear whether CA lobsters actually utilize these areas as habitats or because there is limited spatial data detailing the extent of these areas. Overall CDFW possess a moderate amount of information related to habitat coverage and better assessment of these areas is of the highest priority (Table 5-1). CDFW will continue to incorporate new information to both better calculate the current state of the population's spawning potential as well as to better estimate the baseline condition during the period of stability in the early 2000s, which is necessary to improve the $SPR_{THRESHOLD}$.

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Table 5-1: Categories of EFI identified by the MLMA Master Plan and specific data types identified by this FMP that are within each EFI category

Biological EFI Category (MLMA)	Specific data types used in fisheries management	Current status of knowledge *(poor, moderate, rich)*	Priority for management and FMP *(low, medium, high, highest)*	Data collection methods												
				Logbooks	Landing Receipts	Rec. report cards	At-Sea Sampling	Port sampling	Creel sampling	Research traps	Research SCUBA	MPA monitoring	Larval collectors	Lab studies	Oceanography	Genetics
Age and growth	Individual growth rates	moderate	high				S	S	S	P		P		S		
	Longevity (max age and size)	poor	high									P				
Stock distribution	Catch relative to fishing blocks	rich	low	P	P					P		S			S	
Ecological interactions	Role as predators (e.g., to control grazers)	moderate	low								P			S		
	Essential habitat (e.g., surfgrass / shelters)	rich	medium								P			S		
Indices of abundance	Catch (per season)	rich	**highest**		P	P			P							
	CPUE	rich	**highest**	P		P	P			P						
	Visual surveys on seafloor	moderate	low								P					
Movement patterns	Seasonal/annual movement distances	moderate	medium				P			P						
	Nightly foraging distances	moderate	medium							P	P					
Recruitment	Source and sinks for larvae	poor	medium										P		P	P
	Larval abundance and recruitment	moderate	medium										P		P	
	Sublegal-size lobster abundance	poor	**highest**	P			P			P	S		S			
Reproduction	Size at maturity (SAM)	moderate	high				P			P		S		P		
	Fecundity	moderate	high							P		S		P		
Total mortality	Natural mortality	moderate	high							P		P				
	Fishing mortality (harvest rates)	moderate	**highest**	S	S		P			P		P				
	Handling mortality and sublethal impacts	poor	medium							P	P					
Stock composition	Size structure of stock (length frequency)	moderate	**highest**				P	P		P		P				
	Selectivity of length frequency sampling gear	poor	**highest**							P		P				
	Mean size of lobsters in catch	rich	**highest**	P	P		P	P		S						
	Effects of MPAs on size and abundance	moderate	**highest**				S			P	S	P				
Habitat coverage	% of a habitat type covered by MPAs	moderate	**highest**				P			P	P				S	

For each data type, descriptions are provided for the current status of knowledge and the priority of improving data collection for management under this FMP (i.e., importance for assessing, monitoring, and maintaining sustainability of the fishery). Finally, data collection methods that are best suited to obtaining each data type are indicated. (P = primary data source; S = secondary data source).

5.3 Socioeconomic EFI: Update on the 2013 Economic Report

The purpose of socioeconomic EFI is to help inform CDFW of the social and economic impacts of potential regulatory actions (CDFG, 2001). The FMP Master Plan characterized the CA lobster fishery as data poor back in 2001. Various socioeconomic aspects of the fishery have since been analyzed first in a 2009 report and again in 2013 (Hackett et al., 2009; Appendix VI: Economic Report; Section 2.5). CDFW will continue to pursue similar studies in the future to update established knowledge and fill any knowledge gaps. In particular, future survey efforts should track the popularity of hoop nets as well as improve estimates on groups that have been sparsely sampled in previous socioeconomic surveys (Section 2.5).

Employment

The commercial CA lobster fishery was responsible for 323 full-time equivalent jobs during the 2011-12 fishing season. The commercial fishery was also responsible for a total economic effect of over $22 million in southern California over the same fishing season (Appendix VI: Economic Report). Analysis of the economic effects of the recreational fishery has not been done.

Expenditure

Analysis of the expenditures for both the recreational and the commercial fisheries during the 2011-2012 fishing season indicate that the Commercial fishery expended ~$10.5 million and the recreational fishery expended ~$40.8 million.

Resource Demand

The FMP master plan defines resource demand as "the relationship between the quantity and quality of a good or service, and demand by the user at various market price or cost" (CDFG, 2001). Neither the 2009 nor the 2013 reports on the CA lobster fishery focused on this particular issue. However, recent increase in foreign demand and the associated rise in ex-vessel value for CA lobster show that better analyses on market demand may become increasingly important for effective fishery management.

Revenue

Revenue includes revenue from both sales conducted within the coastal community and sales through exports (CDFG, 2001). The ex-vessel value of lobsters landed in the 2011-2012 fishing season was estimated at ~$12.9 million. The revenue earned by supporting industries (e.g., boatyards, trap makers, etc.) is also part of the economic impact of the commercial fishery, and it has been estimated to be just under $5 million per year between the 2009-10 and the 2011-12 fishing seasons (Appendix VI: Economic Report). However, as with the employment EFI, revenue for the supporting industry of the recreational fishery has not been calculated, and at this point can only be inferred from the sector's expenditure.

User/Industry Demographics

The demographics of the current commercial fishermen have not been analyzed. However, 86% of the recreational fishermen come from zip codes that are within 50 miles of the coastline (Appendix VI: Economic Report). Sport fishermen from further inland spend a disproportionately higher amount of money on their recreational trips (Appendix VI: Economic Report).

5.4 Cooperation and Collaboration in Fisheries Research

Globally, involvement of multiple stakeholders in fisheries research (e.g., the collection of fishery-dependent EFI) is increasing as researchers, managers, and fishermen expand communications and partnerships. The level and type of this involvement by stakeholders can differ widely. Research that involves stakeholders in some specific aspect of the project is considered as cooperative research. In cooperative research, each stakeholder may focus their resources on one aspect of the research or may work jointly on one or several parts of the project (e.g. collecting data aboard a vessel provided by another stakeholder). Collaborative research, like cooperative research, brings stakeholders together to work towards a common goal. However, true collaborative research also involves stakeholders during all phases of research including hypothesis generation, data collection, and interpretation of results (NRC, 2004; Wendt and Starr, 2009).

Wendt and Starr (2009) add the caveat that true collaborative research also includes a joint intellectual effort during all phases of the research. While the distinctions between these two types of research are conceptually distinct, in most cases multi-stakeholder research is neither purely cooperative nor purely collaborative, but a continuum between the two as determined by the specific stakeholder involvement (NRC, 2004).

Cooperative and collaborative fisheries research (CFR) hold significant potential to improve fishery management by increasing the quantity of data collected (Karp et al., 2001; NRC, 2004) as well as improving communication, understanding, and trust between managers and stakeholders (McCay and Jentoft, 1996; Conway and Pomeroy, 2006; Wendt and Starr, 2009). In cases where the knowledge and skill of the stakeholders is successfully incorporated, CFR can also result in increasing the quality of data collected (NRC, 2004; Wendt and Starr, 2009).

While these benefits can be significant, they must also be weighed against the cost of conducting CPR. Elements for evaluating and prioritizing CFR include the expected benefits, the expected research costs, and the expectations for success (NRC, 2004).

Fishery participation in data collection and management is an integral part of some lobster fisheries (Phillips and Kittaka, 2000). In certain fisheries, industry participation focuses mostly upon CFR, in large part because it is cost-effective. However, because of its tight links to co-management, CFR can provide a bridge to locally-based co-management systems that may increase fishery sustainability (Wilson et al., 2003; Gutiérrez et al., 2011). Consequently, industry participation in other fisheries includes co-management arrangements in which industry directly participates in structuring harvest regulations. Important examples of lobster fisheries with CFR and co-management agreements include *P. interruptus* in Baja, Mexico (Scientific Certification Systems, 2011; Phillips et al., 2013), *H. americanus* in Maine (ASMFC, 2009; Acheson and Gardner, 2010), and *J. edwarsii* in some fishing communities in New Zealand (Miller and Breen, 2010).

6. Implementation and Amendment Process of the FMP

6.1 Implementation

The implementation of this FMP can be divided into 3 categories: enforcement, research and monitoring, and management.

6.1.1 Enforcement

CDFW Law Enforcement Division (LED) officers patrol the coast and offshore islands off Southern California on a daily basis. They also conduct inspections of landings, wholesale and retail facilities,

restaurants, and vehicles used to transport fish. These officers serve to ensure compliance with CDFW regulations, including the ones that will result from this FMP, through both education and enforcement actions. They also collaborate with CDFW scientists to conduct research activities, participate in management activities, and provide on-the-ground information to management.

6.1.2 Research and Monitoring

Chapter 4.8 outlines and discusses how CDFW will continue to monitor the CA lobster fisheries and to improve upon the existing state of knowledge regarding the fisheries and the species. These efforts include both primary research aimed at obtaining and refining the essential fishery information as well as periodic monitoring of fishery-dependent data, such as information generated from the recreational lobster report cards and commercial landing receipts and logbooks.

6.1.3 Management

The Marine Life Management Act requires that "[f]ishery management decisions are adaptive and are based on the best available scientific information and other relevant information" (FGC § 7056(g). Furthermore, management systems should be periodically reviewed for its effectiveness and fairness (FGC § 7056(m)). The CDFW will analyze and act on the results of research and monitoring efforts as appropriate to better inform the management framework outlined in the FMP. The ongoing and potential research efforts described in the previous chapter are expected to yield new useful information regarding the CA lobster stock and fisheries.

By design, the HCR is adaptive in nature. The ocean is a dynamic environment, and requiring very specific action could lead to improper management responses. The HCR directs CDFW to investigate the underlying causes of any significant change to the threshold reference points. Refinement with the most up-to-date information will always be part of this process, as will active solicitation of input from stakeholders in interpreting the data. Once the underlying cause of a change is identified, CDFW will undertake analysis (e.g., using the MSE model, constituent input, etc.) to determine the most appropriate course of action.

CDFW will continue to seek input with the various constituents as appropriate. CDFW will also bear the primary responsibility of conducting other future amendment processes. To facilitate active oversight and proactive management, CDFW projects that CA lobster management will require two full-time dedicated scientific staff positions and one scientific aid position in the future. The scientific staff will be responsible for overseeing the commercial data collected from the trap logs and the landing receipts and the recreational data collected from the lobster report cards. The staff will also be conducting and coordinating future research and public outreach efforts. The two scientists will also be responsible for monitoring the threshold reference points and advising CDFW management of the status of the fisheries and the stock.

6.2 Adjustment and Amendment to Administration, Regulations, and the FMP

Under the FGC, each FMP "shall include a procedure for review and amendment of the plan, as necessary" (FGC § 7078). In particular, an FMP shall specify the type(s) of regulations that CDFW can adopt without amendment(s) to the FMP (FGC § 7087(b)). On top of the type of regulations that can be adopted without an FMP amendment, this section will also prescribe the conditions of changing the FMP. This section does not apply to routine day-to-day CDFW operations.

6.2.1 Regulatory Amendments that Do Not Warrant FMP Amendments

The Commission can adopt new regulation concerning the CA lobster fishery without amendment to the FMP. These may include regulations designed to improve the orderly operation of the fisheries or more

efficient conservation of the relevant resources. The LAC recommendations are examples of these regulations. This section does not modify CDFW's and the Commission's power to promulgate regulations during emergencies (e.g., FGC § 240, GC § 11349.6).

6.2.2 When and How FMP Will Be Amended

If new, relevant information becomes available, an FMP amendment based on that information may be appropriate. Any amendment that would affect an existing regulation or requires new regulations would be accompanied by a regulatory amendment proposal for the Commission.

CDFW may propose an FMP amendment out of its own initiative and discretion. In this case, CDFW will solicit opinions from the public and the Commission. CDFW will also provide the public with relevant schedule and agenda. The public will have at least 30 days to review the proposal prior to the hearing. CDFW may submit the proposal to the Commission after 30 days, or it may hold further public meetings before submission (see also FGC § 7077). Interested parties may also propose plan provisions or amendments to either CDFW or the Commission. Existing CDFW and Commission workload and priorities may affect the timeliness of the Commission's response to petitions.

An FMP amendment can be focused on a particular part of the document; an amendment process should not automatically trigger the amendment of the entire FMP. However, an amendment on one part of the FMP should not contradict another part. Adopting a new type of reference point not contemplated in Section 4.3 HCR is one example. Changing or replacing a threshold reference point should not automatically trigger a review of the entire natural history of the CA lobster, but such a change must not contradict other parts of the HCR that are not being amended.

6.3 List of Inoperative Statutes

The implementing regulations of this FMP will render the following section of the Fish and Game code inoperative once they are adopted:

1. FGC § 8251: This section dictates the season length for the commercial CA lobster fishery. The HCR prescribed by this FMP incorporates changes to season lengths as a possible management adjustment.
2. FGC § 8252: This section prescribes the size limit for the commercial sector, which is identical to the recreational sector limit found in the CCR. The limit will be moved into the CCR to give the Commission authority to make adjustment.

This FMP will render the following sections of the Fish and Game code inoperative as applied to only the CA lobster fisheries once the implementing regulations are in place:

1. FGC § 9004: This section requires commercial fishermen to service any deployed trap every 96 hours. However, 14 CCR § 122(n) specifically allows lobster fishermen to deploy unbaited traps more than 4 days before the season opens. Requiring fishermen to service unbaited traps is counterproductive. As such, this section will be rendered inoperative as applied to CA lobster fisheries.
2. FGC § 7857: This section prohibits CDFW from issuing more than one of a single type of permit, including a lobster permit, to a single fisherman. The trap limit program envisioned by the FMP may allow fishermen to stack multiple permits, and thus this section will be rendered inactive.

6.4 Amended Regulations

During the LAC process (section 4.5), several regulatory amendments were discussed. These amendments are meant to address some existing issues within the fisheries as well as to implement part of the HCR management scheme. The following is a list of California Code of Regulation sections that will be amended once the implementing regulations for this FMP are in place:

3. 14 CCR § 1.76: This section currently defined "spearfishing" as including capturing fish with hands. This definition confounds with the requirement that sport fishermen can only take lobsters via hands while diving. The LAC propose to have the "or hand" in this section removed.
4. 14 CCR § 29.80(g): This section forbids divers from taking lobsters other than by hands. However, the section then goes further and explicitly forbids "hooked devices." LAC proposes to have the reference to "hooked device" stripped and further clarifies that a recreational diver while spearfishing may opportunistically take lobsters as long as the spear is not used in the capture of the lobsters.
5. 14 CCR § 29.90: LAC has also proposed to change or at least clarify the start time of the recreational season.
6. 14 CCR § 29.91: As part of the effort to enhance data gathering from the recreational fishery, CDFW plans to require fishermen to record the number of hours spent fishing on a trip as well as number of nets used if the fisherman is uses hoop nets
7. 14 CCR § 122(a): In order to implement the trap limit envisioned in the HCR, a new class of temporary permit is proposed to help ease the commercial fishery for transition
8. 14 CCR § 122(g): This section forbids commercial fishermen from using SCUBA equipment "to assist in the take of lobster." LAC has proposed to amend this language to allow fishermen to use SCUBA equipment to clear entanglement and recover traps.
9. 14 CCR § 122(l): This section allows a licensed fisherman with valid lobster permit to service the trap of another permitted fisherman under specific conditions. The section will be modified to provide a more formal structure for the process.
10. 14 CCR § 122(k): This section will be modified to allow commercial fishermen to brand their commercial buoys with their identification numbers in lieu of painting the numbers, provided that the branding is legible.
11. 14 CCR § 122(n): This section currently gives commercial fishermen 6 days before the start of a season to deploy unbaited gear and 6 days after the end of a season to retrieve deployed gear. Because of the impending trap limit, the threat of overdeployment is minimized. LAC has recommended extending the grace period to 9 days to further minimize safety hazards.

DRAFT

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Personal Communication

Culver, Carolynn. Sea Grant Advisor/Research Scientist. Marine Science Institute, University of California, Santa Barbara. Santa Barbara, CA.

Matthews, Thomas. Fishery Biologist, Florida Fish and Wildlife Conservation Commission. Tallahassee, FL.

Renzullo, Jennifer. Field Manager, CA Lost Fishing Gear Recovery Project. UC Davis Wildlife Health Center. Davis, CA.

Salazar, James. Owner, Saba Slayer Kayak Fishing Guide Service. Rolling Hills Estates, CA.

Appendix I – Letter to Tribes

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State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Santa Barbara Field Office
1933 Cliff Drive, Suite 9
Santa Barbara, CA 93109
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

October 10, 2013

Name
Title
Business
Street Address
City, STATE Zip

Dear Honorable [FILL IN FULL NAME], Chairperson:

The California Department of Fish and Wildlife (Department) would like to inform you as a tribal representative that its Marine staff will be writing and compiling a Spiny Lobster Fishery Management Plan (FMP) over the next several months. The Department would like to know if spiny lobster is a culturally significant species to your Tribe, and, if so, if you would like to provide input into the development of the FMP or to seek government-to-government consultation with the Department about the FMP and the management of the spiny lobster fishery.

The Marine Life Management Act requires that the fishery management plan shall form the primary basis for managing California's commercial and sport marine fisheries. The spiny lobster supports important commercial and sport fisheries in southern California, and this FMP will ensure the continued health of the lobster fisheries in California.
The FMP will summarize all the readily available information on spiny lobster and its fisheries including: lobster natural history and population dynamics; fishery landings, regulations, and participants; current management and conservation measures; monitoring of the fisheries; essential fisheries information that is still needed; and a harvest control rule(s) should the lobster resource show signs of being overfished.

