Western Pacific Invertebrate Fisheries

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Unit 16

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Photo above:
Banded spiny lobster, Northwestern Hawaiian Islands.

INTRODUCTION

The Western Pacific fisheries for invertebrates target myriad species in state, territorial, commonwealth, and remote island waters, including lobsters, shrimp, squid, octopus, precious corals, and other species. Most of these fisheries are small scale and regulated only by the island fisheries agencies in the region.

The now-closed Northwestern Hawaiian Islands (NWHI; Figure 16-1) lobster trap fishery was the major commercial marine invertebrate fishery in the Western Pacific. A small-scale, primarily recreational, fishery for different species of lobster exists in the Main Hawaiian Islands (MHI), American Samoa, Guam, and the Northern Mariana Islands. A deepwater shrimp resource is found throughout the Pacific Islands but currently is lightly exploited. A resource of deepwater precious coral (gold, bamboo, and pink corals) and shallower coral (black corals) exists in Hawaii and possibly other Western Pacific areas. A short-lived domestic precious coral fishery operated in Hawaii from 1974 to 1979, but there was no significant precious coral harvest for 20 years until 1999–2001.

Management Situation

Fisheries management in this area is guided by the Western Pacific Fishery Management Council (WPFMC), approved by the Secretary of Commerce, and implemented by the National Marine Fisheries Service (NMFS). The NWHI lobster fishery and the Hawaii precious coral fishery are the only invertebrate fisheries managed by NMFS in this area.

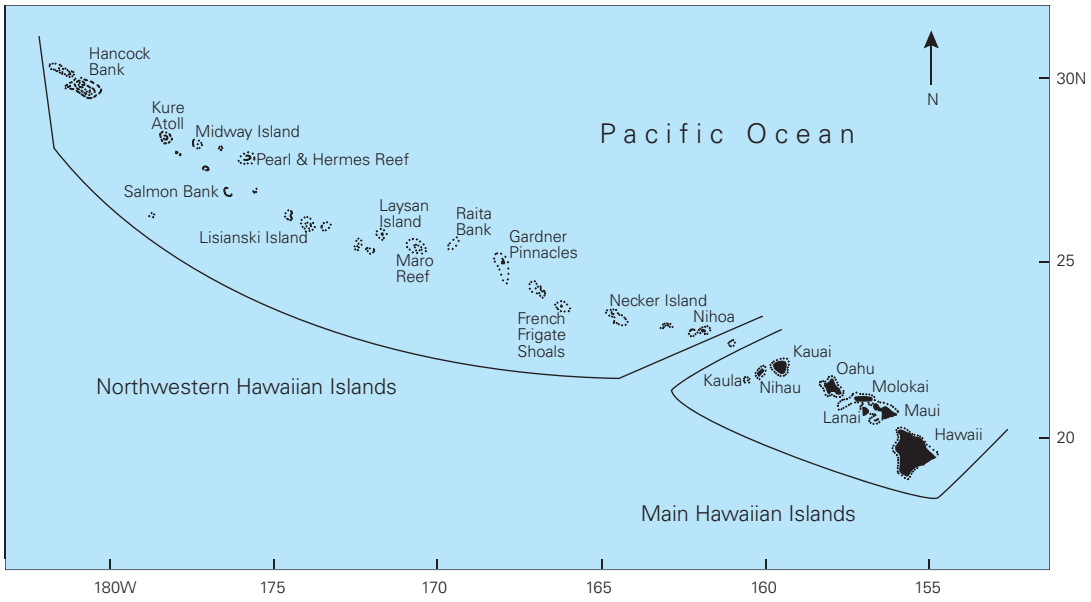


Figure 16-1
The Main Hawaiian Islands and the Northwestern Hawaiian Islands.

The NWHI comprises an isolated range of islands, atolls, islets, reefs, and banks that extend 1,500 n.mi. west-northwest of the Main Hawaiian Islands from Nihoa to Kure Atoll (Figure 16-1). A commercial lobster trap fishery operated in the NWHI from the mid 1970's through 1999. It was a multispecies fishery, primarily targeting the banded (Hawaiian) spiny lobster and blunt slipper lobster (ula-pāpapa). Three other species, pronghorn spiny lobster ('ula-hiwa), Aesop slipper lobster, and sculptured mitten lobster (ula-pehu), were also caught in low abundances. The Fishery Management Plan for the Crustaceans of the Western Pacific Region (Crustaceans FMP) combines all species of lobster into a single management unit. The MHI lobster fishery is managed by the State of Hawaii, although fishing on a few offshore banks is included under the Crustaceans FMP.

