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ANNUAL REPORT OF THE 1989 WESTERN PACIFIC LOBSTER FISHERY

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PREFACE

The Crustacean Fishery Management Plan (FMP) for the western Pacific lobster fishery was implemented in 1983 by the Western Pacific Fishery Management Council (Council). The agency responsible for implementing the regulations of this FMP and for monitoring the fishery is the National Marine Fisheries Service (NMFS). To monitor the fishery, the NMFS collects basic technical information for analyses; such information on the 1989 lobster fishery in Hawaii is presented in this report. All of the material presented herein pertains exclusively to the Northwestern Hawaiian Islands, because lobster fishing permits were issued for only that area during the past year.

A number of NMFS agencies were involved in collecting and preparing the data: The Fishery Management Research Program of the Southwest Fisheries Center (SWFC) Honolulu Laboratory prepared the fishery monitoring information. The Insular Resources Investigation of the SWFC Honolulu Laboratory provided a summary of the biological research on the fishery. Alvin Z. Katekaru of the Southwest Region, Pacific Area Office, and Victor A. Honda of Southwest Enforcement prepared the information on administrative activities and enforcement. Robert F. Harman of the Council's staff prepared the information on Council-related activities.

CONTENTS

INTRODUCTION

For over 11 years a commercial lobster trap fishery has existed in the Northwestern Hawaiian Islands (NWHI), an uninhabited group of islands, islets, banks, and reefs extending 1,500 nmi northwest, from Niihau Island to Kure Atoll. The fishery employs approximately 100 people, and the combined landings of the main target species--spiny lobster, Panulirus marginatus, and common slipper lobster, Scyllarides squammosus (henceforth referred to as slipper lobster)--rank it third in the State of Hawaii in terms of ex-vessel revenue (Hamm and Quach 1989). A third species, ridgeback slipper lobster, S. haanii, became a target of commercial exploitation in 1987.

This report provides details on commercial lobster fishing activity in the exclusive economic zone of the NWHI. Current catch, fishing effort, and revenue statistics are provided in tabular format, along with brief summaries of the biological and economic conditions of the NWHI lobster fishery. The report concludes with separate sections on the administrative and enforcement activities in the fishery. Most the data presented are derived from logbooks and revenue reports provided by active lobster fishermen, as required by the Crustacean Fishery Management Plan (FMP) for the western Pacific lobster fishery.

RECENT DEVELOPMENTS

After 2 years of relative stability, the NWHI lobster fishery experienced a substantial increase in 1989 in fishing effort (Fig. 1) and total ex-vessel revenue (Fig. 2), but annual landings (wet weight) were about equal to 1988 levels (Fig. 3). As a result, the combined catch per unit effort (CPUE; the number of legal lobster per trap-haul) declined slightly in 1989 (Fig. 4). Furthermore, seasonal patterns in CPUE were unique, and none of the usual summer peaks occurred. The monthly CPUE cannot be presented graphically this year because of confidentiality considerations (i.e., less than three vessels fished during several months). The decline in CPUE following an especially good spring, along with a reportedly (albeit as yet unconfirmed) decreasing average tail size, caused concern among several vessel operators who believe that effort may have been excessive in 1989.

During the past 2 years (1987-88), fishing effort had stabilized at 850,000 trap-hauls after a record high of 1.35 million trap-hauls in 1986 (Table 1). In 1989, effort jumped up to 1.1 million trap-hauls, the second highest level in the history of the fishery. Fishing effort per trip as well as per vessel has grown substantially over the past 3 years.

Total ex-vessel revenue jumped substantially in 1989 to a record $6.3 million; of this, spiny lobster contributed 89%, the greatest relative contribution since 1984. The average ex-vessel price of frozen spiny lobster tails jumped 20% from 1988 to 1989 (Fig. 5). However, the price of frozen slipper lobster tails declined in 1989. Wholesalers reported medium to

strong demand for frozen spiny lobster tails throughout most of the year, with ex-vessel prices rising during the first 6 months and then stabilizing at about $12/lb through the year's end. The relatively lucrative spiny lobster price, coupled with a slackened demand for slipper lobster tails (and reportedly reduced abundance due to heavy exploitation in 1985-86), has caused a substantial shift in the targeting practices of the NWHI lobster fishermen: With few exceptions, fishermen targeted spiny lobster throughout 1989 and caught slipper lobster only incidentally--a trend that has occurred over the past 2 years (Fig. 6).