The Department has received suggestions and recommendations from various stakeholder groups, and has worked with a Lobster Advisory Committee that was created last year to develop recommendations. The lobster FMP website is: http://www.dfg.ca.gov/marine/lobsterfmp/ .

The Department understands that the spiny lobster fishery may be of interest to some tribes in California, and the Department is soliciting input from tribes. The Department is also committed to understanding tribal interests, if any, relating to the spiny lobster fisheries in southern California before the draft FMP is completed. Next year, the draft lobster FMP will be peer reviewed both scientifically and by the general public. While tribes can provide comments on the spiny lobster FMP at that time, the Department would like to understand tribal interests early in the process.

The Department would welcome your preliminary input on southern California's spiny lobster resource and fisheries by November 15, 2013, so that it might be considered when writing the draft FMP. Please send your comments to Ms. Kristine Barsky, Senior Marine Biologist and Lobster FMP Coordinator, via email at Kristine.Barsky@wildlife.ca.gov or to the address above. If you would like more information on

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the lobster FMP, or would like to set up either an informal informational meeting or a formal government-to-government consultation, please contact Ms. Barsky at (805) 985-3114.

We look forward to receiving your comments.

Sincerely,

Craig Shuman
Manager of the Marine Region

ec: Steven Ingram, Senior Staff Counsel and Tribal Liaison
Office of the General Counsel
Department of Fish and Wildlife

Sonke Mastrup, Executive Director
California Fish and Game Commission

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Tribes contacted for the Lobster FMP process

Tribe Contacted	Representative Contacted
Costanoan Ohlone Rumsen Carmel Tribe	Chief
Fernandeno Tataviam Band of Mission Indians	President
Gabrieleno/Tongva San Gabriel Band of Mission Indians	Chairperson
Gabrielino Tongva Nation	Chairperson
San Fernando Band of Mission Indians	Chairperson
Tehachapi Indian Tribe	Spokesperson
Juaneño Band of Mission Indians	Chairperson
Juaneno Band of Mission Indians Acjachemen Nation	Chairperson
Juaneno Band of Mission Indians Acjachemen Nation	Chairman
Barona Group of the Capitan Grande	Chairperson LaChappa
Campo Kumeyaay Nation	Chairperson Gofs
Ewiiaapaayp Tribal Office	Chairperson
Inaja Band of Mission Indians	Spokesperson
Jamul Indian Village	Chairperson
Kwaaymii Laguna Band of Mission Indians	Spokesperson
La Jolla Band of Mission Indians	Chairperson
La Posta Band of Mission Indians	Chairperson
Los Coyotes Band of Mission Indians	Spokesperson
Manzanita Band of Kumeyaay Nation	Chairperson
Mesa Grande Band of Mission Indians	Chairperson
Pala Band of Mission Indians	Chairperson
Pauma Band of Yuima	Chairperson
Rincon Band of Mission Indians	Chairperson
San Luis Rey Band of Mission Indians	Chairman
San Pasqual Band of Mission Indians	Chairperson
Santa Ysabel Band of Diegueno Indians	Spokesman
Sycuan Band of the Kumeyaay Nation	Chairperson
Northern Chumash Tribal Council	Spokesperson
Salinan Tribe of Monterey & San Luis Obispo Counties	Chairperson
Coastal Band of the Chumash Nation	Chairperson Cordero
Santa Ynez Band of Mission Indians	Chairperson
Viejas Band of Mission Indians	Chairperson

Appendix II – Executive Summary of the Constituent Involvement Plan

This Constituent Involvement Plan details the activities that will be conducted to involve constituents and participants in the development of the Spiny Lobster Fishery Management Plan (FMP). The FMP is being developed for the spiny lobster fishery by the California Department of Fish and Game as required under the Marine Life Management Act of 1998. An important part of the act is the good faith effort to involve all interested parties in resource management decisions through the dissemination of accurate information and collaboration.

I. Points of Input for Constituents

The Department uses a number of avenues to engage the public in development of the Spiny Lobster Fishery Management Plan (FMP).

Lobster Advisory Committee

- The Advisory Committee is a collaborative body of representatives from major constituencies that provides the Department with advice, recommendations, and feedback regarding actions that need to be taken during the development of the FMP. The Advisory Committee will give guidance on FMP objectives and end products, as well as provide ideas on content and management options that address the key issues put forth by constituents, members of the public, and our contractors. The Committee will review draft documents generated during the FMP process, and will provide feedback on content.

- CDFW ensured that the composition of the Lobster Advisory Committee reflects the diversity of interests and complexity of the California spiny lobster fishery. The Committee is made up of twelve members and five alternates, as follows:

- Rodger Healy (Commercial Fishing Member)
- Jim Colomy (Commercial Fishing Member)
- Shad Catarius (Commercial Fishing Member)
- Josh Fisher (Commercial Fishing Alternate Member)
- Jim Salazar (Recreational Fishing Member)
- Michael Gould (Recreational Fishing Member)
- Al Stasukevich (Recreational Fishing Member)
- Paul Romanowski (Recreational Fishing Alternate Member)
- Lia Protopapadakis (Marine Science Member)
- Kevin Hovel (Marine Science Member)
- Jono Wilson (Marine Science Alternate Member)
- Sarah Sikich (Environmental Organization Member)
- Huff McGonigal (Environmental Organization Alternate Member)
- Sean Hastings (Federal Agency Member)
- David Kushner (Federal Agency Alternate Member)
- Claudette Dorsey (Non-Consumptive Recreational Member)
- Chris Grossman (Non-Consumptive Recreational Member)

Lobster Advisory Committee Schedule

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Note: The **June 20, 2012** meeting was held at the CDFW office in Los Alamitos at 9:00 AM to 4:00 PM. The date for this meeting is firm, and all **LAC members** and **alternates** must attend.

Meeting Dates:

- **June 20, 2012, Los Alamitos (9:00 AM to 4:00 PM)** – LAC Charter and Ground Rules development, Timeline for FMP, List of Lobster FMP Issues, FMP Conceptual Framework, Comments from Public Meetings, and Review of Draft Fishery Overview Chapter
- **August 1, 2012** –Review Summary of Management Options.
- **December 5, 2012** – Discuss findings of Economic Profile Report, and Comments on Draft Fishery Management and Conservation Chapter.
- **April 10, 2013** – Discuss poaching issues and recreational fishery management
- **June 12, 2013** – Review Comments from Public Management Options Meetings.
- **July 10, 2013** – Discuss and evaluate fishing management options
- **August 15, 2013** – Review Management Strategy Evaluation Results.
- **September 11, 2013** – Finalize consensus for recreational fishing management measures, discuss and evaluate the harvest control rule, and identify monitoring and research priorities and funding mechanisms
- **2014 (to be scheduled)** – Comments on Final Draft of FMP Document (Final LAC meeting).

Schedule for Public Meetings

Public Information Meetings

Description (both dates and locations): The purpose is to introduce the Lobster Fishery Management Plan (FMP) process, and explain what an FMP is and what it is not. CDFW will also discuss the general timeline for FMP completion. The majority of this meeting will focus on gathering information from members of the public regarding the issues or management concerns that need to be addressed during the FMP process.

Dates and Locations:
Wednesday, April 18, 2012
Oxnard Performing Arts and Convention Center
800 Hobson Way
Oxnard, CA 93030
http://www.oxnardpacc.com/directions.html

Thursday, April 19, 2012
Grand Pacific Palisades Hotel
Auditorium
5805 Armada Dr.
Carlsbad, CA 92008
http://www.grandpacificpalisades.com/map-directions

Agenda (both dates and locations):

6:00 p.m. Open House Workshop (no pre-registration required)
6:30 p.m. Public meeting begins
6:45 p.m. Highlights of the FMP Process and how to Contribute
7:00 p.m. Public Questions and Comments

8:00 p.m. Open House Workshop
9:00 p.m. Meeting concludes

Management Options Meetings

The purpose is to receive comments on potential management options, the impact of each option, and preferred options or suites of options.

- Dates: **April 23-24, 2013**
- Locations: **Ventura and Orange counties**

Fish and Game Commission Regulator Process

The formal regulatory process will begin in February 2015

Written Comments

- The Spiny Lobster Fishery Management Plan Web Site has the ability to receive written comments. Web Site address: http://www.dfg.ca.gov/marine/lobsterfmp/
- Written comments can also be mailed to:
  Department of Fish and Game
  Attn: Spiny Lobster FMP
  1933 Cliff Drive, Suite 9
  Santa Barbara, CA 93109

II. Methods for Providing Constituents with Information

Since communication and participation are crucial to a successful FMP process, the Department will provide information through a range of options.

Available Resources

- The Spiny Lobster Fishery Management Plan Web Site: http://www.dfg.ca.gov/marine/lobsterfmp/
- Electronic notices. Constituents can sign up for the Lobster FMP News Service through the Spiny Lobster Fishery Management Plan Web Site. The News Service will distribute electronic notices about future events. Once you are signed up, you can expect to receive emails that:
  - Announce the debut of a fully populated Lobster FMP website that includes informative background documents on lobster.
  - Keep constituents informed of news and public meeting information during the Lobster FMP process.
  - Announce the availability of Lobster FMP draft documents
- For those who cannot receive email, the Lobster FMP team will send the identical announcements via the U.S. Postal Service. To sign up to receive the Lobster FMP News Notices via mail, please contact Ms. Rosalyn McFarland at (805) 568-1231 to provide your mailing address.
- Flyers available at Fish and Game offices, and posted at strategic locations.
- Marine Management Newsletter

Special Publications

- Spiny Lobster Stock Assessment
- Technical Panel Review Publication of Stock Assessment

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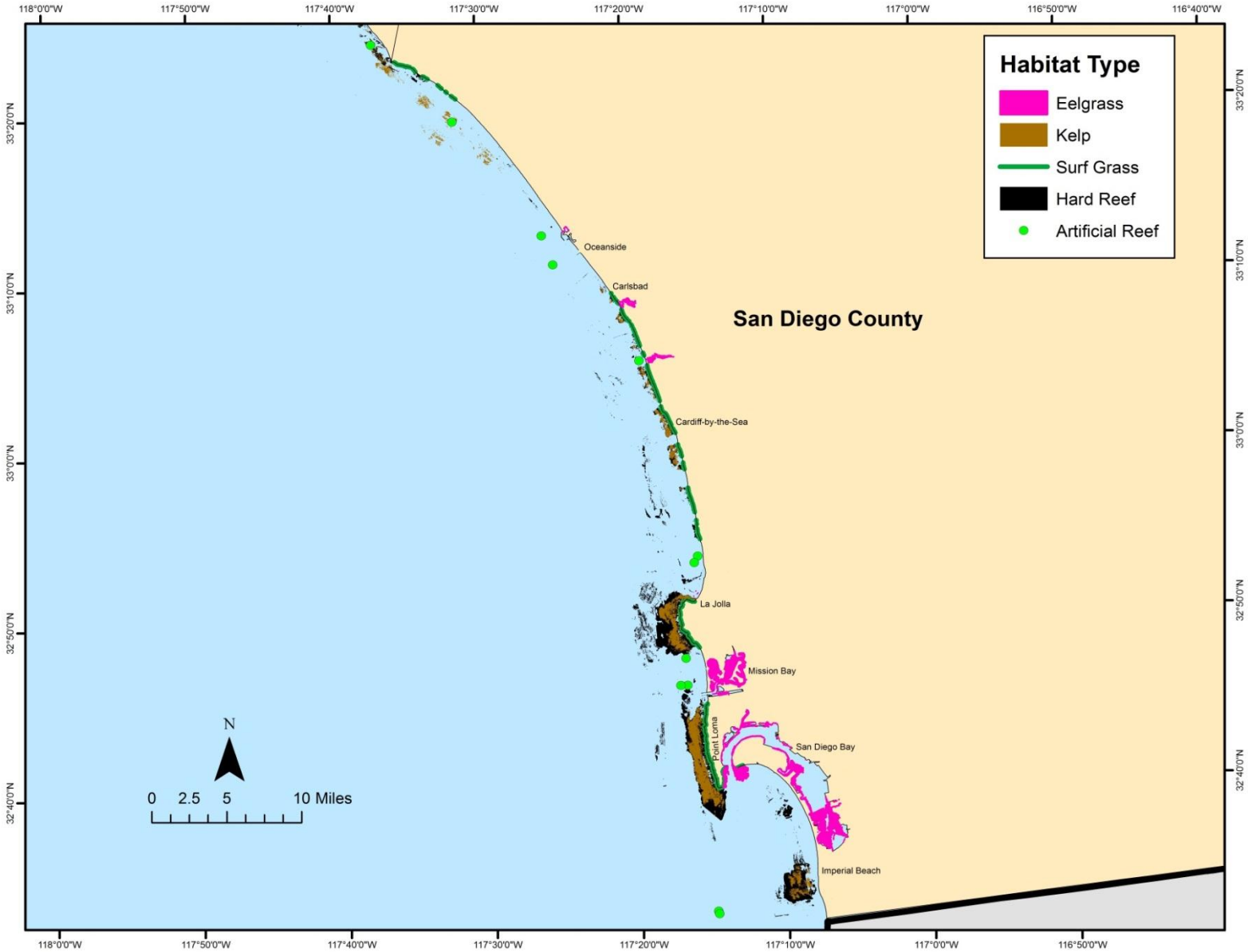
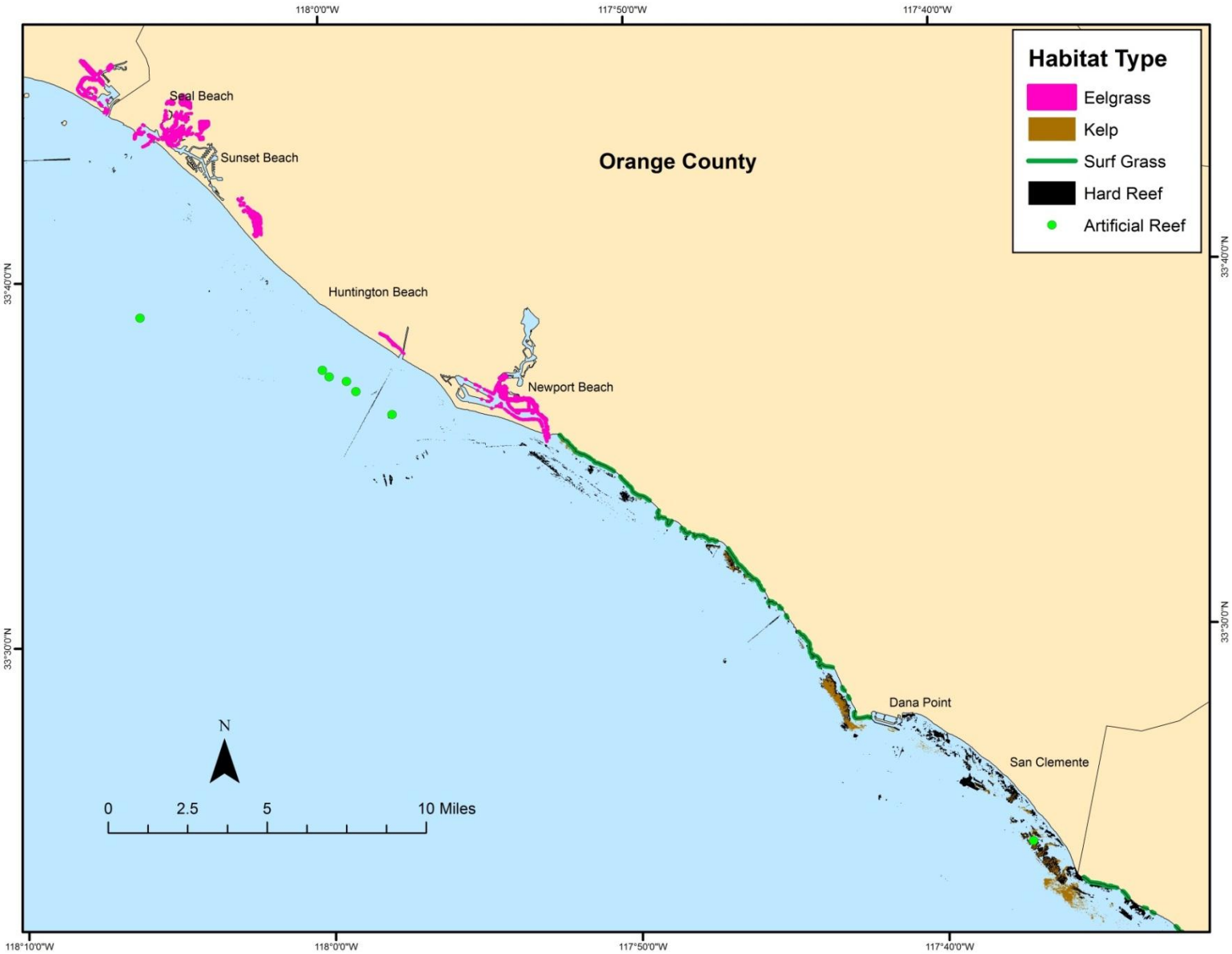
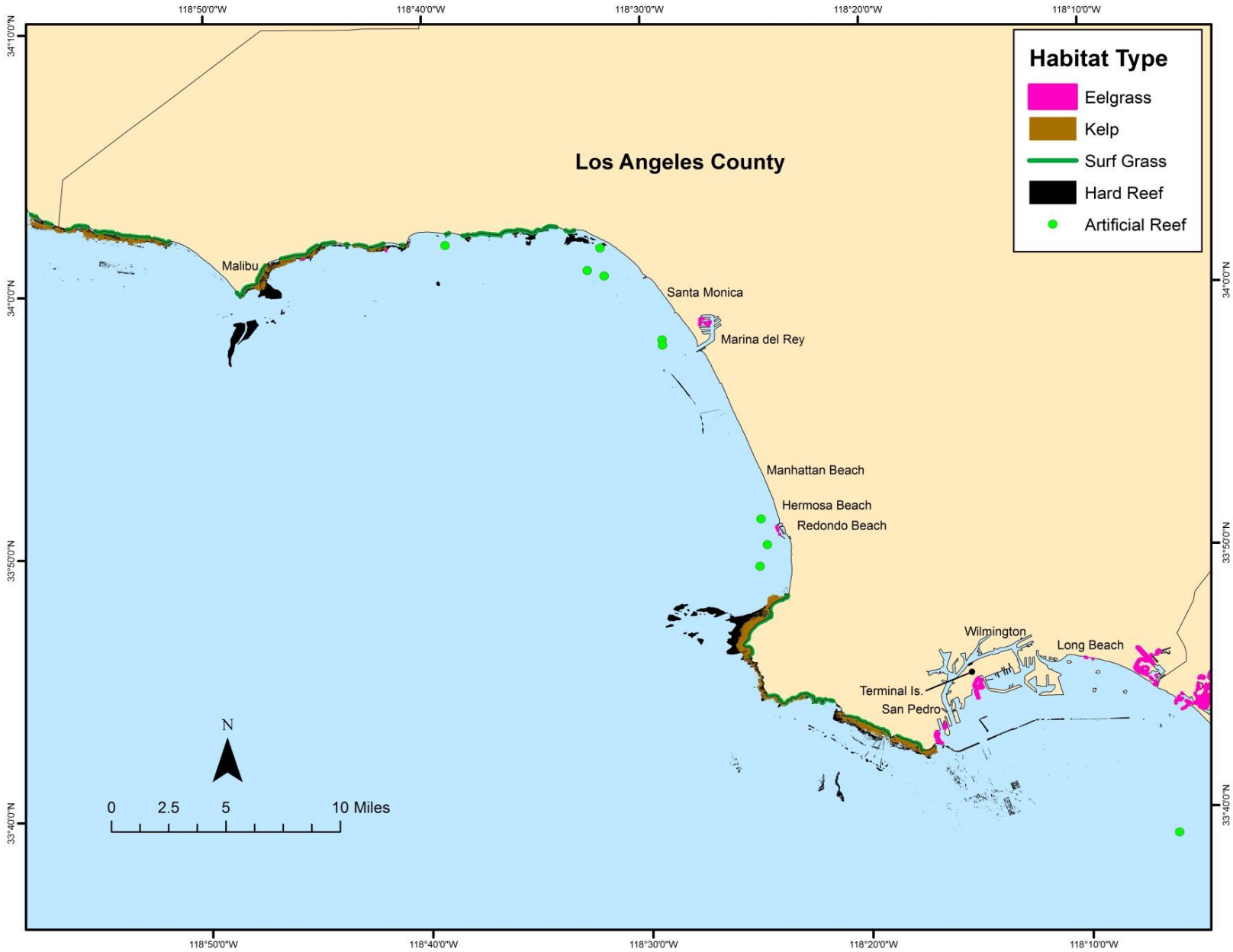
Appendix III: Habitat Maps by Areas