The Crustaceans FMP was implemented in 1983 and has since been amended nine times. Many of the earlier amendments were in response to requirements to eliminate any likelihood of interactions with the Hawaiian monk seal (Amendments 2 and 4), protect spiny and slipper lobster reproductive potentials (Amendments 3 and 5), and specify overfishing definitions (Amendment 6). A significant change occurred in 1992 when, in response to continuing declines in commercial lobster catch per unit of effort (CPUE), Amendment 7 was approved to include an annual 6-month closed season (January–June); limit entry into the fishery to 15 vessels; and establish an annual catch quota. Amendment 9 implemented in 1996 a lobster quota system based on a constant harvest rate that allows only a 10% risk of overfishing in any given year, but allows the retention of all lobsters caught (i.e. replacing the previous size restrictions). Spatial management of the lobster fishery commenced in 1998 with the identification of four management areas in the NWHI: Necker Island, Maro Reef, Gardner Pinnacles, and all other banks combined. The lobster fishery was closed in 2000 by the WPFMC because of uncertainty in the population and assessment models used to assess stock status, and remains so to this date. In December 2000, President Clinton, through Executive Order (EO) 13178 and later through EO 13196, established the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. These EO's also established reserve preservation areas in which fishing activities, including lobster trapping, are prohibited. To continue protection of the NWHI, President Bush designated the NWHI as a National Monument in 2006. The Papahānaumokuākea Marine National Monument is cooperatively managed by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration, in close coordination with the State of Hawaii.

Precious corals occurring in the U.S. exclusive economic zone (EEZ) are managed under a

fishery management plan implemented in 1983. Three types of coral are recognized targets of the fishery, including pink (*Corallium* spp.), gold (*Gerardia* spp., *Narella* spp., *Calyptrophora* spp., and *Callogorgia* spp.) and bamboo (*Lepidisis* spp. and *Acanella* spp.). Quotas are set based on visual surveys of the one fully surveyed coral bed at Makapu'u, Oahu. Exploratory permits with very limited quotas are available for unsurveyed coral beds found elsewhere. The fishery was reinitiated in 1999 and ended in 2001 with fishing conducted at the Makapu'u and Keahole beds.

Surveys using submersibles in 1997 provided solid evidence of recovery of pink coral at the Makapu'u, Oahu, bed that has been the historical focus of the fishery. In prior years no permits for coral harvesting outside of Makapu'u had ever been issued. Nonetheless, it appears that illegal foreign fishing in some remote areas at the north end of the archipelago during the 1970's and early 1980's likely had a very significant impact on some coral beds.

SPECIES AND STATUS

NWHI Lobster

The commercial lobster fishery in the NWHI was initiated with two-chambered wire traps but shifted to plastic traps in the 1980's. Although the traps contained escape vents, the decreased mesh size of the new traps resulted in an increase in the catch of smaller lobsters. Approximately 10 strings of 100 traps each are fished overnight at depths generally ranging from 15 to 35 fathoms (27–64 m). Historically, traps set at the deeper depths caught slipper lobster while the shallower sets caught spiny lobster. In later years, slipper lobsters (particularly at Maro Reef) have been caught at shallow depths, possibly due to the "fishing down" of spiny lobsters and the availability of suitable lobster habitat formerly occupied by spiny lobster; the effect of environmental fluctuations on lobster recruitment may also affect the relative abundance of lobster species.

Historically, most of the lobster catch was processed at sea and landed as frozen tails. In the late 1990's, however, the opening of several foreign markets led to an increase in live landings. Nonetheless, most lobsters continued to be landed as processed frozen tails.