A total of 6,512 ridgeback lobster were landed (3% of the total number of legal slipper lobster landed), making 1989 the second year in which this species has been targeted for the live lobster markets. An estimated 80% of the ridgeback lobster catch was sold as live lobster for an estimated total weight of 8.9 metric tons (t) (19,500 lb), worth more than $148,000. The reported number of *Octopus* spp. (tako) caught was 443, with ex-vessel sales of $150 for 150 lb. No catches or sales were reported in the "other" category.

Production by bank (in terms of number of legal lobster reported caught) and the yearly CPUE trend showed a substantial deviation from recent years. The combined legal lobster catch in 1989 declined at Maro Reef, while the reverse trend occurred at Necker Island and Gardner Pinnacles.

Fishermen reported the average size of spiny lobster was down in 1989; more than 80% of the tails were under 8 oz in some of the off-loadings. Although the smaller size classes normally bring higher prices, fishermen voiced concern at the end of 1989 that the fishery was showing signs of strain. An increase in effort, specifically an unprecedented number of trap-hauls directed at the valuable spiny lobster stocks, along with declining catch rates, was the basis of this concern.

Three Class II vessels, as well as one Class III vessel, were converted from fishing for lobster to longlining for tuna (e.g., *Thunnus* spp.) or broadbill swordfish, *Xiphias gladius*, during the last quarter of 1989. Their vessel owners plan to return to lobster fishing by the spring of 1990, as was the case for 1989. Most other vessel owners did not plan to begin lobster fishing again until March or April 1990, using the off-season for repairs and maintenance.

The number of lost traps has been a recent concern: More than 2,000 traps were lost in 1988, and 1,084 traps were lost in 1989. Since early 1990, the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), NOAA, has been conducting ghost-fishing experiments (see Research below) to address the potential impacts of such trap losses.

LANDINGS AND REVENUE

Total landings of legal lobster in 1989 equaled 668 t (wet weight) with an ex-vessel value of $6.3 million (Table 1). Eleven vessels were active in

the fishery, and 33 trips were completed. The NWHI lobster fleet landed 576 t (wet weight) of spiny lobster and 92 t of slipper lobster (Table 2). Landings increased by 10% during 1989, but they were lower than in 1985. Landing weight statistics (Tables 1 and 2) are wet weight calculated on a whole animal basis from the number of legal lobster reported caught. Table 3 presents a breakdown of revenue by product type (live, frozen whole, or frozen tails) and actual weight of the product landed. These tables contain minor revisions of data from earlier annual reports (e.g., Clarke et al. 1988; Clarke 1989).

FISHING EFFORT

In 1989, fishing effort, by all measures (i.e., number of trips taken, reported fishing days, and trap-hauls), was up from the previous year. A total of 33 trips were recorded for the NWHI lobster fishery compared with only 28 trips in 1988. Fishermen reported 1.1 million trap-hauls, a 27% increase from 1988 but still less than the 1986 peak. Catch and effort were concentrated at Necker Island, Gardner Pinnacles, and Maro Bank (Tables 4 and 5).

The total number of reported fishing days for the fleet increased to 1,323 in 1989 (Table 5). The average number of trap-hauls per reported fishing day rose from 732 in 1988 to 810 in 1989. This increase of 78 additional trap-hauls per fishing day is largely due to the increase in the number of larger vessels during the year.

CPUE

In 1989, the total spiny lobster CPUE (i.e., the number of legal lobster caught per trap-haul) fell to 1.38, and total slipper lobster CPUE was 0.31 (Table 5). Total spiny lobster CPUE in 1989 was less than in 1988 (1.52 lobster per trap-haul), whereas total slipper lobster CPUE was essentially the same as the 1988 level (0.33). Table 5 presents the CPUE information by area.