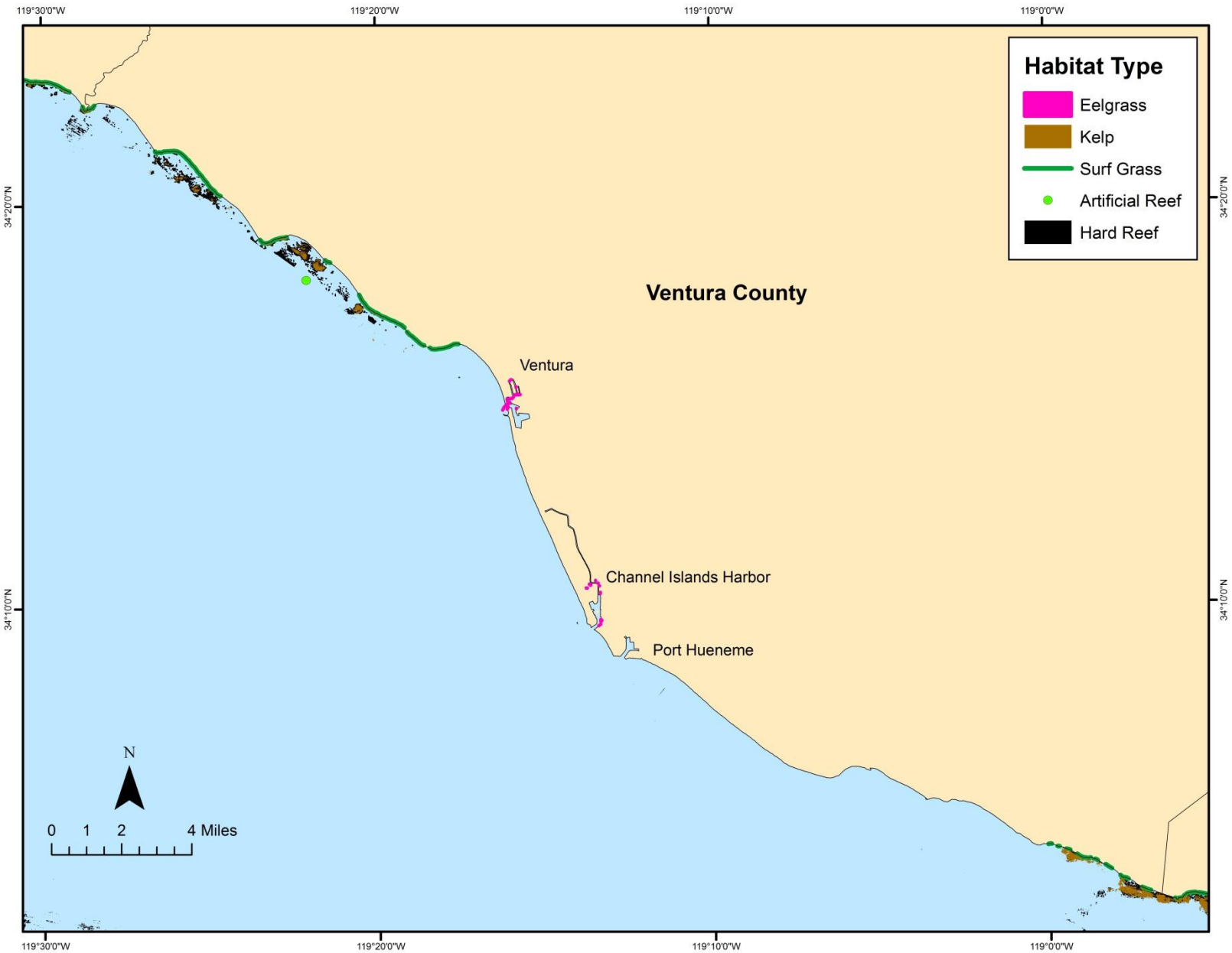
Critical CA lobster habitats along San Diego County



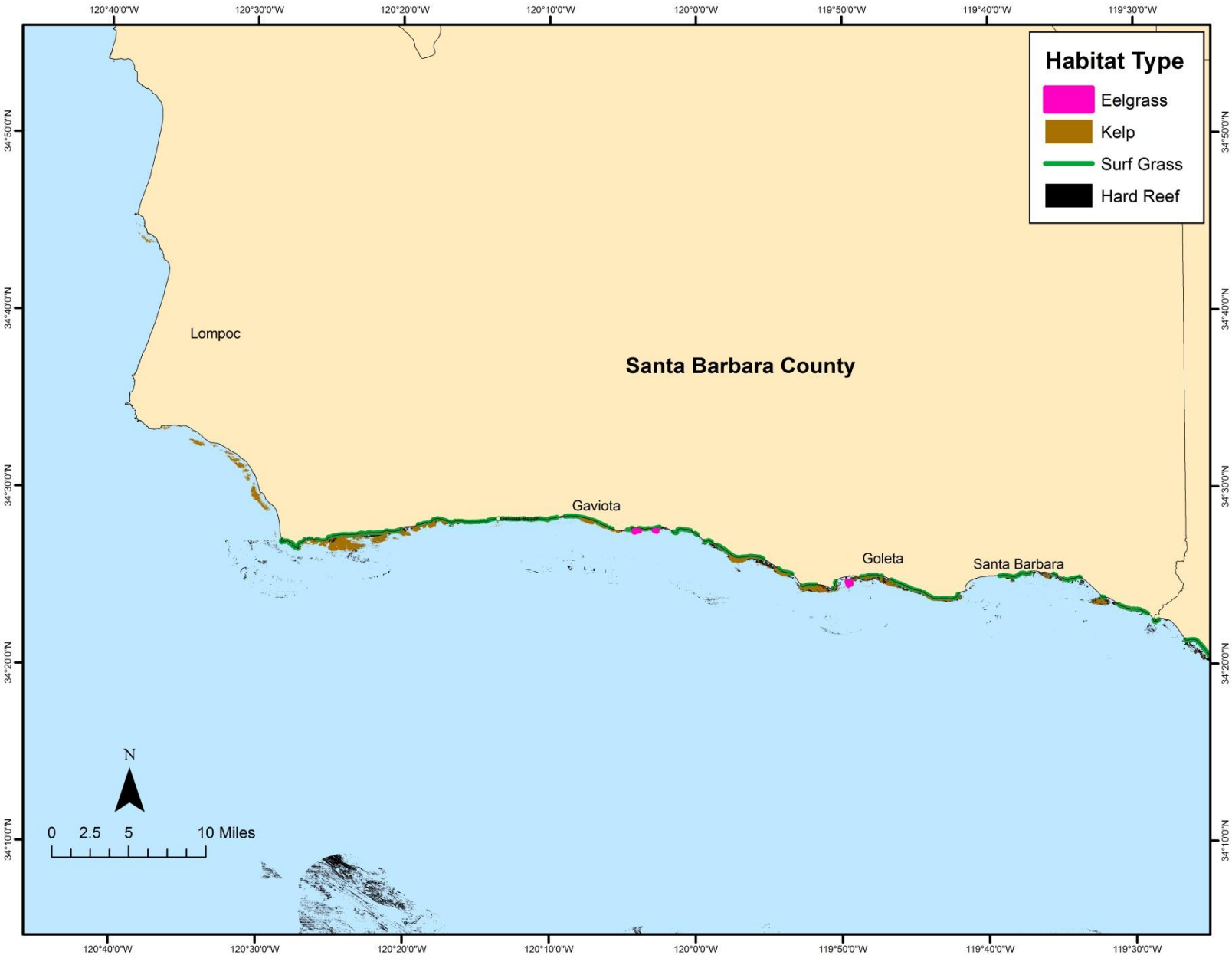
Critical CA lobster habitats along Orange County



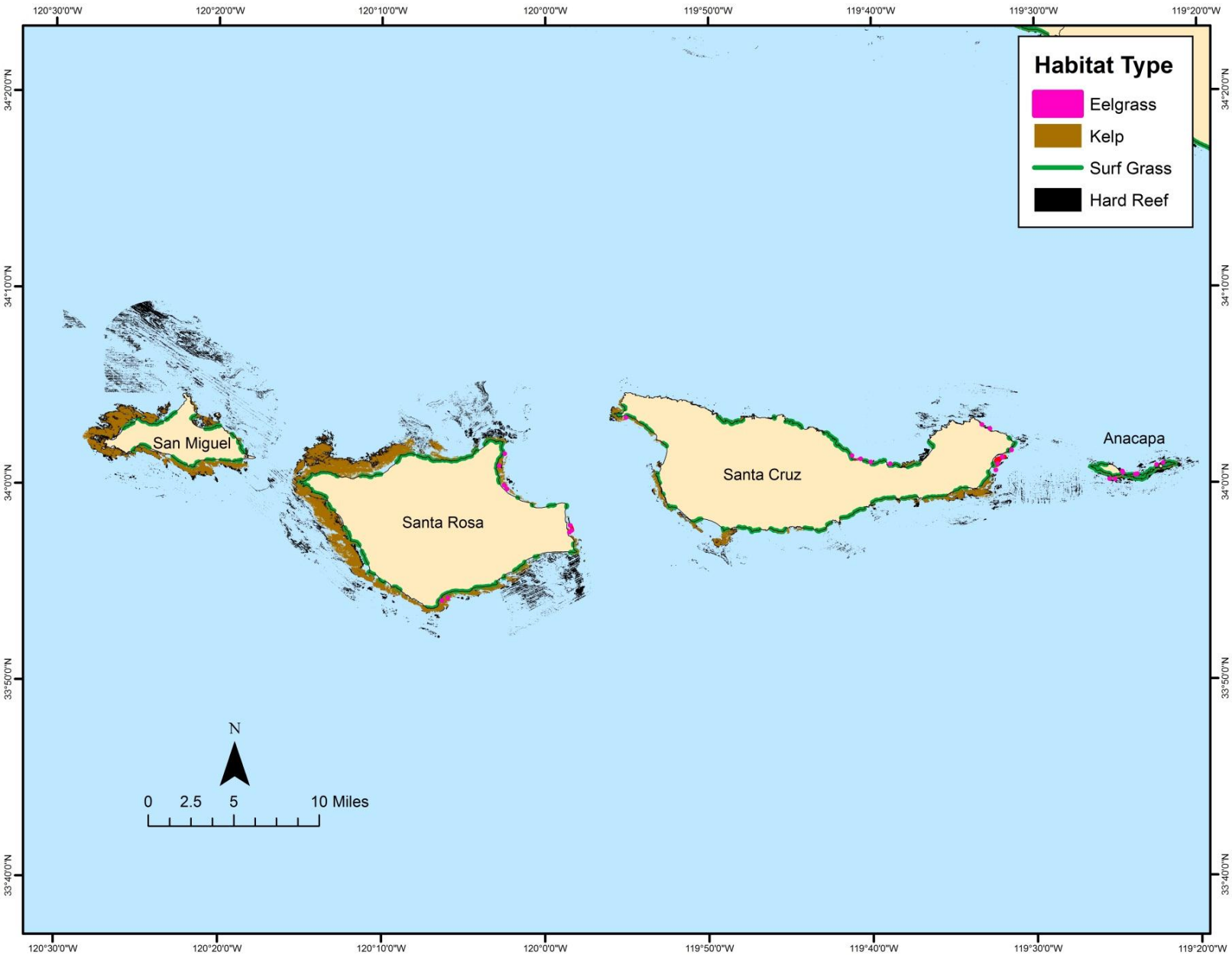
Critical CA lobster habitats along Los Angeles County



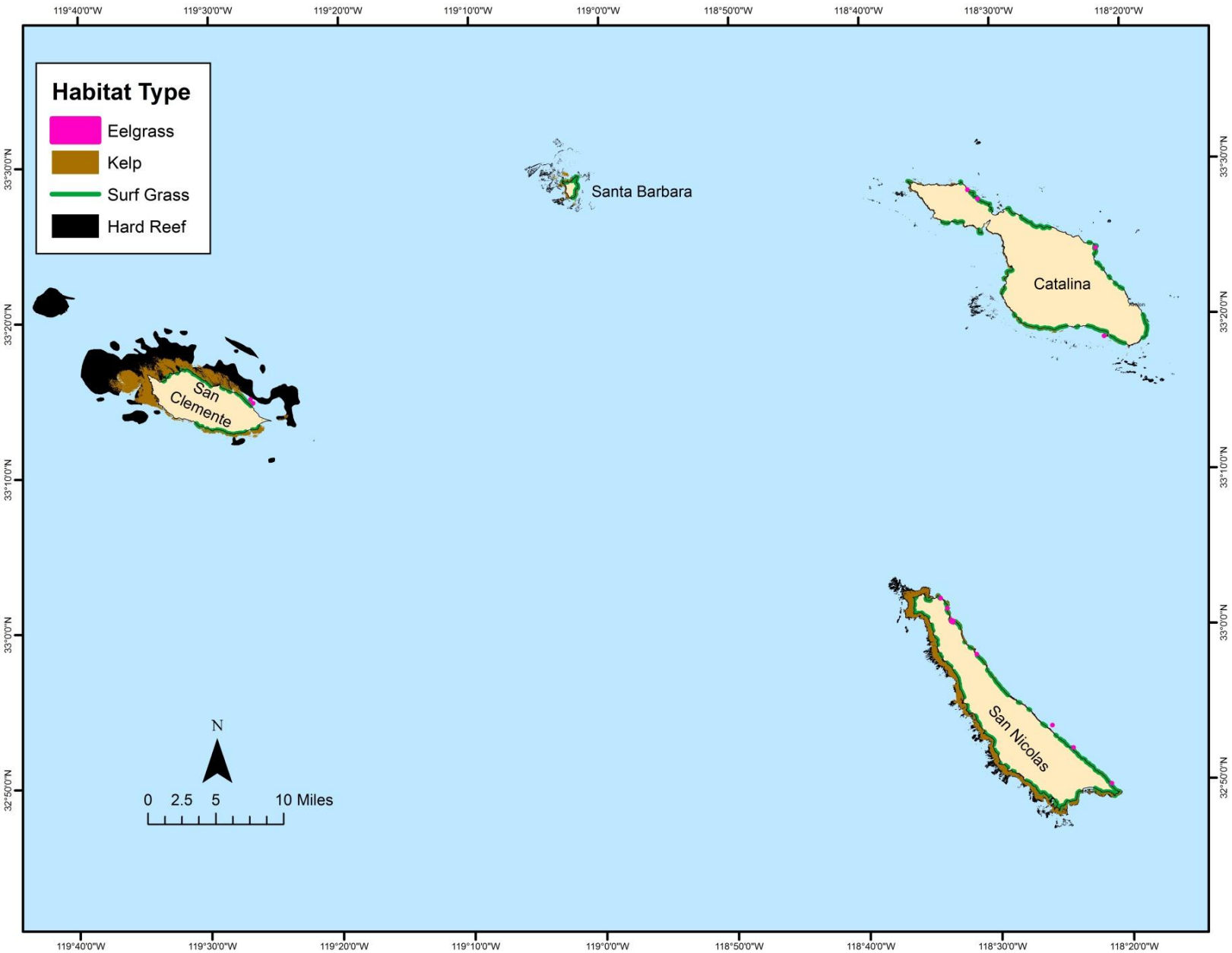
Critical CA lobster habitats along Ventura County