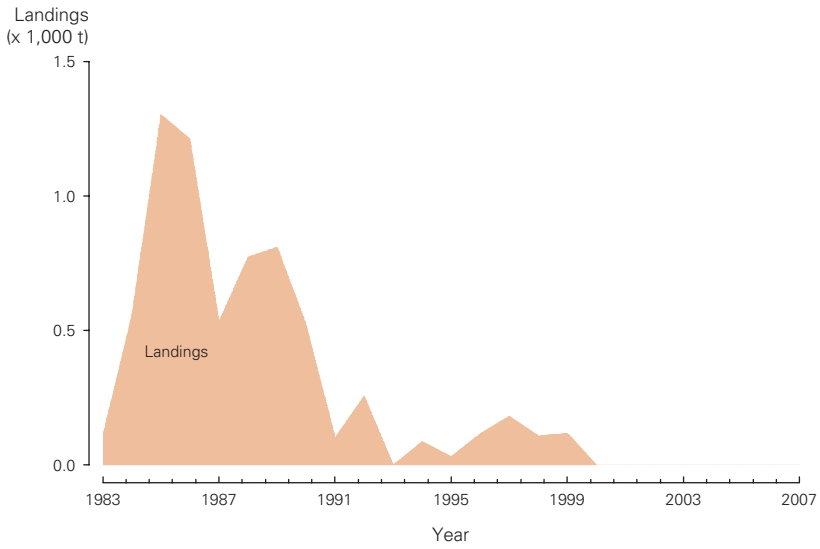


Figure 16-2
Hawaiian lobster (spiny and slipper lobsters) landings in metric tons (t), 1983–2007. The seasons were shortened in 1994 and 1995, and the fishery was closed in 1993 and again from 2000 to the present.

Although as many as 16 banks within the NWHI were fished on an annual basis before the closure in 2000, the proportion of fishing effort at each bank varied both spatially and temporally. The observed spatio-temporal shifts in fishing effort between banks are attributed to declines in spiny lobster CPUE; as spiny lobsters were fished down and catch rates at a particular bank fell below some minimum economic threshold, fishing effort shifted to more productive banks. By the mid 1990's, fishing was generally limited to Necker Island where spiny lobsters were highly concentrated. With the adoption of spatial management in 1998, fishing effort was redistributed throughout the NWHI, and the major target of the fishery changed to slipper lobster.

The combined landings of lobsters peaked in 1985 at 1,075 metric tons (t; worth $5,888,000) and generally declined from 1986 to 1995 (Figure 16-2). The fishery was closed in 1993 and had shortened seasons in 1994 and 1995. Landings in 1999 were 118 t whole weight and consisted of about 87,000 spiny lobster and 149,000 slipper lobster, valued at $1,200,000. The fishery was closed in 2000 as a precautionary measure to prevent overfishing of the lobster resource and currently remains closed (Table 16-1).

Uncertainty exists with the current parameterization of the NWHI lobster population and

Table 16-1
Productivity in metric tons (t) and status of Western Pacific invertebrate fisheries resources.

Species/stock	Recent average yield (RAY)[1]	Current yield (CY)	Sustainable yield (MSY)	Stock level relative to B_{MSY}	Harvest rate	Stock status
Spiny and slipper lobsters (NWHI)[2]	0	Unknown	Unknown	Unknown	Not overfishing	Unknown
Total	0	0	0			

[1]2004–06 average.

[2]Northwestern Hawaiian Islands; fishery has been closed since 2000.

Blunt slipper lobster, Northwestern Hawaiian Islands.

assessment models, and the status of NWHI lobster stocks is indeterminate. Many of the model assumptions may be invalid, and independent estimates of key fishing performance and biological parameters are inconsistent with estimates derived from current NWHI lobster population and assessment models. Much of the uncertainty stems from processes that are related to spatial scale and the treatment of data, which has been pooled across species. Previous assessments did not recognize the importance of spatial heterogeneity and assumed synchronous dynamics among local populations of NWHI lobsters, regardless of species. Improving lobster stock assessments will require better population models with sufficient spatial and species resolution that explicitly characterizes the dependence between local lobster populations. The development of spatially structured population models for NWHI lobster populations is progressing and should provide for more reliable stock assessments.