As the number of trap-hauls and fishing days increased in 1989, the CPUE for legal spiny lobster dropped for most banks, except Necker Island where CPUE increased from 0.89 in 1988 to 0.95 in 1989. The CPUE for the other fishing areas (i.e., those not delineated in Table 5) more than doubled. Based on the combined CPUE's for legal spiny and slipper lobsters, Maro Reef had the highest CPUE (1.24 legal lobsters per trap-haul), down slightly from 1988.

The monthly trend in recent years indicates that the combined legal lobster CPUE reportedly was lowest in January and February, rose as slipper lobster landings increased in the spring, dropped slightly before rising again as spiny lobster catches increased in the summer, and then finally leveled off in the fall and winter (Clarke et al. 1988). In 1989, however, the combined legal lobster CPUE increased through January and February,

peaked in March, dropped slightly but stabilized in April-June, and then declined through the summer and fall. This trend was an anomaly, considering the relative importance of the spiny lobster component, which historically is lowest in February-April and strongest in August. A slight increase in legal slipper lobster CPUE appeared in late spring-early summer but was masked by heavy targeting on spiny lobster, which comprised the major component of the catch throughout the year.

Reasons for this early jump in lobster catch rates are uncertain, but fishermen reported mild weather during what is normally a stormy portion of the year. Fishermen also reported that fishing was especially strong at Maro Reef early in the year, but catch rates leveled off substantially after the early season "bite" (i.e., the beginning of the season when lobster enter traps or are active) and never recovered to the normally strong production levels found in summer. Because Maro Reef was not productive, vessels shifted to Gardener Pinnacles and, later, to Necker Island, two areas that fortunately produced well.

VESSEL OPERATIONS

The sea days of the NWHI lobster fleet in 1989 are reported in unadjusted and adjusted modes (Table 6). Adjusted data annualize trip activity by deleting incomplete or experimental trips and then taking vessel participation for part of a year and projecting it for the entire year. Based on these data, fishing per vessel was more intensive in 1989 than in previous years. The adjusted fleet class configuration shows one Class I-S, two Class I, five Class II, and three Class III vessels active in 1989. The Class I-S category was created to represent a new vessel that has unique characteristics but somewhat resembles the Class I vessels. For a complete description of vessel classes and sea day analysis, see Clarke and Pooley (1988). Entry and exist patterns for all active vessels in the fleet are in Table 7.

BIOLOGICAL ASSESSMENT

The combined maximum sustainable yield (MSY) for spiny and slipper lobsters in the NWHI fishery, based on a dynamic Gompertz model, is estimated at about 1.0 million lobster from an effort of about 1.0 million trap-hauls. Combined landings of slipper and spiny lobsters in 1989 totaled 1.16 million from 1.07 million trap-hauls of fishing effort. Estimated fishing mortality at the 1989 effort level was about equal to natural mortality, and spawning stock biomass per recruit at this level of fishing was 52% of the spawning stock biomass per recruit in the absence of fishing. The average annual increase in exploitable stock size equaled 2.7 million lobster (Polovina 1990).

RESEARCH

Biological Research

Ongoing studies on the NWHI lobster fishery include larval dispersal surveys and ghost-fishing experiments by the Insular Resources Investigation of the Honolulu Laboratory. The larval dispersal surveys are conducted on a seasonal basis, using a rope trawl from the NOAA ship *Townsend Cromwell*, to determine whether lobster larvae primarily recruit to the bank where they are spawned or are dispersed throughout the NWHI. The ghost-fishing experiments comprise a three-phase program designed to assess the potential impacts of derelict traps. Phase one is the deployment of a string of traps off the Island of Oahu, followed by the periodic monitoring of trap decay and of the interactions between the traps and the surrounding benthic community. Phase two is a tank study in which the behavior of lobster in traps will be monitored and their ability to exit the traps will be assessed. Phase three will use the *Townsend Cromwell* to locate and observe derelict gear on the fishing grounds at Maro reef and Necker Island and also to record the bottom habitat and reef communities associated with lobster fishing activity.