Critical CA lobster habitats along Santa Barbara County



Critical CA lobster habitats around the Northern Channel Islands



Critical CA lobster habitats around the southern Channel Islands

Appendix IV: Sample Logs and Landing Receipt

CALIFORNIA DEPARTMENT OF FISH AND GAME

DAILY LOBSTER LOG

SL 242726

FISHERMAN LAST NAME	F.I.	FISHERMAN ID 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 ID 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) 1) 2)

CREW ID 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) 1) 2)

CREW ID NUMBERS L L

DFG 122 (5/09) GREEN = DEPT. OF FISH & GAME COPY ******* YELLOW = FISHERMAN COPY

Sample Fishing Log

FISHERMAN LAST NAME	F. I.	ID NUMBER	PORT OF FIRST LANDING	LOCATION WHERE FISH WERE CAUGHT
		L		

VESSEL NAME	VESSEL ID	FISH BUSINESS NAME	FISH BUSINESS ID
			-

FISH NAME	POUNDS	PRICE	TOTAL AMOUNT	CONDITION	GEAR
1) SHEEPHEAD 145	, .	$.			
2) CALIF 260 SCORPIONFISH	, .	$.			
3) CABEZON 261	, .	$.			
4) SABLEFISH 190	, .	$.			
5) HAGFISH 457	, .	$.			
6) CALIF 452 MORAY EEL	, .	$.			
7) LOBSTER 820	, .	$.			
8) RED ROCK 341 CRAB	, .	$.			
9) YELLOW ROCK CRAB 342	, .	$.			
10) BROWN ROCK CRAB 343	, .	$.			
11) ROCKCRAB 801	, .	$.			
12) SPIDER 803 CRAB	, .	$.			
13) KELLET'S 731 WHELK	, .	$.			
14) SPOT 815 PRAWN	, .	$.			
15)	, .	$.			
16)	, .	$.			
17)	, .	$.			
18)	, .	$.			
19)	, .	$.			

PRIMARY GEAR USED

GEAR LEGEND

21 FISH TRAP
22 PRAWN TRAP
27 CRAB / LOBSTER TRAP
OTHER

(BIOLOGIST USE) FISH CODE

NOTE PAD

TOTALS # _____ $ _____

CORRECTIONS - FOR FIELD BIOLOGIST USE ONLY

LINE #	FISH CODE	POUNDS	PRICE	CONDITION	GEAR
		, .	$.		
		, .	$.		
		, .	$.		

CHANGES ON BACK

FISHERMAN/PERMITTEE SIGNATURE _____ RECEIVED BY _____

CERTIFIED UNDER PENALTY OF PERJURY AS TRUE AND CORRECT

F&G 625 -O (11/10) GREEN = DEPT. OF FISH & GAME COPY ******* YELLOW = FISHERMAN COPY ******* PINK / GOLDENROD = FISH BUSINESS COPY (2)

Sample Landing Receipt

Appendix V: Climate Change Vulnerability of the CA Spiny Lobster

By Dr. Douglas j. Neilson

The science of climate change (CC) involves the study of climatic stressors (e.g., atmospheric air temperature) affected by increasing man-made atmospheric greenhouse gas (GHG) concentrations, and their associated environmental responses. An exhaustive discussion of all the potential stressors is beyond the scope of this chapter and only a small portion, deemed to have obvious potential impacts when applied to the California spiny lobster fishery, will be covered. For the most part, these impacts are restricted to those acting directly on the lobster or fishery. There are understood to be indirect impacts as well, where CC affects some aspect of the environment that cascades down to the lobster. While changes to lobster habitat included in ecosystems that also include lobster will be briefly discussed, the larger topic of how ecosystem interactions are affected by CC is beyond the scope of this chapter. As our understanding of CC evolves, and direct or cascading responses in the environment are newly recognized or better resolved, this chapter should be revisited. As such, this chapter should be considered an initial step in an ongoing effort to addressing lobster-related CC issues.

This chapter will briefly discuss the life history and associated habitats for the California spiny lobster which will be important to understand as we discuss CC vulnerabilities. What CC is, and the underlying cause – GHG, and specifically changes in CO_2 - will then be discussed. Since CC is understood to be a global phenomenon and is being driven at this scale, this chapter will first lay out how the selected climate variables are expected to change over time. The relatively local response to CC in California will then be discussed, followed by how the spiny lobster population, habitat, and fishery, are potentially affected. Finally, ocean acidification will be briefly addressed. Ocean acidification is not a result of CC but rather is caused by the same rise in atmospheric CO_2 that contributes to CC.

Spiny Lobster Life History and Habitats

The California spiny lobster is endemic to the west coast of North America from Monterey, California southward at least as far as Magdelena Bay, Baja California (Wilson, 1948; Schmitt, 1921), with a small isolated population in the northwestern corner of the Gulf of California (Kerstitch, 1989). The main portion of the population resides in Mexico, and relatively few lobsters are found north of Pt. Conception. In U.S. waters, spiny lobsters are commercially fished from Pt. Conception south to the Mexican Border. Lobsters spend their larval phase, which can last up to ten months, as part of the plankton (Mai & Hovel, 2007; Mitchell 1971). Carried by currents, lobster larvae have been found as far as 530 km offshore and at depths as deep as 137m (California Department of Fish and Game, 2001). The final, puerulus, stage is a strong swimmer and moves inshore in search of shallow, vegetated habitats such as eelgrass or surfgrass beds (Mai & Hovel, 2007) in which to settle. Survival of the individual is therefore dependent on both the starting distance offshore of the puerulus and its ability to locate suitable habitat. Sub-adult and adult lobster are bottom dwellers and found at depths ranging from the intertidal to 64 m (California Department of Fish and Game, 2001)

Spiny lobster are found in rocky areas often with plant communities dominated by giant kelp (*Macrocystis* sp.), feather boa kelp (*Egregia* sp.), coralline algae (*Corallina* sp.), and surf grass (*Phyllospadix* sp.) (Lindbergh, 1955). They are also associated with eel grass (*Zostera* sp.) which flourishes in sandy areas (California Department of Fish and Game, 2001). Spiny lobsters are a major predator of benthic invertebrates and act as a keystone species preying on mussels along rocky shores (Robles et al., 1990) and on sea urchins in kelp forests (Tegner and Levin, 1983; Lafferty, 2004).

Climate Change

Climate Change is occurring as evidenced by observations of increasing global air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007). The scientific consensus is that the driving force behind this change is man-made sources of greenhouse gases (GHG) - CO_2, methane, and nitrous oxide - and globally the average net effect of human activities since pre-industrial times has been one of warming. While methane and nitrous oxide concentrations are significant contributors to climate change, CO_2 is the currently the primary contributor and will be the focus of this discussion. The primary source of CO_2 is fossil fuel consumption.

In 2005, global atmospheric CO_2 levels were measured at 379ppm, far exceeding the range observed over the last 650,000 years, and emissions grew by approximately 80% between 1970 and 2004 (IPCC 2007). In 2012, average atmospheric CO2 levels had grown to 392.6 ppm globally, and exceeded 400 ppm for the first time at several arctic sites (Blunden and Arndt, 2013).

Responses to Climate Change

Local responses to climate change may not follow the global trend in either magnitude or direction of response. Because of this, global trends will be discussed briefly to introduce each climate stressor and lay the foundation on which to compare and contrast the local, California responses.

Global Responses

The IPCC (2007) reported that eleven of the twelve years from 1995 to 2006 ranked among the twelve warmest years since 1850. All of the ten warmest years on record have occurred since 1998 including 2012 (Blunden and Arndt, 2013), and 1998 was the only year in the 20th century hotter than 2012 (NOAA 2012). The trend appears to be continuing; July 2013 was the 37th consecutive July and 341st consecutive month with a global temperature above the 20th century average (Osborne and Lindsey, 2013). The rate of warming has also increased. Since 1880, the decadal rate of increase has been 0.11 °F increasing to 0.28 °F per decade since 1970 (NOAA, 2012).

Global average sea level rise (SLR) has occurred at an average rate of 1.8 mm yr^{-1} since 1961, increasing to 3.1 ± 0.7 mm yr^{-1} since 1991 (IPCC, 2007). Estimations of future global sea rise are on the order of 8-23 cm (3.15-9.06 in) by 2030, 18-48 cm by 2050, and up to 140 cm by 2100, all relative to sea level in 2000 (NRC 2012). These estimates vary however based upon which models are used and which variables are included; the NRC values, for instance, are higher than the IPCC (2007) estimation (18-59 cm) for the year 2100.

California Responses

Air temperatures are expected to increase more over continental land masses than over the oceans (Bakun, 1990). Along the California coastline this will result in atmospheric pressure gradients leading to intensification of winds (Field et al., 1999). Stronger winds, in turn, are expected to intensify upwelling along the west coast of the US. Under normal conditions, intensification of upwelling would lead to cooler water temperature. However, higher air temperature can also lead to stronger thermal stratification and a deepening of the thermocline (Roemmich and McGowan, 1995), reducing the cooling effect of, and nutrient delivery by, the upwelling. On millennial timescales, upwelling has been positively correlated to air temperatures (Pisias et al., 2001), and upwelling along the California coast has increased over the last 30 years (Snyder et al., 2003). Previous warm periods were associated with reduced current flow in the California Current system (Pisias et al., 2001).

SLR will vary depending on a number of factors both long-term and short term. These include storm events, melting ice and glaciers, circulation patterns, climate variations, and tectonics. (NRC, 2012). Modelled SLR at west coast tide gage locations predicted relative sea level rises of around 0.35 ± 0.25 mm yr^{-1}. Total SLR off Los Angeles, relative to 2000, is projected at 14.7 ± 5.0 cm (5.79 ± 1.97 in) by 2030, 28.4 ± 9.0 cm by 2050, and 93.1 ± 24.9 cm by 2100.

The primary force behind year-to-year variability along the California coast is the El Niño Southern Oscillation (ENSO) (Field et al., 1999). The name refers to coupled ocean-atmospheric processes where the Southern Oscillation is a flip-flop of atmospheric pressure over the south Pacific, and where El Niño refers to the in-water response. El Niños result in rapid warming events in California, increased storminess, and drops in phytoplankton and kelp productivity. Strong El Niño events can increase sea levels 10 to 30 cm (3.94 – 11.81 in),raise sea surface temperature (SST) an average of 2.7 °F, increase stratification, and decrease nutrient delivery into surface waters, all over a few winter months. El Niño events persist for a few months to a year with some extreme El Niños lasting for two years. La Niña displays an equally abrupt and short-lived effect on California coastal ecosystems. However, in the case of La Niña, SST is suppressed (-1.8 °F on average). Currently it is unknown whether ENSO activity will be enhanced, or damped, or whether the frequency of ENSO events will change (Collins et al., 2010)

Lobster

Increased SST conditions will likely favor the spiny lobster fishery since behavioral changes related to warm temperatures, increase harvest (Pringle, 1986; Koslow et al., 2012). Also, California is situated at the northern edge of the lobster's current domain range; lower numbers of lobster north of Pt. Conception are generally attributed to the cooler water found there. Increasing SST could therefore result in a general extension northward of lobster, particularly during El Niño years or times of enhanced Davidson Current northward flow. These latter two conditions are also thought to provide episodic transport of larvae north from Mexico which would also increase the spiny lobster abundance over time. (Pringle, 1986).

As SST increases assemblages within southern California kelp forests will shift to more dominance of southern species – such a shift has already been observed in some kelp forests (Field et al. 1999). Kelp itself may be impacted by increasing SST and reduced nutrients, although it is unclear at this point exactly what response, positive or negative, kelp forests will have relative to climate change. Likewise, It is unclear if the California spiny lobster, being more tropical, would be directly (i.e. physiologically) affected negatively by increasing SST.

There is an increased likelihood of disease with higher water temperatures. As an example, the bacterial infection, epizootic shell disease, is present in American lobster stocks on the east coast of the US and is possibly linked to higher water temperatures. Catchability increases with increasing temperature. Considered alone, this could lead to higher harvests in the future. Even if countered by other climate change factors, variations in catchability would still need to be understood and addressed in stock assessment and modeling efforts for accurate results.

It is still unclear whether increased stratification or upwelling, countering stratification, will be the dominant response to climate change. Increased stratification, however, is projected to lead to declines in zooplankton abundance (Roemmich and McGowan, 1995) which could adversely affect the zooplankton larval phase of the spiny lobster directly or indirectly by reducing food sources. Conversely, upwelling and alongshore transport are strong determinants of dispersal and recruitment (Gaylord and Gaines, 2000; Connolly et al., 2001). Harley et al. (2006) cited modeling work that suggested increased

offshore movement (e.g., upwelling) can be negatively correlated with population size in benthic species. Very strong upwelling, therefore, could reduce the ability of lobster to maintain adult populations in some areas. This is probably more applicable to regions north of Pt. Conception and, as such, would act to reduce northward movement of the lobster range rather than impact the southern California population.

Increasing SLR will lead to coastal inundation and increased coastal erosion, in particular when accompanied by expected higher intensity storm events coinciding with high tidal periods. Coastal erosion can lead to silting of coastal habitat necessary for the lobster, in particular sea grass beds used for settlement and adult foraging. Even in areas spared from excessive silting, sea grass beds would still be sensitive to changing wavelengths of light brought about by increased turbidity and water depth. The fishing industry could also experience flooding at dock and harbor facilities. This would potentially affect both the fishermen and dealers.

Sea grass beds could be impacted by more frequent, higher intensity storm events damaging part of a bed, or completely destroying it. These events could also become relatively common occurrences. Damage or destruction of sea grass beds would impact lobster through reduction in suitable habitat for puerulus settlement. This could result in adult mortality exceeding recruitment leading to local loss of populations. Similarly, kelp beds could be damaged or destroyed at more frequent intervals. Lobsters are considered, along with urchins and kelp, to be necessary for the health of the kelp forest ecosystem. If kelp is lost at higher frequencies the result could be an imbalance in the kelp/lobster/urchin relationship leading ultimately to loss of the ecosystem (and by extension, the lobster located there). In terms of the fishery, these storm events could also affect the fishermen economically by hindering their ability to fish, and by the destruction of gear.

Changes to the lobster stock may also occur via altered larval distribution and settlement, loss or gain of coastal nursery habitats, and altered abundances of strongly interacting species (e.g. predators and prey) (Pecl et al. 2009). Though first-stage larval abundance generally is correlated with SST (Fig. 5), changes in wind patterns and storm frequency may alter larval dispersion and settlement (Caputi et al. 2010). Because spiny lobster larvae spend up to 10 months in the plankton, and the final larval stage actively swims from offshore to coastal nursery habitats, settlement success is dependent on the planktonic larvae's distance offshore at the time of final molt. Any change in currents and storms that result in farther offshore dispersion will have an adverse effect on harvest in the future.

Ocean Acidification

Although not specifically caused by climate change, ocean acidification is a separate phenomenon also related to increasing amounts of atmospheric CO_2. The ocean absorbs CO2 from the atmosphere naturally and acts as a buffer for atmospheric CO2. The pH of the oceans, however, is affected by the level of absorbed CO2. With increasing levels of atmospheric CO2, the ocean's CO2 level also rises and the water becomes more acidic. It has been estimated that the oceans have absorbed half of the anthropogenic-induced CO2 from the atmosphere (Pecl et al., 2009), and this has resulted in a more acidic ocean. (Caldeira and Wickett, 2003; Royal Society, 2005; Pecl et al, 2009). As acidity continues to increase, there will be increasingly adverse effects on many organisms that use calcium carbonate for their shells and skeletons since calcium carbonate will dissolve as acidity increases. Water corrosive enough to dissolve seashells has been observed off California and similar occurrences are expected to become more frequent (Feely, 2008). The types of organisms potentially affected include snails and mussels, corals, and many phytoplankton species. It is unclear if there will be any adverse effects of

acidification directly on lobster (Pecl et al., 2009). Also, distribution, extent, and composition of coastal vegetated habitats that house lobster all may change due to altered dissolved CO_2 concentrations.