The estimated populations of spiny and slipper lobsters declined dramatically from the mid 1980's through the mid 1990's. Much of this decline has been attributed to a shift in oceanographic conditions affecting recruitment in the mid 1980's. While vagaries in oceanography may have contributed to the decline of NWHI spiny lobster, improvements in our understanding of the spatial structure of the NWHI spiny lobster population, the dynamics of larval transport, and commercial fishery data suggest that spiny lobster populations in the NWHI constitute a metapopulation[1] and that a suite of factors (both anthropogenic and biotic) contributed to the observed decline. As the population size is reduced, the chance of population collapse due to environmental stochasticity increases, particularly when the population is spatially structured. Although oceanographic conditions have returned to a more typical long-term state and the fishery has been closed since 2000, recent NMFS research surveys have not indicated any increase in spiny lobster populations at Necker Island. While increases in spiny lobster relative abundance have been detected in isolated locations around Maro Reef, it is premature to assess the impact of this change at the population level.

The primary objective of the Crustaceans FMP is to prevent overfishing and is defined in terms of recruitment overfishing.[2] The criterion used to assess overfishing is the spawning potential ratio (SPR), defined as the ratio of the spawning potential of a population in a fished condition relative to that in an unfished condition. The FMP defines

[1]A group of populations inhabiting discrete patches of suitable habitat that are connected by the dispersal of individuals between patches; the degree of isolation for local populations may vary depending on the distance between habitat patches.

[2]Recruitment overfishing refers to a level of fishing intensity that reduces the adult spawning stock to the point that the number of recruits produced is greatly reduced and is insufficient to maintain the population.

the 20% level as a minimum SPR threshold, below which the stock is considered overfished, and establishes a warning SPR threshold at 50%, indicating the need for additional conservation measures. The NWHI lobster fishery was managed with a constant harvest rate such that there was only a 10% chance in any given year that the fishing mortality will exceed the mortality associated with the minimum SPR threshold.

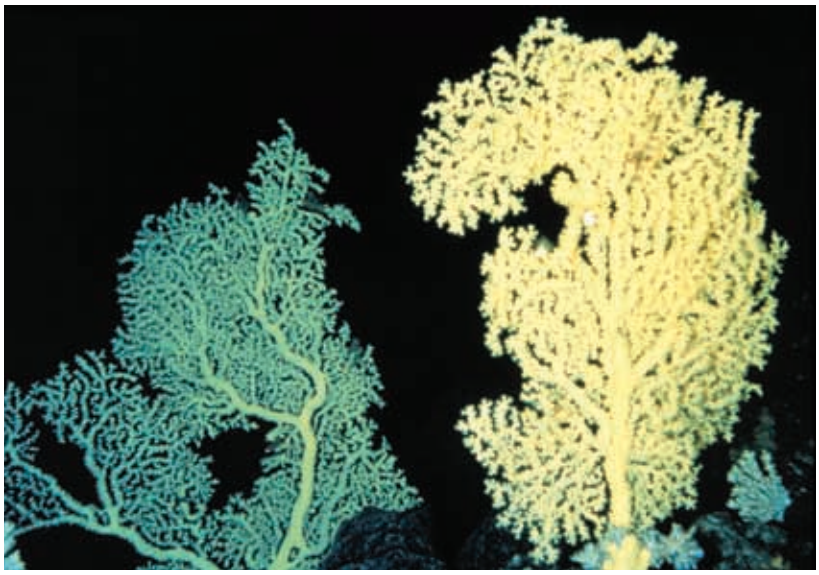
Precious Coral

For the first time since the mid 1970's, deepwater precious corals (pink, gold, and bamboo corals) were harvested beginning in 1999 through 2001. Historical landings of precious corals are shown in Figure 16-3. A single company collected corals at the established coral bed of Makapu'u, Oahu, and in the exploratory bed off Keahole, Hawaii. Because only one company was fishing, it is not possible to report data on landings without compromising NMFS confidentiality provisions; however, the allowable harvest quotas were not filled in either location. Makapu'u, Oahu, has a 2-year quota for 2,000 kilograms (kg) of pink coral and 600 kg each for bamboo and gold coral. The exploratory beds have a combined quota of 1,000 kg of any of the coral target species. Single-person submarines were used to selectively harvest coral colonies and minimize collateral damage to the habitat. Although the fishery remains open, the company has suspended harvesting due to the high cost of operating submarines and the low bid price for coral. The only shallow water coral species currently harvested are black corals (*Antipathes dichotoma, A. grandis,* and *Myriopathes ulex*). Black corals are collected by three independent divers working 80 m and shallower, all within the Au'au channel, Maui.