Economic Research

The CY&P model, a bioeconomic model of the NWHI lobster fishery, was completed in 1989 by Clarke et al. (in prep.). Their paper reports the results of applying several bioeconomic models to the fishery by using a surplus production approach to the biological parameters and the economic baseline developed by Clarke and Pooley (1988) for the economic parameters. The biological production model that best explains the dynamics of the fishery is a modification of the Fox model using a Gompertz distribution. The model tests a number of alternative conceptual frameworks for applying opportunity costs in the economic analysis.

A number of estimates were obtained with the CY&P model: The MSY is 1.1 million lobster from 1.1 million trap-hauls; the maximum economic yield is 950,00 lobster from 580,000 trap-hauls, a substantial decrease in effort; and the open access equilibrium (when fleet profits and resource rents are exhausted) is 1.0 million lobster from 1.4 million trap-hauls, based on ratios of long-term costs and prices (Fig. 7).

Other Research

Commercial catch and effort data were fit to the Leslie model to estimate pre-exploitation abundance and the catchability coefficient of slipper lobster in the NWHI (Clarke and Yoshimoto in press). A single vessel fished for 34 consecutive days in 1987 in the vicinity of Laysan Island and caught 126,127 slipper lobster in 36,170 trap-hauls. The adjusted catch of legal slipper lobster dropped from a high of 3.70 to 1.16 lobster per trap-haul (Fig. 8). Pre-exploitation abundance at Laysan Island was an estimated

204,000 legal slipper lobster; an extrapolation of this figure yields 1.2×10^6 to 3.8×10^6 lobster for the entire slipper lobster fishery in the NWHI.

ECONOMIC ANALYSIS

The economic assessment of the NWHI lobster fishery in 1989 is based upon a projection to fleet levels from the economic performance of individual classes of vessels using the methodology by Clarke and Pooley (1988). In 1989, six vessels entered the fishery (two were new entrants and four returned to the lobster fishery), one exited, and total fishing activity (as measured in trap-hauls) increased substantially. This was anticipated because of the good economic returns and catch rates in 1988 (Clarke 1989). Also, not unexpectedly, catch rates, declined in 1989 with increased fishing effort. However, total gross revenue increased by 26% (proportional to effort), total income also increased, and net revenue remained positive (Table 8). These increases were somewhat unexpected, given the decline in catch rates, but they can be explained by four factors: 1) the prices of spiny lobster increased by 20% in 1989; 2) the activity of Class II boats (the most efficient performers) increased relative to the fleet as a whole; 3) the precise determination of operating costs for the combined Class I and I-S vessels (the largest sized vessels with high fixed and operating costs) was difficult because of changes in vessel configuration; and 4) the adjustment of average annual earnings per vessel to an "annualized" basis (cf. Table 8) was greater than in previous years, because vessels on average participated in the NWHI lobster fishery for fewer months than in 1986-88. Some of the vessels were able to generate additional revenue in Hawaii's longline fishery, but detailed information on that activity was not available.

The gross revenue necessary to support the fleet at the level of earnings implied by this analysis would be $8.1 million, which would represent another increase (33%) in landings to a level that the NWHI lobster fishery probably could not sustain. Altogether, the net revenue (profit) of the fleet amounts to an estimated return on investment of 10.2%, generally considered inadequate for high risk investments such as distant-water commercial fishing. However, if alternatives in other fisheries are not good, especially those on the U.S. mainland where information on the condition of the NWHI lobster fishery may be dated or incomplete (e.g., based simply on the record levels of total revenue), then there may be attempts to expand fishing effort in 1990.

With the declining catch rates throughout the second half of 1989 and with total fishing effort considered above optimum, many operators in the fleet are concerned that returns will fall dramatically in 1990. Of particular concern to these vessel captains is the intensity of fishing operations (certain areas being fished continually throughout the year) and the apparent demise of the slipper lobster stocks.