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Appendix VI: Economic Report

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H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

An Economic Report on the Recreational and Commercial Spiny Lobster Fisheries of California

Photo Courtesy of: California Department of Fish and Wildlife

Prepared by:

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3 April 2013

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Executive Summary

- The project scope was to update annual expenditure estimates associated with commercial spiny lobster fishing in California from Hackett et al. (2009); to use the California Ocean Fish Harvester Economic (COFHE) model from Hackett et al. (2009) to estimate the economic impacts associated with ex-vessel commercial landings in California; to develop a spiny lobster recreational fishing sampling design and survey questionnaire; and to use the survey results to estimate recreational fishing expenditures in California.
- Based on 2012 interview data and prior "bottom-up" expenditure modeling from Hackett et al. (2009), we estimate that commercial fishermen targeting spiny lobster in California spent ~$10,555,000 on fishing- and vessel-related expenditures in the 2011-12 fishing season.
- Based on the mean of total ex-vessel revenue from the 2009-10 through 2011-12 commercial fishing seasons in California, we estimate that the multiplier effect associated with commercial landings resulted in total annual statewide economic output of ~$22,523,000 and 323 jobs. Of the California counties in which spiny lobster landings occurred, San Diego County experienced the largest share of statewide output and jobs. Based on 2012 survey data we estimate that annual expenditures in the recreational fishery in California were ~$37,093,000. Note that not all of these expenditures necessarily occur in California. Also note that these are expenditures and not total economic impact, which is beyond the scope of this report.
- The average recreational fisherman has fished spiny lobster for nearly 9 years and spends an average of just over 2/3 of a day on a typical fishing trip. Spiny lobster fishing constitutes an average of just over 1/3 of a recreational fisherman's total fishing effort in a given year. Private vessels provided just over 1/2 of all access to the recreational fishery, and on average about 8% of a vessel's annual usage was estimated to be targeted at spiny lobster fishing.

Table of Contents

Executive Summary i
Table of Contents ii
Section 1.0 Introduction 1
Section 2.0 Estimated Commercial Expenditures in the Spiny Lobster Fishery 2
Section 3.0 Economic Impact Estimates for the Commercial Spiny Lobster Fishery 6
3.1 Overview of Economic Impact Assessment 6
3.2 Economic Impacts Associated with the Mean Value of Ex-Vessel Landings over the 2009-10 through 2011-12 Fishing Seasons 8
Section 4.0 Estimated Expenditures in the Spiny Lobster Recreational Fishery 11
4.1 Survey Methodology 11
4.2 Expenditure Estimates for the Spiny Lobster Recreational Fishery 17
4.2.1 Estimation Methods 17
4.2.2 Demographic Information and Estimated Expenditures in California's Recreational Fishery for Spiny Lobster 19
Section 5.0 References 29

Tables

Table 1. Annual Estimated Expenditures for the California Spiny Lobster Commercial Fishing Fleet for Fishing Season 2011-12 5
Table 2. Definitions of Economic Impact Terms Used in this Report 7
Table 3. Economic Impacts for the State of California 8
Table 4. Economic Impacts by County: Los Angeles, Orange, Santa Barbara, San Diego, and Ventura 9
Table 5. Sample Sizes by Stratum 16
Table 6. Demographic Estimates for the Spiny Lobster Recreational Fishery, Means and Standard Deviations 20
Table 7. Proportion of Recreational Fishermen who Fish for Spiny Lobster by Access Type 21
Table 8A. Estimated Annual Recreational Fisherman Expenditure Estimates 22
Table 8B. Estimated Annual Recreational Fisherman Expenditure Estimates 23
Table 8C. Estimated Annual Recreational Fisherman Expenditure Estimates 24
Table 9. Estimated Total Recreational Fisherman Annual, Trip, and Grand Total Expenditures, with 95% Confidence Intervals 25
Table 10A. Estimated Recreational Fisherman Trip Expenditures 26
Table 10B. Estimated Recreational Fisherman Trip Expenditures 27
Table 10C. Estimated Recreational Fisherman Trip Expenditures 28

Figures

Figure 1. Map of Potential Home Origin of California Spiny Lobster Recreational Fisherman. 13
Figure 2. Smoothed Probability Density Distribution Curves for Activity Patterns by Gear Type 15

Appendices

Appendix A. Commercial Expenditure Update Survey A-1
Appendix B. Recreational Fishery Expenditure Survey B-1

Section 1.0 Introduction

The California spiny lobster, *Panulirus interruptus* (hereafter spiny lobster), occurs in shallow, rocky coastal areas from Point Conception (Santa Barbara County) into Mexico, including offshore islands and banks (Barsky 2003). A significant commercial and recreational fishery exists for spiny lobster, and the season in California runs from early October to mid-March, with approximately 2/3 of landings usually being made from October through December. Commercial fishermen targeting spiny lobster set baited, wire traps from vessels that usually range between 22 to 49 feet in length. Spiny lobster has been a relatively lucrative fishery. A total of 751,000 pounds of spiny lobster was landed by commercial fishermen in 2011 in California at a total ex-vessel value of ~$12,910,000, yielding an average price per pound of ~$17.00 (CDFW 2013). In 2012, preliminary data indicate roughly similar landings as 2011. Price per pound fluctuates throughout the season, and in the 2012/13 fishing season it ranged from $12 to $25 per pound. Export markets (e.g., China) have helped drive higher prices in the commercial fishery in recent years (Barsky, pers. comm., 2013).

This economic report provides an update of direct expenditure information by commercial fishermen described in Hackett et al. (2009). Commercial expenditure updating occurred by way of interviewing a set of commercial spiny lobster fishermen and identifying the extent to which mean expenditure levels by category have changed since 2007. This report also utilized the California Ocean Fish Harvester Economic (COFHE) commercial fishery economic impact model from Hackett et al. (2009) to estimate total economic impact. This was done by applying the COFHE multipliers (available at http://www.dfg.ca.gov/marine/economic structure.asp) to the mean of total seasonal ex-vessel revenue averaged over the 2009-10, 2010-11, and 2011-12 fishing seasons. Commercial fishery economic impacts were estimated at the county, region, and statewide scales. Note that in Hackett et al. (2009) the spiny lobster fishery was grouped with crab in the "Lobster and Crab" operational configuration (OC). In contrast, this report focuses entirely on the targeted spiny lobster fishery.

This report also includes an estimate of the direct expenditures made by recreational fishermen targeting spiny lobster in the recreational fishery off the coast of California. These direct expenditures were estimated from survey data gathered in collaboration with California Department of Fish and Wildlife (CDFW) using the spiny lobster report card database. It is beyond the scope of this study to estimate economic impact. To do so one would need to "margin" the retail expenditures to get a wholesale estimate, group expenditures by appropriate economic sector category, and apply multipliers (e.g., RIMS II) or use economic impact software (e.g., IMPLAN).

In Section 2 below we summarize commercial expenditures in the spiny lobster fishery. In Section 3 we describe economic impacts associated with the mean of the last 3 season's worth of ex-vessel revenue from commercial spiny lobster harvest. In Section 4 we summarize estimated expenditures in the spiny lobster recreational fishery. The survey instruments used to elicit commercial and recreational fishing data are provided in the Appendices to this report.

Section 2.0 Estimated Commercial Expenditures in the Spiny Lobster Fishery

The overall goal for this portion of the report was to update the expenditure information for the "lobster and crab" operational configuration (OC) from Hackett et al. (2009). Due to resource constraints, we were unable to reproduce the comprehensive survey methodology used in Hackett et al. (2009). Instead we used a key-informant interview methodology in which we asked commercial spiny lobster fishermen the extent to which (inflation-adjusted) expenditures by category (averaged at the individual fisherman level) reported in Hackett et al. (2009) reflected expenditures for a "typical" commercial fisherman. We asked contacts at CDFW to identify commercial fishermen who were likely to have a broad, industry-wide perspective and who would thus be able to reflect on the expenditures made by a typical commercial spiny lobster fisherman.

Annual average fixed and variable cost information from the lobster and crab OC in Hackett et al. (2009) was provided to the interviewees in numerical and pie-chart format (see Appendix A for an example used for the small-vessel stratum). These "cost sheets" were adjusted for inflation (2007 nominal expenditures from Hackett et al. (2009) were adjusted to 2012 values). Interviewees were asked to determine a percentage by which those expenditures should be increased or decreased to reflect the expenditure experience of a "typical" spiny lobster commercial fisherman. Some expenditure categories from Hackett et al. (2009) such as "electrical gear" and "other gear" purchases and repairs were consolidated into a "gear purchases" and "gear repairs" category. The cost sheets were stratified into vessel size classes used in Hackett et al. (2009) – small (< 26 feet), medium (26 to 36 feet), and large (> 36 feet). Cost sheets for a given size class were given to selected fishermen with vessels of the same size class, and afterwards personnel from H. T. Harvey & Associates called to interview the commercial fishermen and complete the questionnaire component of the cost sheets.

A total of 10 commercial fishermen participated in the interviews. We use the term "interviewee" below to refer to these commercial spiny lobster fishermen who were interviewed in 2012 to help us update Hackett et al. (2009) expenditures circa 2007. Of the 10 interviewee responses, 8 were determined to be useable, while 2 were not (addressed below). When participants reported a range of values (e.g., "bait expenses from the cost sheet need to be increased by 10-30%"), then the mean of the range (in this instance, 20%) was coded and used in the analysis. If a fisherman simply indicated that costs should "increase" or "decrease", those data were treated as a blank (unanswered) and not used in the following analysis (there were very few of these responses). Percentage changes for each cost category were averaged within each vessel size class (small size class and a combined medium-large size class).

As noted above, we asked interviewees to report a "typical" commercial fisherman's expenditures within a vessel size class in the spiny lobster fishery, and to indicate the percentage increase or decrease that should be made to the 2007 expenditure information from Hackett et al. (2009). Many of the interviewees indicated that expenditures we reported from the 2007 study were far too low, even after the figures were inflated to

current dollars, and suggested very large expenditure increases. When such expenditure increases were implemented fleet-wide, net revenues (e.g., ex-vessel revenue less reported expenditures) were estimated to be negative. Conversations with CDFW contacts indicated that negative net revenues were very unlikely for this lucrative fishery. We then turned to an analysis of activity level. An analysis of trip frequency determined that the interviewees selected by CDFW were more active fishermen than the average commercial fisherman. As a result it is likely that the interviewees were reporting "typical" expenditures that actually reflected the experience of the top 10-20% of commercial fishermen. As many categories of estimated expenditures increase with activity level, applying percentage increases from these highly active fishermen would result in a substantial over-estimate of fleet-wide expenditures. To correct for this likely overestimate of expenditures, we developed an "activity-based" weighting system.

First we used the expenditure estimation models by category from Hackett et al. (2009) and applied those to each commercial fisherman in the commercial spiny lobster fishery based on their vessel type, home port, and number of trips. Next we inflated these expenditures to current dollars. We then adjusted these expenditures using the mean percentage change by expenditure category provided by the commercial spiny lobster interviewees (one set of mean percentage change values was calculated from small-vessel interviewees, and another set was calculated from combined medium and large vessel interviewees). This percentage change is likely to be too high for most commercial spiny lobster fishermen, for reasons described in the preceding paragraph. Accordingly, we then applied the activity-based weight to each expenditure category for each commercial spiny lobster fisherman in a given vessel size class. The activity-based weight is a quotient equal to the individual fisherman's total number of fishing trips in 2011 divided by the mean number of fishing trips by the relevant interviewee group in 2011. The effect of this activity-based weight is to deflate (inflate) the percentage change from the interviewee group when an individual fisherman's level of activity is less than (greater than) that of the interviewee group. This weighting system was not applied to expenditure categories that are unlikely to be related to activity level – slip fees, member association fees, harbor fees, and interest.

Note that responses from 2 interviewees remained inexplicable and substantial outliers even after consideration of their vessel size, number of trips, and other observable characteristics. This raised concern about their reliability, ultimately resulting in those interviewee responses not being included in the analysis.

We also discovered that while we asked participants to provide an annualized value for engine, hull, and other major capital purchases, the responses were consistent with reporting an actual purchase price rather than an annualized "debt service" type value. For example, we might receive a reported annual expenditure of $16,000 for engine purchase, when what we wanted was the "annualized" cost (which might be ~ $1,800 per year as debt service on a 10 year loan). We thus needed to annualize these capital expenditure percentage change values from the interviewee group. To do so, we used data on frequency of capital purchases from Hackett et al. (2009) to develop an additional "annualized capital purchase" weighting system. The annualized capital purchase weight simply equals the frequency of non-blank and non-zero capital expenditure responses from the commercial fisherman survey in Hackett et al. (2009). Annualized engine and hull purchase expenditures for each commercial spiny lobster fisherman were thus estimated the same way as

other expenditure categories described in the preceding paragraph, except that the additional annualized capital purchase weight was also applied.

Commercial license, permit, and boat registration expenditures were calculated from CDFW 2011/12 fees. Once we estimated all expenditure categories for each individual commercial spiny lobster fisherman as described above, a fleet-wide expenditure total was built from the bottom up by summing expenditures estimated for each commercial fisherman. The resulting annual expenditure estimates for the commercial spiny lobster fishery are provided in Table 1. We estimate that commercial spiny lobster fishermen spent $10,555,000 in expenditures related to spiny lobster fishing for the 2011-12 fishing season. Nearly one half of this figure was estimated to derive from crew wages, bait, and fuel.

Table 1. Annual Estimated Expenditures for the California Spiny Lobster Commercial Fishing Fleet for Fishing Season 2011-12

	Estimated Total Expenditures			
Vessel Size Categories	**< 26**	**26 - 36**	**> 36**	**Grand Total**
Fixed Expenditures				
Hull Repair	51,754	191,515	129,482	**372,751**
Hull Purchase	37,380	100,317	32,348	**170,045**
Engine Repair	116,752	216,295	65,951	**398,997**
Engine Purchase	65,139	152,793	10,490	**228,423**
Gear Repair	195,973	216,341	161,195	**573,509**
Gear Purchase	116,509	217,036	119,781	**453,326**
Insurance	73,819	169,990	102,172	**345,981**
Storage	110,863	69,906	24,653	**205,422**
Interest	0	79,243	78,019	**157,262**
Registration and License Fees	54,582	57,890	20,675	**133,147**
Slip	181,581	317,976	142,250	**641,807**
Variable Expenditures				
Bait	733,113	590,865	282,964	**1,606,941**
Food	54,218	126,005	69,993	**250,217**
Fuel	496,234	508,249	325,447	**1,329,930**
Crew Wages	603,042	900,017	366,229	**1,869,287**
Harbor Fees	0	9,434	3,322	**12,756**
Transportation	250,753	139,917	65,304	**455,974**
Member Fees	3,398	10,869	3,827	**18,094**
Federal Tax	238,043	618,720	263,595	**1,120,359**
State Tax	44,170	117,054	50,045	**211,268**
	Total			
Grand Total Expenditures	3,427,322	4,810,431	2,317,742	**10,555,495**

Section 3.0 Economic Impact Estimates for the Commercial Spiny Lobster Fishery

3.1 Overview of Economic Impact Assessment

The material below draws closely from Hackett et al. (2009). Firms in every industry are linked through their purchases and sales with firms in other industries and with households. Inter-industry linkages and the impact of activities in one industry on overall household income, employment, business sales, tax revenues, and other economic conditions are important but not always apparent by examining direct industry statistics. Input-output models display direct, indirect, and induced economic linkages, and measure impacts of changes or proposed changes in industrial activity or in government policies that are expected to change industrial activity. Direct impacts are associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support an increase in industry output. Indirect impacts are associated with additional "rounds" of inter-industry purchases and sales that are generated as a result of direct impacts. Induced impacts are from increases in household expenditures that result from increases in household income associated with direct and indirect impacts.

Input-output models form the core of modern economic impact assessment decision support tools. Hackett et al. (2009) offers economic impact assessment models for California's commercial fisheries. To build these models, Hackett et al. (2009) collected statewide commercial fishing expenditure and earnings data in 2007 for 20 different OCs or fishery sectors that reflect vessel and gear types and the associated commercial fishing expenditures for target species groups. These expenditure data, combined with CDFW landings and revenue data, were used to develop input-output models with 20 detailed OCs for the state of California, 4 coastal regions within California, and 22 individual counties that make up those coastal regions. These 27 models, collectively called the COFHE Model, were developed by King and Associates, Inc. (coauthors in Hackett et al. 2009) from a widely used and respected regional economic modeling tool called the IMPLAN (IMpact Analysis for PLANning) system (MIG 2013).

The COFHE models are designed to show the economic linkages and impacts of California's commercial fish harvesting industries and how they are affected by external economic, regulatory, or environmental changes that affect ex-vessel revenues. These models show how each commercial fishing OC is linked with other industries and with households. The models were then used to develop economic "multipliers" that show the "ripple" effects of changes in fisheries and fisheries management decisions on the California economy. The multipliers developed through the COFHE model are presented per million dollars of direct sector output.

The most typical use for the COFHE model is to assess the economic impact associated with a regulatory change that has known impacts on ex-vessel revenues due to changes in landings. In this report we apply the COFHE model multipliers to total ex-vessel revenue at county, region, and statewide scales. The resulting economic impact is associated with the existence of the commercial spiny lobster fishery in California. If,

hypothetically speaking, this fishery were newly opened, then the economic impact figures provided below would provide an estimate of the additional economic activity associated with opening the fishery at different geographical scales. Key economic impact terms are defined in Table 2 below.

Table 2. Definitions of Economic Impact Terms Used in this Report

IMPLAN Term	Definition
Direct Effects	The impacts associated with the direct purchases of inputs (e.g., labor and intermediate inputs) by an industry to support a $ 1 increase in industry output.
Indirect Effects	The impacts associated with additional "rounds" of inter-industry purchases and sales that are generated as a result of direct impacts. Indirect impacts include the direct impacts of purchases of inputs (e.g., labor and intermediate inputs) by industries that sell to the industry responsible for the direct impacts, and by the industries that sell to those industries, and so on.
Induced Effects	The impacts associated with increases in household expenditures that result from increases in household income associated with direct and indirect impacts. The inclusion of induced impacts based on "income effects" is what distinguishes Type II multiplier Effects from Type I multiplier effects.
Total Effects	The total of all direct, indirect, induced impacts.
Industry Output	Total industry production, equal to shipments plus net additions to inventory.
Jobs	Annual average number of full time-equivalent jobs, including self-employed individuals.
Employee Compensation	Total payroll costs, including wages and salaries plus benefits.
Indirect Business Tax	Sales, excise fees, licenses and other taxes paid during normal operation. This includes all payments to the government except for taxes based on income.
Labor Income	Sum of Employee Compensation and Proprietor's Income.
Other Property Income	Includes corporate income, rental income, interest and corporate transfer payments.
Proprietor Income	Income from self-employment.
Total Value Added	The value added during production to all purchased intermediate goods and services. This is equal to employee compensation plus proprietor's income plus other property income plus indirect business taxes.