In 2000 and 2001, scientists surveyed all known precious coral beds in the Hawaiian Archipelago using the submersibles of the Hawaii Undersea Research Laboratory. These surveys have provided the first real insight as to the relative abundance of precious corals across the archipelago. Post-harvest inspections of the coral beds at Makapu'u and Keahole found numerous live colonies with little evidence of damage associated with harvesting. The 2001 survey of the Makapu'u bed will be compared with a pre-harvest survey data collected at Makapu'u in 1997 to evaluate possible harvesting impacts. Both divers and submersibles also surveyed the black coral bed of the Au'au channel in 2000 and 2001. Submersible surveys at depths below 80 m observed an invasive species of soft coral (*Carijoa riisei*) overgrowing black coral trees. At depths shallower than 80 m, divers surveyed the size structure of black coral trees and their associated fish assemblages. A follow-up survey of size structure was conducted in 2004 and will be used to revisit the harvesting regulations presently in place.

Figure 16-3
Historical precious coral landings in metric tons (t), 1966–98. No fishery occurred in 1998; data are not available for 1999–2001 because only one company was fishing and confidentiality provisions prevent the release of landings information. Although the fishery remains open, harvest has been suspended due to high operation costs.

Photo below:
Gold coral in Hawaii.


OAR/NURP; Hawaii Undersea Research Lab

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Northwestern Hawaiian Islands lobster phyllosoma larva.

ISSUES

Scientific Information and Adequacy of Assessments

Despite the multispecies nature of the NWHI lobster fishery and regulatory measures, most of the biological research has been directed at spiny lobster. Future research is needed to address knowledge shortfalls of slipper lobster biology. Estimates of the exploitable population of lobsters in the NWHI have been based solely on commercial catch and effort data from the NWHI lobster fishery as a whole. This approach neglects the fact that fishermen target areas with higher concentrations of lobsters and may lead to estimates of exploitable biomass that are biased. More accurate assessments will require the integration of fishery-independent data, such as the annual NWHI lobster resource survey and the lobster-tagging program, into assessments to fine-tune the parameter estimates and assessment of exploitable biomass on a bank-specific basis.

Biological information necessary for management of precious corals remains limited. Estimates on the growth rate of pink coral and black coral have been documented, but the growth rate of gold coral is unknown. Understanding the growth rate is essential to effectively evaluating the rate of recruitment and setting a reasonable harvest size to protect the reproductive population. During the 2000 and 2001 surveys of coral beds, gold coral colonies large and small were marked and will be measured again in following years. Archival temperature recorders were also deployed at these sites to account for environmental variables that could influence differences in growth rates between sites.

Factors Affecting Abundance

In predicting the response of the NWHI lobster population to fishing harvest, it must be noted that research to date has identified a dynamic change in the spatial and temporal structure of the NWHI lobster population. One major fishing area, Maro Reef, continues to be characterized by low spiny lobster abundance. Based on oceanographic research, size class and genetic structure analysis, and trends in CPUE, recruitment in the NWHI spiny lobster population appears to differ between the southeastern and northwestern segments of the archipelago, and remains depressed in the northwestern segment relative to 1975–85 levels. Numerous hypotheses have been advanced to explain population fluctuations of lobsters in the NWHI, including environmental, biotic (e.g. habitat and competition), and anthropogenic (e.g. fishing). Each hypothesis by itself offers a plausible, but simple, explanation to a rather complex phenomenon operating in a system of high dimensionality. It is likely that population fluctuations of lobsters in the NWHI will be more accurately explained by a mix of the hypotheses presented, each describing a different set of mechanisms.

Multispecies Interactions

The long-term effects of fishing on ecosystems are not well understood, and cautious management controls are required. The removal of one species, or complex of species, could result in species composition shifts. Although both spiny and slipper lobsters are harvested in the NWHI lobster fishery, spiny lobster is the primary target at most banks. As large numbers of spiny lobster were removed from banks in the NWHI, the abundance and spatial distribution of slipper lobster on these banks apparently increased; areas traditionally defined as spiny lobster habitat appear now to be occupied by slipper lobster. However, it is unknown if this sort of shift has occurred at all banks because NMFS lobster resource surveys occur only at Necker Island and Maro Reef.