These possibilities can be evaluated with the CY&P bioeconomic model (Clarke et al. in prep.). The baseline condition for the fleet with 1989

price and cost ratios is in Figure 9A; the open access equilibrium (zero industry profits) is estimated at 1.036 million trap-hauls (the positive intersection of the revenue and total cost curves), MSY at 1.040 million trap-hauls (representing $475,000 net revenue), and maximum economic yield at 470,000 trap-hauls ($2.1 million net revenue). Net revenue (profit and loss) based on fleet-wide trap-hauls is in Figure 9B. Because of the particular relationship between lobster price ($5.42 per lobster) and the average cost of fishing effort ($5.09 per trap-haul) in 1989, open access equilibrium is strikingly close to MSY, implying that, in this fishery and at these price and cost levels, the unregulated fishing (in the sense of effort limitations) is in economic equilibrium near the biological optimum. It is important to realize that, unlike the overall results from the bioeconomic model, these are not long-term results, because the cost and price levels reflect only the current year (1989) averages. As a result, the relationship between open access equilibrium and MSY has changed from the CY&P model introduced in Clarke et al. (in prep.).

The CY&P model can be used to explore three simple scenarios for fishing conditions in 1990 and 1991 (Table 9). The first scenario considers the situation in which the 1989 level (1.07 million trap-hauls) continues in 1990 and 1991. In this case, catch rates would decline from the present 1.08 lobster per trap-haul to 1.02 in 1990 and 0.98 in 1991. Total revenue in 1991 would decline by 9% compared with 1989, and net revenue would be fall by 72%. The second scenario considers the situation in which effort increases in 1990 by 30% to 1.4 million trap-hauls. In this case, catch rates would decline to 0.93 lobster per trap-haul in 1990 and 0.79 in 1991. Total revenue in 1991 would decline by 5%, despite the increase in effort, and $1.1 million in net revenue losses would occur. The third scenario considers what effort level would be required in 1991 to return the catch rate to the 1989 level after a 30% increase in fishing effort in 1990. In this case, the level of fishing effort in 1991 would need to fall 74% from the 1989 level (i.e., to 274,000 trap-hauls), supporting only three full-time Class II and III vessels. Total revenue would have declined 74% from 1989 levels to $1.6 million.

Naturally these results are speculative, but they buttress the common sense point of view that effort levels in the NWHI lobster fishery cannot be increased substantially with the current fleet configuration. The fishery management question is whether effort will diminish rapidly enough (in terms of vessels exiting the fishery) and whether entry by new vessels will be precluded, thereby minimizing the economic adjustment costs implied by this analysis.

ENDANGERED AND THREATENED SPECIES INTERACTIONS

Endangered and threatened species interactions were observed over a wider range among fishermen compared with 1988 levels and are summarized in Table 10. All interactions appear to be incidental and nonthreatening.

COUNCIL ACTIVITIES

In February 1989, the Western Pacific Fishery Management Council approved its Scientific and Statistical Committee's (SSC) recommendation requesting that the Honolulu Laboratory 1) review available information on lobster trap losses and 2) prepare a report on the potential of ghost-fishing in the NWHI fishery. In July 1989, the Council reviewed a report by Moffitt and Parrish (1989) of the Honolulu Laboratory on ghost-fishing in the NWHI. The Council encouraged the Honolulu Laboratory to conduct studies to improve knowledge on the specific effects of the traps used in the NWHI lobster fishery.

In April 1989, the Council directed its staff to monitor the progress of proposed State of Hawaii legislation regarding the minimum mesh size for traps. The Council worked with the Honolulu Laboratory to define possible impacts to the lobster and shrimp fisheries in Hawaii. They concluded that the legislation posed problems to both fisheries; however, the bill was passed into law as originally written. The Council was also directed to work with the Honolulu Laboratory to request voluntary information on sea state and weather conditions from lobster fishermen for a 1-year trial period. These data would then be evaluated for their usefulness in understanding fluctuations in CPUE.