*Source: Adapted from IMPLAN User Guide, Version 2.0

3.2 Economic Impacts Associated with the Mean Value of Ex-Vessel Landings over the 2009-10 through 2011-12 Fishing Seasons

Below we provide economic impact estimates at the county, region, and state-wide scales. Note that these economic impact estimates are based on the mean value of ex-vessel landings over the 2009-10, 2010-11, and 2011-12 spiny lobster commercial seasons. We estimate that the multiplier effect associated with commercial landings resulted in total annual statewide economic output of ~$22,523,000 and 323 FTE jobs (Table 3). Of the California counties in which spiny lobster landings occurred, San Diego County experienced the largest share of statewide output and jobs (Table 4).

Table 3. Economic Impacts for the State of California

	California			
	Direct Effects	**Indirect Effects**	**Induced Effects**	**Total Effects**
Output	$11,188,354	$4,992,389	$6,342,309	$22,523,052
Employee Compensation	$695,893	$1,401,744	$1,778,367	$3,876,004
Proprietor's Income	$3,831,866	$208,003	$293,616	$4,333,496
Labor Income Effect	$4,527,770	$1,609,747	$2,071,983	$8,209,500
Other Property Type Income	$198,604	$691,843	$1,315,695	$2,206,142
Indirect Business Taxes	$750,257	$337,810	$373,031	$1,461,110
Total Value Added	$5,476,632	$2,639,411	$3,760,708	$11,876,751
Jobs	241.4	34.8	46.7	322.8

Table 4. Economic Impacts by County: Los Angeles, Orange, Santa Barbara, San Diego, and Ventura

	Los Angeles				Orange			
	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$1,943,905	$882,078	$1,098,382	$3,924,364	$1,650,987	$676,320	$790,676	$3,117,983
Employee Compensation	$120,907	$243,046	$310,368	$674,321	$102,688	$197,796	$216,747	$517,231
Proprietor's Income	$665,764	$38,835	$52,973	$757,571	$565,442	$29,148	$40,142	$634,732
Labor Income Effect	$786,671	$281,882	$363,343	$1,431,894	$668,130	$226,945	$256,889	$1,151,963
Other Property Type Income	$34,506	$120,716	$228,897	$384,119	$29,307	$102,006	$173,631	$304,944
Indirect Business Taxes	$130,354	$58,824	$64,413	$253,590	$110,710	$48,917	$49,292	$208,919
Total Value Added	$951,530	$461,423	$656,651	$2,069,603	$808,147	$377,868	$479,811	$1,665,826
Jobs	41.9	6.1	8.2	56.2	35.6	4.8	5.8	46.3

	Santa Barbara				San Diego			
	Direct Effects	Indirect Effects	Induced Effects	Total Effects	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$2,353,173	$659,931	$899,510	$3,912,615	$3,643,257	$1,303,157	$1,665,442	$6,611,856
Employee Compensation	$146,363	$205,255	$259,506	$611,126	$226,603	$394,015	$472,866	$1,093,487
Proprietor's Income	$805,931	$32,763	$44,623	$883,317	$1,247,768	$56,011	$76,763	$1,380,543
Labor Income Effect	$952,296	$238,019	$304,129	$1,494,443	$1,474,375	$450,026	$549,629	$2,474,027
Other Property Type Income	$41,771	$103,191	$205,634	$350,597	$64,671	$193,329	$370,064	$628,061
Indirect Business Taxes	$157,797	$53,097	$58,194	$269,088	$244,306	$100,142	$107,902	$452,350
Total Value Added	$1,151,864	$394,307	$567,957	$2,114,128	$1,783,352	$743,494	$1,027,595	$3,554,438
Jobs	50.8	6.0	7.7	64.4	78.6	10.8	13.3	102.8

	Ventura			
	Direct Effects	Indirect Effects	Induced Effects	Total Effects
Output	$1,597,033	$517,177	$582,053	$2,696,263
Employee Compensation	$99,332	$160,609	$166,446	$426,387
Proprietor's Income	$546,963	$18,479	$26,436	$591,880
Labor Income Effect	$646,295	$179,088	$192,883	$1,018,267
Other Property Type Income	$28,349	$76,490	$135,721	$240,560
Indirect Business Taxes	$107,092	$41,226	$39,983	$188,301
Total Value Added	$781,738	$296,804	$368,587	$1,447,128
Jobs	34.5	4.2	4.9	43.5

Section 4.0 Estimated Expenditures in the Spiny Lobster Recreational Fishery

We developed a recreational survey instrument that, like other recreational fishing surveys, seeks expenditure information associated with spiny lobster fishing. Capital expenditures on vessel and non-specific gear are weighted by the reported percentage of targeted usage in the spiny lobster recreational fishery. The survey instrument is provided in Appendix B of this report. A stratified random sampling design was also developed for CDFW. In order to preserve confidentiality, CDFW conducted the telephone surveys and provided us with tabulated results. We begin with an overview of the survey methodology, and then provide demographic summary information and expenditure estimates drawn from the tabulated results of the survey.

4.1 Survey Methodology

A stratified random sampling design was developed for sampling spiny lobster recreational fishermen, as it is likely that there are substantially different levels and types of expenditure across groups of fishermen. Stratified sampling takes advantage of the ability to create groups where the target of interest (i.e., angler expenditures) is most similar among units (i.e., recreational fishermen) within a stratum, which helps reduce variation of the overall estimate (Thompson 1992, see Cochran 1977, for greater detail on stratified sampling). In this case we use strata that delineate groups based on home origin (i.e., the fisherman's residence), catch location, and gear type.

Stratification based on home origin regions was used in an attempt to account for potential differences in expenditure incurred by geographic area. Home origin is defined as the location where people live, and was determined based on the zip codes provided on spiny lobster report cards. The rationale for home origin groups is based on the likelihood that fishermen traveling to the catch location from further away have an increased likelihood of incurring a lodging expense. Catch location pertains to the area fished, as indicated by the location codes on the report cards. The rationale for catch location groups is based on the likelihood that fuel and related expenditures linked to additional vessel transit distance to the fishing grounds will vary across catch locations. This is especially the case for offshore and island catch locations where transit expenditures are expected to be considerably higher than catch locations that are closer to the coast.

We based our final decision on appropriate home origin regions on sample size considerations, geographical breaks related to population density (extent of urbanization), and graphical analyses. As illustrated in Figure 1 the majority of returned cards are from coastal zip codes immediately adjacent to the coast (1,174 of 4,640), or zip codes for locations outside the immediate coastal strip but within 50 miles of the coast (2,834 of 4,640). There was a large drop-off in the number of returned report cards beyond 50 miles from the coast (632 of 4,640), suggesting a substantial decrease in activity from fishers further than 50 miles from the coast, assuming that reporting rates do not differ with distance from the coast. In addition, most of the population

lives within 50 miles of the coast, and are more likely to take day trips to go fishing with reduced expenditures per fishing trip compared to those who would travel from further away and make longer trips.

In summary, we utilized the following home origin regions:

1. Coastal (zip codes directly adjacent to the coast)
2. Regional (i.e., close enough to the coast for reasonable day trip, < 50 miles, but beyond coastal)
3. Beyond (> 50 miles from the coast)

Figure 1. Map of Potential Home Origin of California Spiny Lobster Recreational Fisherman. Note that "Within 50 miles to Coast" includes zip code areas that are partially within this zone

In addition to home origin regions, we also pre-stratified based on catch location regions. Fishing grounds in coastal waters off San Diego, Los Angeles/Orange County, and Santa Barbara/Ventura were grouped into a "Not Offshore" category (3,679 of 4,640 report cards). Due to the potential for greater trip expenditures associated with catch locations in the Channel Islands and more distant offshore grounds, a second category, "Offshore and Islands" (961 report cards) was created.

Finally, gear type is an important consideration for pre-stratification in that the focus of the trip and behavior patterns/investment in the recreational fishery may differ a great deal. Anglers targeting spiny lobster generally utilize either some type of diving gear, or deploy some form of hoop net. The equipment associated with each method also differs, as does the expenditure of the equipment.

For the purposes of pre-stratification, we collapsed the 2 types of hoop netting (traditional basket-style hoop nets and rigid conical-style hoop nets) into one category, "hoopers", and the 2 types of diving (skin and scuba) into another category, "divers" (Barsky 2003). Overall there were a greater number of returned report cards for hoopers (2,840) than divers (1,800). The CDFW's 2007 creel survey of recreational lobster fishermen found that 80% used hoop nets and 20% were divers.

We had considered finer breaks in categories (e.g., between traditional and rigid hoop nets, or between scuba and skin diving), but concluded that differences in net technology did not warrant further stratification. Due to sample size considerations (i.e., relatively few skin divers), and the large degree of overlap between the 2 activities for many fishermen, we opted for a single comprehensive "divers" category.

Analysis of activity patterns also showed the strongest differences between gear types (see Figure 2), supporting the idea that the expenditures between hoopers and divers may be considerably different. Distributions of activity patterns were plotted using kernel smoothing techniques (Bowman and Azzalini 1997) to allow graphical comparisons among gear types. Kernel smoothing was used to estimate probability densities for the range of values of activity patterns found in the dataset. These probability densities were plotted against the number of trips to graphically represent distributions of activity patterns. In general, divers tended to take more trips per year than hoopers, and were more likely to make > 5 trips in a year/season.

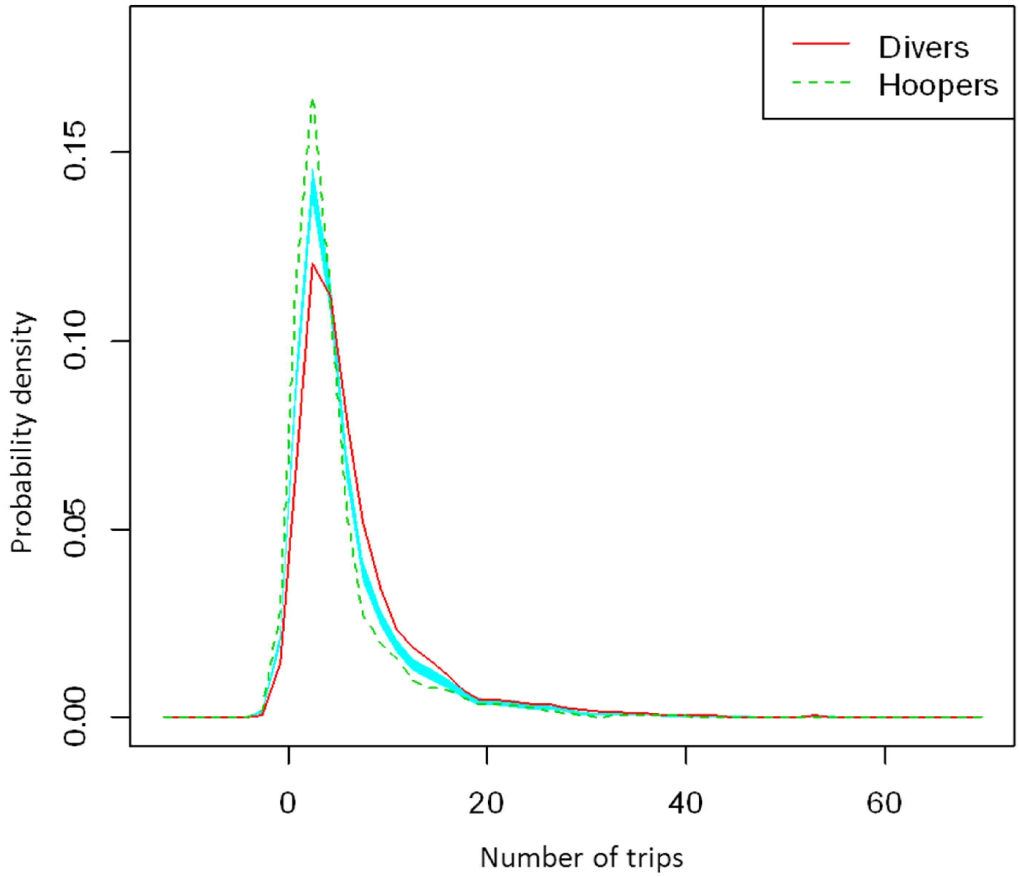

Figure 2. Smoothed Probability Density Distribution Curves for Activity Patterns by Gear Type. The turquoise band is a reference band of equality (see Bowman and Azzalini 1997); if both lines fall within the band, there is no difference between the 2 distributions.

To classify the data, we designated a dominant gear type used by a fisherman (defined as > 50% of trips, i.e., > 50% of trips diving resulted in classification as "divers"; > 50% of trips hooping resulted in classification as "hoopers"; 50/50% of trips for "divers"/"hoopers" resulted in classification as "both" (1 report card)). If no one category represented > 50% of the trips (27 report cards), we evaluated the detailed record of trips to determine the appropriate gear category (23 of 27 were deemed "both"). Due to the small number of fishermen in the "both" category however, we decided to lump this category with the category that had the most similar pattern of activity, the "hoopers."

We developed stratum-specific sample sizes that are proportional to the stratum size (i.e., proportional allocation). If we had more information regarding variance of expenditures within each stratum, we could try to achieve optimal allocation of sampling effort using different sampling proportions per stratum, minimizing variance for a given expenditure; however, this information does not currently exist. Proportional allocation is the same as the optimal allocation scheme in that it minimizes variation for a given expenditure under certain conditions (i.e., when the stratum variances are equal and the costs of sampling each unit within a given stratum are equal) (Chambers and Clark 2012). For the purpose of this study, we are assuming that

both conditions hold. Although it would be desirable to allocate more effort to those strata that have greater variance, there are no data to support that allocation at this time. In addition, it is reasonable to assume that calling an angler from one stratum will have a similar cost to calling a fisherman in any other stratum. Table 5 provides the proposed stratum sizes and the sample sizes by stratum.

Table 5. Sample Sizes by Stratum

Home Origin	Location	Gear Type	Stratum Size	Proportion of Total	Proposed Sample Size	Actual Sample Size
< 50	Not offshore	Hoopers	1,711	0.37	111	140
< 50	Not offshore	Divers	708	0.15	46	64
< 50	Offshore	Hoopers	236	0.05	15	20
< 50	Offshore	Divers	179	0.04	12	17
Beyond	Not offshore	Hoopers	198	0.04	13	18
Beyond	Not offshore	Divers	114	0.02	7	10
Beyond	Offshore	Hoopers	44	0.01	3	4
Beyond	Offshore	Divers	276	0.06	18	24
Coastal	Not offshore	Hoopers	537	0.12	35	47
Coastal	Not offshore	Divers	411	0.09	27	37
Coastal	Offshore	Hoopers	114	0.02	7	10
Coastal	Offshore	Divers	112	0.02	7	10
Total			4,640		300	401

A minimum proposed sample size per stratum of 3 was selected, as this is the absolute minimum required to generate a reasonable estimate of variance. For the vast majority of strata, proposed sample sizes are much greater than 3 (see Table 5). The strata selected were a balance between the idea of lumping strata to provide the greatest sample sizes possible per stratum, and making sure that we had enough strata to capture the groups most likely to have relatively large differences in expenditures with similar expenditures within each group. This approach resulted in a recommendation of a total sample size of 300 completed interviews, which amounts to picking the sample size that allows us to use 3 at a minimum for any given stratum under proportional allocation.

Interviews were conducted by telephone by CDFW personnel based on a list of randomly selected spiny lobster report card identification numbers. CDFW personnel then linked the selected identification numbers to the appropriate phone numbers before making the telephone calls. Potential survey participants were selected from recreational fishery participants who returned a 2011 spiny lobster report card. Interviewers would call a number, and if they were unsuccessful with the target interviewee (no answer, refusal to

participate, language barrier), then they would move on to the next contact on the list. If they completed the list for a particular stratum and still had not met the target number of completed surveys, then they would start over from the top of the list in an attempt to reach target interviewees who did not answer the first time (skipping prior refusals, language barriers, and completed interviews). Under this procedure the maximum number of times that a contact could be called was twice. In contrast meeting the sample size for some of the stratum groups was easier (more people answered the phone, fewer refusals, language barriers, etc.) and interviewers did not have to call all of the contacts on the list. A few contacts were obviously erroneous or didn't have phone numbers: Interviewers did not attempt to contact these people. CDFW generally found anglers to be willing to participate, and as a result CDFW elected to increase sample size by about 1/3 overall, with increases spread as evenly as possible across all strata. The column "actual sample size" in Table 5 indicates the number of recreational fishers interviewed by CDFW.