Activities related to the precious coral fishery might interfere with the endangered Hawaiian monk seal. Studies of monk seal foraging patterns using seal-mounted satellite tags documented a small number of seals visiting sites with deepwater precious coral beds. Depth-of-dive records from one study show that a small percentage of the seals' dives reached depths of 350–500 m. In another study of diving behavior, three seals at French Frigate Shoals in the NWHI dove below 350 m. One seal was documented foraging at subphotic depths, while all three of the seals were heard making feeding sounds at depth. A follow-up study also recorded seals visiting black coral beds on successive nights to feed on eels hiding among the corals. This feeding behavior is considered analogous

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Researchers PIT tagging a slipper lobster (left) and a spiny lobster (right) during the 2003 Northwestern Hawaiian Islands lobster tagging cruise. These lobster tagging cruises are a cooperative effort between the NMFS Pacific Islands Fisheries Science Center and Hawaiian commercial fishermen.

to the foraging activity proposed for seals in the subphotic deepwater precious coral beds. These studies have spurred concern that coral harvesting might impact the seals' use of the deepwater fish community. Consequently, surveys conducted at all the coral beds (in 2000–01) included assessment of fish populations both in and outside of coral beds to evaluate the degree to which the corals aggregate deepwater fish species. Comparative surveys of bank summits at the northern extreme of the NWHI were conducted in 2002, and these data will be combined with data from the 2000 and 2001 surveys for full analysis. In 2003, a seal was observed by a submersible at 540 m near precious coral, further strengthening the link between seals and precious coral beds.

Metapopulation Approach

Treating spiny and slipper lobsters in the NWHI as metapopulations is consistent with the available data and represents a departure from the status quo. Given the dependence among local populations of spiny lobster in the NWHI, overfishing or depletion of local populations could result in catastrophic impacts to the population as a whole (e.g. reduction in average recruitment or recruitment failure), particularly when a large number of local populations, or the most productive populations, are heavily exploited. Also, when spatial correlation among local populations is high (as it appears to be for NWHI spiny lobsters), bank-specific relationships between population size and fishing can become decoupled, masking the true impact of fishing. The decline of spiny lobsters at Laysan Island may provide an example of this decoupling.

This paradigm shift also changes the data requirements for NWHI lobster stock assessments. While the discrete population model relied solely on commercial catch and effort data as input, metapopulation models require data (both biological and fishery related) with greater spatial resolution. Because of life history differences between spiny and slipper lobsters, the models may also need to be species-specific.

Invasive Species

Recent surveys of the Au'au channel bed have documented an infestation by an invasive soft coral, *Carijoa riisei*, which settles on and smothers black coral colonies. *Carijoa* has infested nearly every black coral below depths of 80 m where light levels are dim enough for *Carijoa* to colonize. Black corals in shallower depths are exposed to more light that constrains the *Carijoa* to the undersides of ledges. The loss of deep black corals, beyond the reach of coral divers, removes a functional reproductive reserve for the black coral stock. Consequently, the black coral stock and any associated fishery parameters are in need of revaluation.

Progress

Much progress in assessing the status of exploited lobster stocks of the Western Pacific region has been made during recent years. At-sea sampling of the commercial fleet by biological technicians was conducted in 1995 and 1997–99, providing infor-

mation to characterize the commercial catch as well as spatial heterogeneity of lobster abundance and size composition. These data were used to enhance the annual NWHI lobster fishery-independent survey and provided a more representative basis for future stock assessments.

To provide independent estimates of population size and updated estimates of population dynamics and fishery parameters, a NWHI lobster tagging program was implemented. Spiny lobsters at Necker Island were tagged with external ribbon tags in 1998, 1999, and 2002 on both Federal and chartered commercial vessels. In 2003, spiny lobsters at Necker Island and slipper lobsters at Maro Reef were tagged with internal PIT (passive integrated transponder) tags aboard chartered commercial vessels. Further population and assessment model development will require an increase in the program's scope to include tagging at other banks.

Significant progress in population and assessment model development, as well as CPUE standardization, has also occurred. A spatially explicit population model has been developed for spiny and slipper lobsters and feasibility testing of the model is progressing. In situ research is focusing on the behavior of lobsters in and around traps to better interpret CPUE time series. Larval drift models are being developed to further understand the role oceanographic conditions have on recruitment.

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