Late in 1989, the Council's Crustacean Planning Team and the SSC concluded that the Crustacean FMP is consistent with the revised guidelines for National Standards 1 and 2 of the Magnuson Fishery Conservation and Management Act and that an amendment to the FMP was not required. In December 1989, the Council directed its staff and the Crustacean Planning Team to draft a statement of consistency for submission to the NMFS Southwest Region. The statement is now under review by the Region.

The Council also heard concerns in December 1989 from NWHI lobster fishermen that the average lobster size and CPUE were declining in the NWHI. At the request of the Council, the Honolulu Laboratory is collecting data on the size structure of the of NWHI lobster catches and will analyze these data, along with existing data, to see whether there is a basis for the fishermen's concerns. The Honolulu Laboratory also held a meeting in early 1990 with NWHI lobster fishery captains to discuss this and similar research concerns.

ADMINISTRATIVE ACTIVITIES

The Southwest Region, Pacific Area Office, issued 17 permits for commercial lobster fishing in the western Pacific region during calendar year 1989. All of the permits issued were for area 1, the NWHI exclusive economic zone. No permit applications were received for area 2 (main Hawaiian Islands (MHI)) and permit area 3 (American Samoa and Guam). Five permits were issued to new entrants into the fishery while 12 were for renewals. There was a 35% decrease in the total number of permits compared with 1988. This decrease

was due primarily to the nonrenewal of 14 permits by 4 MHI vessels and 9 NWHI vessels.

The trap carrying capacity (as recorded for the 17 permitted boats versus 11 active boats in the 1989 fishery) of all NWHI vessels in 1989 was 16,322 traps (Table 11). The total carrying capacity of the 11 active NWHI lobster vessels in 1989 was 12,382 traps, a net increase of 2,962 (31%) traps over the previous year. The average carrying capacity of active vessels in 1989 was 1,126 traps, slightly more than in 1988.

ENFORCEMENT ACTIVITIES AND VIOLATIONS

On 12 occasions in 1989, NMFS Southwest Enforcement agents inspected returning lobster vessels that off-loaded their catches in Honolulu. Agents are not aware of any landings of lobster other than in Honolulu. No violations that required formal documentation were observed.

The use of escape vents in the lobster traps seems to benefit the resource by allowing the undersized lobster to escape. Fishermen generally were satisfied with this trap requirement.

The 1990 goal for NMFS Southwest Enforcement is to increase the coverage of returning lobster vessels, even though compliance with this highly regulated fishery seems adequate.

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Table 1.--Annual landings, ex-vessel revenues (US$), fishing effort (trap-hauls, vessels, and trips), catch per unit effort (CPUE; number of legal lobster per trap-haul), and prices (US$/lb) of slipper and spiny lobsters from the Northwestern Hawaiian Islands, 1977-89. Data are from vessel logbooks and revenue reports.

Year	Landings		Revenue	Trap-hauls (No.)	Vessels (No.)	Trips (No.)	Combined legal CPUE[b]	Price/lobster
	No.	Pounds[a]						
1977	--	72,000	209,000	--	5	14	--	--
1978	--	45,000	135,000	--	2	12	--	--
1979	--	100,000	320,000	--	2	6	--	--
1980	--	328,000	1,115,000	--	3	12	--	--
1981	--	780,000	2,730,000	--	10	25	--	--
1982	148,214	187,000	673,000	47,738[c]	7	19	3.10	4.54
1983	234,700	203,000	591,000	84,870	4	19	2.77	2.52
1984	872,400	1,017,000	2,624,000	363,000	11	38	2.40	3.01
1985	1,812,700	2,368,000	5,887,000	983,062	16	62	1.80	3.25
1986	1,787,400	2,202,000	5,982,000	1,352,580	16	60	1.32	3.35
1987	737,800	969,000	3,988,000	804,723	11	38	0.92	5.41
1988	1,057,600	1,405,000	5,000,000	845,200	9	28	1.25	4.73
1989	1,160,253	1,470,000	6,291,000	1,071,538	11	33	1.08	5.42

[a]Includes the weight of frozen lobster tails expanded to represent whole weight (spiny lobster tail weight = 35.6% of whole weight; slipper lobster tail weight = 33.3% of whole weight).