4.2 Expenditure Estimates for the Spiny Lobster Recreational Fishery

4.2.1 Estimation Methods

Estimates of the mean expenditures were generated using a bottom-up approach, taking estimates of the mean expenditure from respondents and extrapolating to the total number of report cards that were sold. Estimates of expenditures (mean, standard deviation) were first generated by stratum in accordance with the stratified sampling design used to select participants for the telephone survey. Mean expenditure for each stratum was generated based on the following formula for stratified estimators from Cochran (1977):

$$\bar{y}_{st} = \sum \frac{N_h}{N} \cdot \bar{y}_h ,$$

where N_h is the number of spiny lobster report cards in stratum h, N is the total number of spiny lobster report cards sold in 2011 adjusted by the % of returned cards that did not fish (13.5%), N = 28,868, and $\bar{y}_h$ is the estimated mean expenditure for stratum h. Once this estimate was obtained, the total was simply calculated as:

$$\hat{Y} = N \cdot \bar{y}_{st} .$$

Estimates of the 95% confidence interval for total expenditures were calculated based on the estimated sampling variance as:

$$\hat{Y} \pm t \cdot \sqrt{\hat{V}\left(\hat{Y}_{st}\right)} ,$$

where t is the appropriate t-value, and the sampling variance is estimated as:

$$\hat{V}\left(\hat{Y}_{st}\right) = \sum \frac{N_h(N_h - n_h)(s_h^2)}{n_h},$$

where N_h is as defined previously, n_h is the stratum sample size, and s_h^2 is the stratum variance (Cochran 1977).

All trip-related expenditures were attributed to spiny lobster fishing expenditures, as the survey instrument specifically asked for typical expenditures associated with spiny lobster fishing trips. In contrast, annual boat-related costs, which included items such as boat insurance and gear replacement, were attributed to spiny lobster fishing based on the percentage of annual boat or water craft usage that was reportedly dedicated to spiny lobster fishing in 2011. Note that these costs are subject to potential inestimable inaccuracies of the interviewee's perception of the percentage of their boat usage for spiny lobster fishing. The exceptions to the calculations based on the percentage of annual boat or water craft usage for spiny lobster fishing were fishing gear and related expenditures specifically linked to spiny lobster fishing. In calculating the average annual expenditure for the "other" costs (Question 10 of the annual, seasonal, one-time expenditure section), we assumed that these costs were strictly related to spiny lobster due to the way the question was worded (i.e., "…related to recreational lobster fishing…"), and so these costs were not adjusted based on vessel usage in the spiny lobster fishery.

In their 2006 estimation of the economic contribution of marine angler recreation in the U.S., Gentner and Steinback (2008) utilized a mail survey methodology applied to a sample of anglers originated from the Marine Recreational Information Program (MRIP) intercept survey to elicit angler expenditure information. As with the present study, Gentner and Steinback (2008) used a license-based random survey frame for their California angler expenditure estimates. They report the potential for avidity bias that could affect certain categories of durable expenditures, based on prior experience, and corrected for avidity bias using weights developed by Thomson (1991). One can argue that mail surveys such as those employed by Gentner and Steinback (2008) require an elevated level of commitment and initiative on the part of the angler to complete and return, and this commitment and initiative may be correlated with their level of avidity. In contrast, our telephone interview methodology at least partially addresses this issue and we therefore do not believe there is a strong case for avidity bias in our data, and consequently do not apply avidity weights.

For total annual travel expenditures, most categories of responses were multiplied by the respondent's number of trips (extracted from a separate CDFW database). We also applied $0.55 per mile to reported spiny lobster fishing-related ground transportation based on the federal rate from 2011. To determine total annual respondent expenditures on dive or party boat trips, we multiplied the reported cost per trip fare by the reported number of such trips in 2011.

For the calculation of the 95% confidence interval (CI) for total cost for a particular expenditure category, we used a weighted average of the degrees of freedom based on the effective "n" (see Satterthwaite 1946, as cited

in Cochran 1977) for each cost type (i.e., annual boat purchase cost, boat insurance, etc.) to find the appropriate t-value; weights were based on the contribution of the cost type to the total annual cost.

4.2.2 Demographic Information and Estimated Expenditures in California's Recreational Fishery for Spiny Lobster

Means, totals, and standard deviations (SD) for expenditures are presented in Tables 6 through 10. The average recreational fisherman has fished spiny lobster for nearly 9 years and spends an average of just over 2/3 of a day on a typical fishing trip (Table 6). Spiny lobster fishing constitutes an average of just over 1/3 of a recreational fisherman's total fishing effort in a given year (Table 6). Private vessels provide just over 1/2 of all access to the recreational fishery (Table 7), and on average about 8% of a vessel's annual usage was estimated to be targeted at spiny lobster fishing (Table 8A).

Annual expenditures in the recreational fishery for spiny lobster in California are estimated to be $37,093,000 (Table 9). The largest sources of expenditures were non-coastal residents who live within 50 miles of the coast who fished spiny lobster along the coast, and those who live more than 50 miles from the coast who dove for spiny lobster offshore (Table 9). Spiny lobster gear, boat/gear maintenance, and boat purchases were the largest annual expenditure categories (Table 8), while transportation, vessel fuel, meals and beverages, and dive/party boat fees were the largest trip-based expenditure categories (Table 10). Note that not all of these expenditures necessarily occur in California. Also note that these are expenditures and not total economic impact, which is beyond the scope of this report.

Table 6. Demographic Estimates for the Spiny Lobster Recreational Fishery, Means and Standard Deviations

Home Origin	Location	Gear Type	Years Fishing for Spiny Lobster		Spiny Lobster Fishing Trip Duration (Days)		Fraction of Total Fishing Effort (Lobster)	
			Mean	SD	Mean	SD	Mean	SD
<50	Not offshore	Hoopers	3.91	5.95	0.31	0.40	0.26	0.30
	Not offshore	Divers	18.18	13.45	0.31	0.35	0.43	0.29
	Offshore	Hoopers	8.10	11.17	1.28	0.82	0.26	0.26
	Offshore	Divers	12.88	11.76	0.81	0.97	0.57	0.33
Beyond	Not offshore	Hoopers	2.12	1.41	0.57	1.24	0.34	0.42
	Not offshore	Divers	7.70	13.00	1.73	1.43	0.41	0.47
	Offshore	Hoopers	2.50	1.29	2.38	1.49	0.37	0.44
	Offshore	Divers	9.46	11.15	3.90	2.77	0.49	0.43
Coastal	Not offshore	Hoopers	9.91	16.38	0.18	0.07	0.28	0.32
	Not offshore	Divers	11.57	11.35	0.24	0.35	0.47	0.34
	Offshore	Hoopers	2.60	0.94	0.79	1.35	0.30	0.38
	Offshore	Divers	21.70	16.73	1.41	1.55	0.45	0.29
		Overall	8.75	3.86	0.68	0.25	0.35	0.13

Table 7. Proportion of Recreational Fishermen who Fish for Spiny Lobster by Access Type

			Proportion by Access Type											
Home Origin	Location	Gear Type	Beach	Beach/ Boat	Boat	Charter Boat	Jetty	Kayak	Launch from Beach	Party Boat	Pers. Water-Craft	Pier	Private Boat	Shore
<50	Not offshore	Hoopers	0.03	0.00	0.00	0.00	0.01	0.04	0.01	0.05	0.00	0.22	0.64	0.00
	Not offshore	Divers	0.50	0.00	0.00	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.44	0.00
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.95	0.00
	Offshore	Divers	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.41	0.00
Beyond	Not offshore	Hoopers	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.28	0.56	0.00
	Not offshore	Divers	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.10	0.00	0.00	0.30	0.00
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Offshore	Divers	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.17	0.00
Coastal	Not offshore	Hoopers	0.04	0.00	0.00	0.00	0.02	0.00	0.00	0.06	0.02	0.15	0.70	0.00
	Not offshore	Divers	0.68	0.03	0.11	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.11	0.03
	Offshore	Hoopers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
	Offshore	Divers	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.30	0.00
		Mean	0.18	0.00	0.01	0.00	0.01	0.02	0.02	0.10	0.00	0.11	0.54	0.00

Table 8A. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	Boat or Water Craft		% of Annual Boat or Water Craft Usage (for Lobster)		Boat Insurance		Slip Fees	
			Total	SD	Mean	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$996,904	$6,358,197	0.08	0.17	$132,034	$331,774	$159,637	$979,413
	Not offshore	Divers	$823,356	$3,560,214	0.13	0.25	$119,658	$303,138	$307,318	$1,198,819
	Offshore	Hoopers	$0	$0	0.08	0.12	$94,743	$168,694	$247,802	$850,070
	Offshore	Divers	$0	$0	0.09	0.18	$81,912	$246,970	$263,756	$820,755
Beyond	Not offshore	Hoopers	$369,600	$1,083,138	0.09	0.20	$116,458	$435,255	$246,640	$1,045,327
	Not offshore	Divers	$0	$0	0.10	0.32	$56,720	$179,364	$10,635	$33,631
	Offshore	Hoopers	$0	$0	0.04	0.07	$4,829	$9,119	$0	$0
	Offshore	Divers	$0	$0	0.00	0.01	$486	$2,383	$0	$0
Coastal	Not offshore	Hoopers	$24,880	$147,694	0.12	0.23	$64,926	$209,046	$80,596	$264,884
	Not offshore	Divers	$62,197	$378,331	0.08	0.20	$22,446	$85,459	$74,844	$362,830
	Offshore	Hoopers	$177,250	$560,514	0.02	0.03	$53,459	$168,057	$116,560	$236,388
	Offshore	Divers	$0	$0	0.06	0.08	$55,412	$135,934	$170,068	$402,831
		Overall	$2,454,188	$7,399,602	0.08	0.08	$803,083	$781,569	$1,677,855	$2,303,579

Table 8B. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	DMV Registration Fees (Boat and Trailer)		Boat Taxes		Annual Maintenance or Replacement of Boat Gear and Equipment	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$88,976	$524,967	$32,809	$124,490	$743,664	$2,074,209
	Not offshore	Divers	$30,517	$105,277	$44,115	$139,018	$1,320,574	$3,934,693
	Offshore	Hoopers	$3,242	$6,473	$55,775	$97,186	$375,212	$708,445
	Offshore	Divers	$13,171	$48,453	$11,795	$48,633	$156,615	$488,614
Beyond	Not offshore	Hoopers	$5,041	$17,584	$704,978	$2,900,032	$162,610	$359,090
	Not offshore	Divers	$2,127	$6,726	$19,143	$60,535	$141,800	$448,411
	Offshore	Hoopers	$1,199	$1,968	$103	$206	$10,275	$20,550
	Offshore	Divers	$236	$865	$347	$1,495	$1,216	$5,273
Coastal	Not offshore	Hoopers	$19,001	$60,846	$24,197	$88,904	$489,314	$1,228,024
	Not offshore	Divers	$6,256	$19,150	$1,555	$6,971	$85,438	$264,160
	Offshore	Hoopers	$2,184	$6,709	$28,360	$89,682	$52,466	$133,029
	Offshore	Divers	$1,046	$3,306	$33,805	$92,672	$183,311	$548,287
		Overall	$172,996	$541,800	$956,982	$2,912,914	$3,722,496	$4,769,842

Table 8C. Estimated Annual Recreational Fisherman Expenditure Estimates

Home Origin	Location	Gear Type	Electronic Gear		Spiny Lobster Fishing Gear		Other Expenditures	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$102,838	$421,853	$1,237,232	$2,089,914	$49,765	$251,005
	Not offshore	Divers	$105,514	$461,687	$956,023	$1,616,749	$310,185	$896,550
	Offshore	Hoopers	$371,829	$1,598,685	$128,267	$167,942	$0	$0
	Offshore	Divers	$0	$0	$441,668	$916,559	$6,553	$27,018
Beyond	Not offshore	Hoopers	$34,393	$145,152	$142,638	$301,803	$34,222	$53,711
	Not offshore	Divers	$0	$0	$138,539	$163,857	$9,217	$29,147
	Offshore	Hoopers	$8,220	$16,440	$22,263	$32,311	$0	$0
	Offshore	Divers	$179	$876	$223,925	$351,706	$114,467	$507,369
Coastal	Not offshore	Hoopers	$47,201	$180,077	$436,463	$595,724	$99,306	$205,614
	Not offshore	Divers	$8,120	$34,446	$587,765	$950,450	$40,322	$126,447
	Offshore	Hoopers	$13,294	$39,024	$14,180	$29,894	$1,418	$4,484
	Offshore	Divers	$6,970	$22,041	$59,594	$108,607	$0	$0
		Overall	$698,557	$1,733,168	$4,388,555	$3,059,985	$665,455	$1,089,486

Table 9. Estimated Total Recreational Fisherman Annual, Trip, and Grand Total Expenditures, with 95% Confidence Intervals

Home Origin	Location	Gear Type	Annual			Trip			Grand Total		
			Total	95% CI		Total	95% CI		Total	95% CI	
<50	Not offshore	Hoopers	$3,543,861	$2,361,061	$4,726,661	$3,834,313	$3,150,282	$4,518,343	$7,378,174	$6,011,104	$8,745,243
	Not offshore	Divers	$4,017,260	$2,599,456	$5,435,064	$3,985,715	$2,738,220	$5,233,210	$8,002,975	$6,114,130	$9,891,820
	Offshore	Hoopers	$1,276,869	$415,100	$2,138,638	$980,949	$680,996	$1,280,902	$2,257,818	$1,344,622	$3,171,015
	Offshore	Divers	$975,471	$333,234	$1,617,707	$1,548,263	$834,119	$2,262,408	$2,523,734	$1,563,307	$3,484,161
Beyond	Not offshore	Hoopers	$1,816,581	$273,546	$3,359,615	$1,965,233	$730,433	$3,200,033	$3,781,813	$1,804,999	$5,758,628
	Not offshore	Divers	$378,181	$57,898	$698,463	$1,212,433	$629,897	$1,794,968	$1,590,613	$926,116	$2,255,110
	Offshore	Hoopers	$46,888	$4,951	$88,826	$301,277	$168,425	$434,128	$348,165	$208,946	$487,384
	Offshore	Divers	$340,857	$93,260	$588,453	$4,446,683	$3,417,064	$5,476,301	$4,787,540	$3,729,359	$5,845,720
Coastal	Not offshore	Hoopers	$1,285,883	$872,100	$1,699,667	$1,064,607	$759,732	$1,369,482	$2,350,490	$1,836,345	$2,864,636
	Not offshore	Divers	$888,944	$524,635	$1,253,253	$1,470,411	$956,378	$1,984,444	$2,359,354	$1,729,461	$2,989,248
	Offshore	Hoopers	$459,170	$53,438	$864,901	$362,971	$161,455	$564,488	$822,141	$368,839	$1,275,443
	Offshore	Divers	$510,204	$69,977	$950,431	$379,741	$198,481	$561,001	$889,945	$413,520	$1,366,370
		Overall	$15,540,168	$12,752,113	$18,328,223	$21,552,594	$19,103,798	$24,001,390	$37,092,762	$33,381,291	$40,804,233

Table 10A. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Dive/Party Boat		Trip Duration (Days)		Dive Gear Rental		Gas for Boat	
			Total	SD	Mean	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$344,214	$2,738,838	0.01	0.06	$0	$0	$1,145,767	$2,382,055
	Not offshore	Divers	$138,689	$573,076	0.11	0.39	$56,439	$311,032	$1,866,268	$4,559,396
	Offshore	Hoopers	$58,720	$262,604	0.05	0.22	$0	$0	$482,671	$512,848
	Offshore	Divers	$357,791	$498,163	0.74	1.03	$14,416	$41,824	$424,303	$1,041,751
Beyond	Not offshore	Hoopers	$110,196	$262,896	0.22	0.55	$0	$0	$586,432	$2,013,328
	Not offshore	Divers	$41,831	$111,676	1.30	2.75	$15,385	$27,500	$111,313	$186,151
	Offshore	Hoopers	$0	$0	0.00	0.00	$0	$0	$37,675	$46,627
	Offshore	Divers	$960,447	$762,612	2.31	1.41	$15,024	$73,601	$233,226	$804,117
Coastal	Not offshore	Hoopers	$45,104	$188,994	0.34	1.13	$28,789	$197,371	$340,833	$590,418
	Not offshore	Divers	$289,563	$920,521	0.22	0.58	$21,424	$74,856	$427,157	$931,467
	Offshore	Hoopers	$0	$0	0.00	0.00	$0	$0	$211,353	$279,208
	Offshore	Divers	$76,670	$181,309	0.35	0.75	$12,546	$26,653	$129,642	$185,872
		Overall	$2,423,223	$3,118,636	0.30	0.19	$164,024	$387,211	$5,996,639	$5,820,325

Table 10B. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Bait		Lodging		Meals and Beverages	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$550,088	$1,202,154	$29,350	$208,747	$606,951	$951,956
	Not offshore	Divers	$100,145	$401,754	$69,516	$406,371	$788,712	$1,611,999
	Offshore	Hoopers	$40,084	$61,474	$0	$0	$258,148	$338,814
	Offshore	Divers	$0	$0	$199,865	$809,822	$123,195	$184,072
Beyond	Not offshore	Hoopers	$131,687	$290,395	$99,929	$294,769	$357,964	$1,098,757
	Not offshore	Divers	$0	$0	$120,530	$226,806	$156,689	$172,392
	Offshore	Hoopers	$2,466	$2,882	$21,920	$26,846	$75,350	$51,867
	Offshore	Divers	$7,512	$20,770	$263,989	$527,002	$413,869	$729,396
Coastal	Not offshore	Hoopers	$189,079	$275,496	$0	$0	$269,793	$715,548
	Not offshore	Divers	$57,360	$221,558	$31,099	$189,166	$172,494	$274,195
	Offshore	Hoopers	$1,702	$4,474	$0	$0	$105,641	$130,282
	Offshore	Divers	$0	$0	$0	$0	$86,428	$115,243
		Overall	$1,080,122	$1,349,124	$836,197	$1,147,645	$3,415,234	$2,458,166

Table 10C. Estimated Recreational Fisherman Trip Expenditures

Home Origin	Location	Gear Type	Transportation		Harbor Fees		Other Expenditures	
			Total	SD	Total	SD	Total	SD
<50	Not offshore	Hoopers	$953,741	$1,073,774	$125,505	$296,981	$78,697	$286,990
	Not offshore	Divers	$674,139	$1,075,725	$138,386	$537,214	$153,421	$372,181
	Offshore	Hoopers	$79,690	$62,024	$40,737	$69,441	$20,900	$71,281
	Offshore	Divers	$349,141	$416,393	$25,163	$42,923	$54,389	$201,778
Beyond	Not offshore	Hoopers	$666,020	$1,259,517	$13,004	$33,400	$0	$0
	Not offshore	Divers	$713,013	$858,995	$15,953	$31,850	$37,719	$89,981
	Offshore	Hoopers	$153,591	$111,652	$8,905	$12,925	$1,370	$2,740
	Offshore	Divers	$2,474,852	$2,122,295	$52,726	$115,647	$25,040	$76,783
Coastal	Not offshore	Hoopers	$131,013	$306,673	$15,923	$63,522	$44,073	$135,831
	Not offshore	Divers	$318,532	$701,644	$57,152	$269,856	$95,630	$280,999
	Offshore	Hoopers	$36,477	$97,904	$7,799	$17,189	$0	$0
	Offshore	Divers	$62,203	$53,579	$3,346	$10,580	$8,906	$20,991
		Overall	$6,612,411	$3,150,726	$504,599	$690,215	$520,145	$615,246

Section 5.0 References

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Appendix A. Commercial Expenditure Update Survey

Following is the cover letter and the questionnaire used in the key-informant interviews with commercial spiny lobster fishermen. We produced fixed and variable cost questionnaires for each of 3 vessel size class strata – large, medium, and large. Included below are the cover letter and questionnaire used for informants with small vessels.

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

15 August 2012

Name of Recipient
1234 Street
City, CA 12345

Dear Commercial Lobster Fisherman:

A fishery management plan is in progress for the spiny lobster fishery, and we are updating expenditure information so that we better understand the positive economic contribution of commercial lobster fishermen to the state and to local economies in California.

In 2007 we did an economic survey of all commercial fishermen in California in order to generate expenditure information and to demonstrate their positive economic contribution. In this brief survey, we are providing you with average annual expenditures by category based on the 2007 survey results. We are asking you whether you feel that these averages are still a reasonable estimate of typical annual costs for a commercial lobster vessel less than 26 feet in length.

As you complete the survey, please note that we are not asking you to compare your expenditures to the averages, as each individual's annual expenditures on categories such as engine purchase will vary quite a bit. Instead we ask whether these averages are a reasonable estimate of typical annual costs for a commercial lobster vessel less than 26 feet in length.

If the answer is yes, then simply indicate that on the sheet. If they are not reasonable, then for a given cost category (such as bait or engine repair), please indicate to us how much higher or lower (in percentage terms) the typical annual expenditure should be.

We will call you within the next two weeks to get your responses. If you have any questions, please contact Sharon Kramer at skramer@harveyecology.com or (707) 822-4141 ext 101.

Please note that your individual responses will be kept confidential, and will be aggregated along with those from others to develop an updated estimate of total expenditures by all commercial lobster fishermen. Our goal is to generate an accurate estimate of the total positive economic contribution from commercial lobster fishing in California.

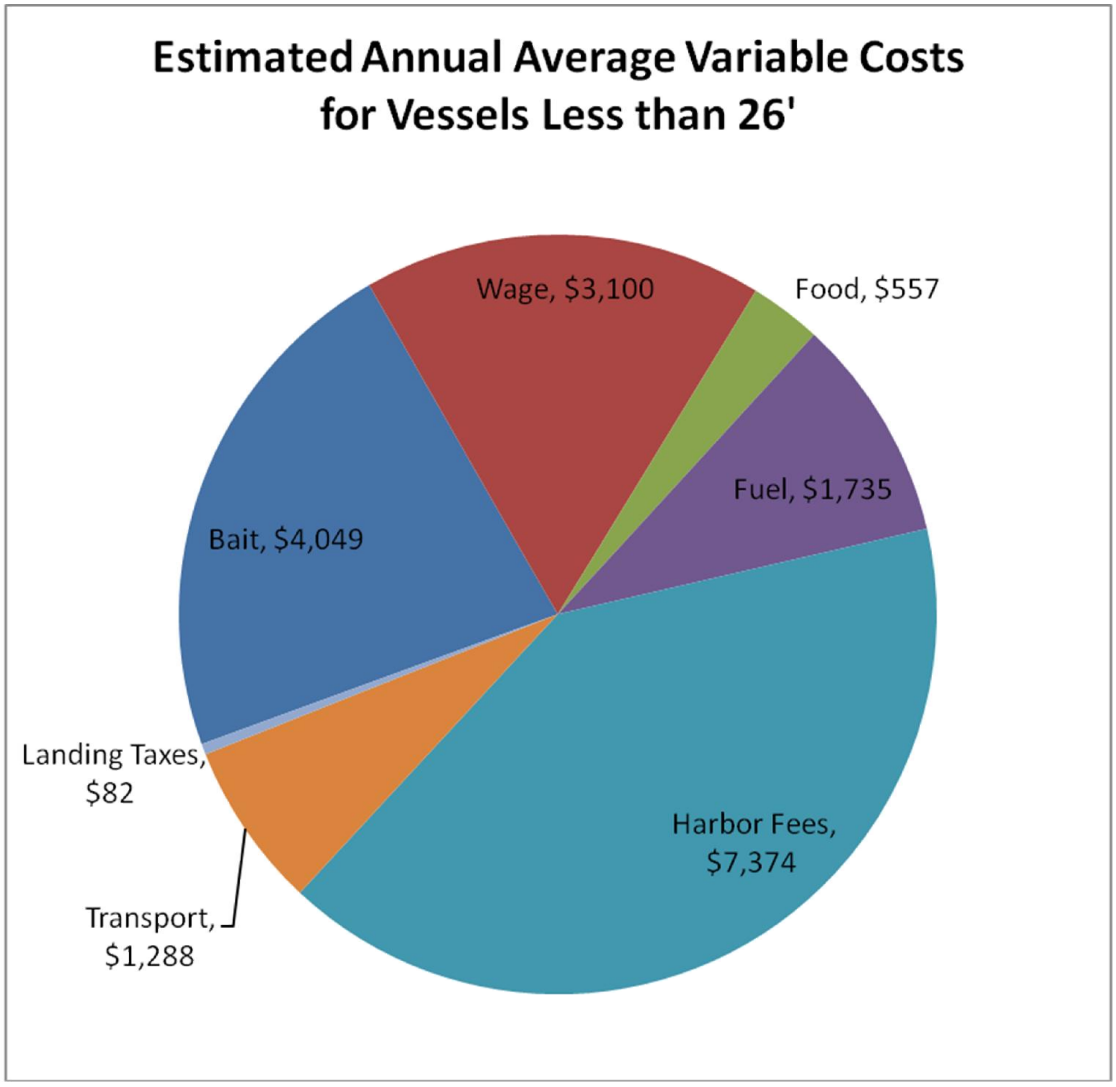
Thank you,

Steven C. Hackett

Sharon H. Kramer

Dr. Steven C. Hackett
Humboldt State University

Dr. Sharon Kramer
H. T. Harvey & Associates



Variable Costs are costs that increase or decrease based on how much you fish. The above estimated annual variable costs (adjusted for inflation) are averaged across all responses to our 2007 survey. These costs imply an average per-trip cost of $849.

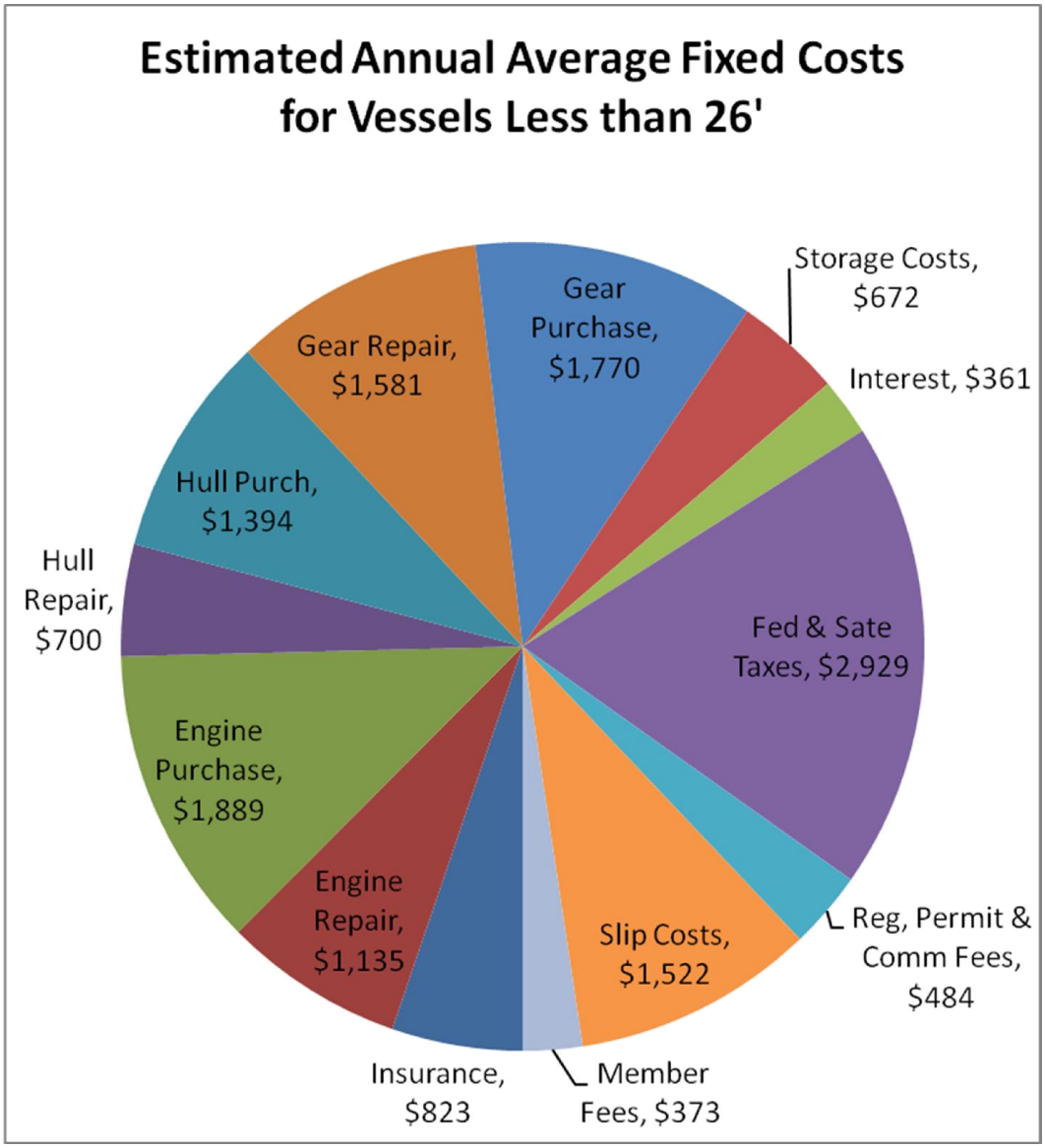
Do you feel that these are a reasonable estimate of typical annual variable costs for a lobster vessel less than 26 feet in length? **Yes / No** (circle one).

If **not**, then please correct the cost categories below. Circle whether the cost should increase or decrease, and indicate the correct percentage increase or decrease with an X.

Bait	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $4,049	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Crew Wages/Comp.	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $3,100	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Food (fishing-related)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $557	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Fuel & Lube (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,735	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Harbor Fees (ex: hoist)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $7,374	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Transportation*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,288	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Landing Taxes	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $82	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

* Transportation related to fishing (truck and auto)



Fixed Costs are costs that commercial fishermen incur whether they fish or not. The above estimated annual fixed costs (adjusted for inflation) are averaged across all responses to our 2007 survey.

Do you feel that these are a <u>reasonable estimate of typical annual fixed costs</u> for a lobster vessel less than 26 feet in length? **Yes / No** (circle one).

If **not**, then please correct the cost categories (ex. "Engine Purchase") needing adjustment. Circle whether the cost should increase or decrease, and indicate the correct percentage increase or decrease with an X.

Insurance (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $823	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Engine Repair (vessel)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,135	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Engine Purch. (vessel)*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,889	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Gear Repair	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,581	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Gear Purchase*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,770	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Hull Repair	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $700	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Hull Purchase*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,394	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Storage (vessel, gear)	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $672	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Interest (vessel)*	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $361	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Member/Assoc. Fees	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $373	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Federal & State Taxes	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $2,929	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)
Permit, License, Reg.	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $484	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

Slip Costs	increase / decrease	by:	___	0% - 20%	___	60% - 80%
Ann. Avg. = $1,522	(circle one)		___	20% - 40%	___	80% - 100%
			___	40% - 60%	___	100% + (specify %)

* The annual average cost reported for engine and hull purchases come directly from our 2007 survey. As these expenditures only occur infrequently (thankfully), the cost reported here can be thought of as an annualized cost, somewhat like an annual loan payment absent the interest. Vessel-related interest expenditures from vessel-related loan payments are listed separately above.

Appendix B. Recreational Fishery Expenditure Survey

Following is the telephone interview script used to gather demographic and expenditure information from participants in the spiny lobster recreational fishery. The sample frame was derived from CDFW's spiny lobster report card database of recreational fishery participants. Due to CDFW's confidentiality agreement associated with the report card database, the research team provided a survey methodology and sampling design and the calls were conducted by CDFW personnel.

RECREATIONAL LOBSTER PARTICIPANT SURVEY

Opening Script:

Introduce yourself
Describe purpose of call and of the project
DFG is trying to determine how much money is being generated by the recreational lobster fishery in the state of California. The information that we are interested in collecting goes beyond license sales. This survey will help DFG to accurately characterize the economic contribution of the fishery.

Responses will be protected, interviewee can contact Kristine Barsky for questions or comments [kbarsky@dfg.ca.gov, tel.# (805)985-3114]

Basic Questions Script:

I would like to start with some basic questions about your fishing history and how you fish. I will then turn to the economic questions.

1. How many years have you been fishing for lobster?
2. What is your most common type of access when you fish for lobster?
   Do you fish from a Pier/dock, launch from a beach, use a private boat, go on a party boat, or use a personal watercraft (kayak, etc.)?
3. On average, how many hours or days does the average lobster fishing trip take you, including travel time to and from fishing grounds (fraction of day is ok). I'm only asking about trips that you just fished for lobster. *Please tabulate as days (or fraction of days – xx hrs/24).*
   Trip definition = the time period in which a fisherman travels to the fishing grounds, seeks lobster, concludes fishing, and returns home
4. Approximately what percentage of your total fishing effort (including all fishing trips) was dedicated to lobster fishing in 2011?

Expenditure Questions Script:

Moving on to the economic questions. The first questions will address **annual, seasonal, or one-time expenditures** you have made that are linked to your lobster fishing activity. After that I'll ask about typical trip-related expenditures.

Do you own a boat or other water craft that you use for lobster fishing or diving?
If they answered yes, start with question 1, otherwise skip to question 9.

1. Did you purchase your boat or water craft this past year? If so, then how much did you spend?
2. What percentage of your annual boat or water craft usage was for fishing for lobster?
3. How much do you spend per year on boat insurance?

4. Do you keep your boat in the water, (If yes) then how much do you spend in total cost annually on slip fees?
5. How much do you spend annually on DMV registration fees for your boat and trailer?
6. How much do you spend annually on taxes (e.g., property or luxury taxes) on your boat?
7. How much did you spend last year on maintenance (like hull cleaning) or replacement of boat gear & equipment (boat, engine, equipment)?
8. If you own a boat or other water craft, did you purchase any electronic gear (GPS, radio, fish finder, radar, etc) this past year that was used for fishing lobster? If so, then how much did you spend?
9. Did you purchase any lobster fishing gear (dive gear, hoop nets, other lobster equipment) this past year? If so, then how much did you spend?
10. Excluding the cost of fishing licenses and report cards, are there any other annual, seasonal, or one-time expenditures related to recreational lobster fishing that you would like to add in?
    Ask for $$ and category

I would like to finish the survey with some questions about your **typical expenditures** associated with **lobster fishing trips**.

1. Did you purchase a spot on a dive boat or a party boat for lobster this last year (2011)?
2. If so, then how much do you typically spend on a single boat trip (just the cost of the trip fare)?
3. Did you rent dive gear for lobster fishing last year? If so, then how much do you typically spend on dive gear rentals per lobster fishing trip?
4. How much do you typically spend on gas for the boat you use (yours or a shared boat) on each lobster fishing trip?
5. How much do you typically spend on bait on a lobster fishing trip?
6. How much do you typically spend on lodging during a lobster fishing trip?
7. How much do you typically spend on meals and beverages during a lobster fishing trip?
8. How many miles (one-way) did you drive to a port, dock, or beach for each lobster fishing trip? [*Note: Researchers will double on-way miles you record and multiply by the average total cost per mile driven from the Department of Transportation to get $$ expenditure*]
9. If you trailer a boat to a launch facility for lobster fishing trips, then how much do you typically spend on harbor fees (boat launch, docking, or parking) per trip? (Includes smaller craft if relevant (kayak, paddle or surf board….).
   This should be entered as $0 if (i) the fisherman keeps a boat in the water and already provided a cost earlier in the survey, or (ii) they don't use a boat to fish
10. Are there any other expenditures you usually make on a typical recreational lobster fishing trip you would like to add?
    Ask for $$ and category; Examples = power wash, SCUBA tank air refills