[b]Legal CPUE for slipper lobster before 1988 is calculated as 0.72 * number of retained slipper lobster.

[c]Estimate is from Clarke et al. (in prep.).

Table 2.--Estimated landings, ex-vessel prices (US$/lb), and ex-vessel revenues (US$) of spiny and slipper lobsters landed from the Northwestern Hawaiian Islands, 1977-89. Data are from vessel logbooks and revenue reports.

	Spiny lobster				Slipper lobster			
Year	Pounds[a]	Metric tons	Price ($/lb)	Revenue ($)	Pounds[b]	Metric tons	Price ($/lb)	Revenue ($)
1977	72,000	30	2.90	209,000	--	--	--	--
1978	45,000	20	3.00	135,000	--	--	--	--
1979	100,000	50	3.20	320,000	--	--	--	--
1980	328,000	150	3.40	1,115,000	--	--	--	--
1981	780,000	350	3.50	2,730,000	--	--	--	--
1982	187,000	80	3.60	673,000	--	--	--	--
1983	203,000	90	2.91	591,000	--	--	--	--
1984	935,000	425	2.66	2,490,000	82,000	37	1.63	134,000
1985	1,438,000	654	2.94	4,227,000	930,000	423	1.78	1,660,000
1986	1,149,000	521	3.23	3,710,000	1,053,000	479	2.16	2,272,000
1987	530,000	241	4.67	2,479,000	439,000	200	3.44	1,509,000
1988	1,218,000	553	3.66	4,453,000	186,000	85	3.12	581,000
1989	1,266,000	576	4.44	5,624,000	203,000	93	3.28	667,000

[a]Includes frozen lobster tails expanded to represent whole weight (tail weight = 35.6% of whole weight).

[b]Includes frozen lobster tails expanded to represent whole weight (tail weight = 33.3% of whole weight).

Table 3.--Estimated landings, ex-vessel prices (US$/lb), and ex-vessel revenues (US$), by product type, from the Northwestern Hawaiians Islands, 1977-89. Data are from vessel logbooks and revenue reports.

			Spiny lobster				Slipper lobster					
Year	Product	Type	Pounds	Metric tons	Price	Revenue	Pounds	Metric tons	Price	Revenue	Vessels (No.)	Trips (No.)
1977	Live		72,000	33	2.90	208,800	--	--	--	--	5	14
1978	Live		45,000	20	3.00	135,000	--	--	--	--	2	12
1979	Live		100,000	45	3.20	320,000	--	--	--	--	2	6
1980	--		--	--	--	--	--	--	--	--	--	--
1981	--		--	--	--	--	--	--	--	--	--	--
1982	--		--	--	--	--	--	--	--	--	--	--
1983[a]	Live		25,000	11	4.46	111,600	--	--	--	--	4	12
	Frozen	Whole	15	0	4.00	60	--	--	--	--	1	1
	Frozen	Tails	51,400	23	7.41	380,800	--	--	--	--	2	7
1984	Live		36,500	17	4.70	171,700	--	--	--	--	7	9
	Frozen	Whole	3,500	2	3.98	13,800	100	--[b]	3.00	400	3	6
	Frozen	Tails	318,600	145	7.23	2,304,500	27,300	12	4.92	134,000	10	31
1985	Live		35,200	16	4.71	165,800	30	--[b]	3.90	100	7	21
	Frozen	Whole	2,800	1	4.08	12,800	600	--[b]	2.73	1,600	3	8
	Frozen	Tails	498,000	226	8.13	4,050,000	310,000	141	5.35	1,660,000	15	56
1986	Live		18,200	8	5.10	92,880	100	--[b]	5.25	600	6	16
	Frozen	Whole	15,500	7	3.84	59,500	3,600	2	2.45	8,700	6	9
	Frozen	Tails	397,000	180	8.96	3,558,000	350,000	159	6.47	2,263,000	16	56
1987	Live		12,400	6	6.50	80,900	5,500	3	7.29	40,400	3	9
	Frozen	Whole	800	--[b]	5.78	4,600	1,800	1	3.96	7,100	3	3
	Frozen	Tails	183,200	83	13.00	2,383,000	143,000	65	10.16	1,452,000	10	37
1988[c]	Live		6,000	3	7.51	44,900	4,400	2	7.64	34,100	4	8
	Frozen	Whole	1,400	--[b]	4.00	5,500	--	--	--	--	3	3
	Frozen	Tails	431,000	196	10.24	4,402,200	60,500	28	9.04	547,000	9	28
1989	Live		24,700	11	7.62	188,300	14,500	7	7.03	102,000	4	9
	Frozen	Whole	2,200	1	5.00	11,100	--	--	--	--	--	--
	Frozen	Tails	441,300	200	12.29	5,424,600	62,900	29	8.98	565,000	11	33

[a]April through December 1983.
[b]Less than 1 metric ton landed.
[c]Revised from 1987 annual report.

Table 4.--Annual fishing effort (vessels and traps) and catch (number) of spiny and slipper lobsters, by area, in the of Northwestern Hawaiian Islands, 1989. Data are from vessel logbooks and revenue reports.

Area	Vessels (No.)	Trips (No.)	Catch (No.)							
			Spiny lobster				Slipper lobster			
			Legal	Sublegal	Berried	Total	Legal	Sublegal	Berried	Total
Necker Island	9	14	298,981	130,390	40,495	469,866	50,348	7,998	4,481	62,827
French Frigate Shoals	3	4	16,644	5,238	2,114	23,996	2,951	787	264	4,002
St. Rogatien Bank	4	9	72,576	18,108	10,273	100,957	11,540	2,918	1,738	16,196
Gardner Pinnacles	9	13	234,041	85,293	57,306	376,640	37,456	10,949	5,474	53,879
Maro Bank	10	17	308,908	125,958	56,817	491,683	108,446	45,130	36,424	190,000
Other[a]			12,949	3,760	1,932	18,641	5,413	1,434	396	7,243
Total	13	33	944,099	368,747	168,937	1,481,783	216,154	69,216	48,777	334,147

[a]Includes Nihoa, Brooks Bank, Rita Bank, Northhampton Bank, Lisianski Island, Salmon Bank, Pearl and Hermes Reef, and Midway.

Table 5.--Annual fishing effort (days fished and trap-hauls) and catch per unit effort (number of lobster per trap-haul) for spiny and slipper lobsters in the Northwestern Hawaiian Islands, 1989. Data are from vessel logbooks and revenue reports.

Area	Days fished (No.)	Trap-hauls (No.)	Catch per unit effort							
			Spiny lobster				Slipper lobster			
			Legal	Sublegal	Berried	Total	Legal	Sublegal	Berried	Total
Necker Island	417	314,356	0.95	0.41	0.13	1.49	0.16	0.03	0.01	0.20
French Frigate Shoals	36	28,755	0.58	0.18	0.07	0.83	0.10	0.03	0.01	0.14
St. Rogatien	89	88,695	0.82	0.20	0.12	1.14	0.13	0.03	0.02	0.18
Gardner Pinnacles	317	271,289	0.86	0.31	0.21	1.39	0.14	0.04	0.02	0.20
Maro Reef	416	334,563	0.92	0.38	0.17	1.47	0.32	0.13	0.11	0.57
Other[a]	48	33,880	0.38	0.11	0.06	0.55	0.16	0.04	0.01	0.21
Total	1,323	1,071,538	0.88	0.34	0.16	1.38	0.20	0.06	0.05	0.31

[a]Includes Nihoa, Brooks Banks, Raita Bank, Northampton Seamount, Lisianski Island, Salmon Bank, Pearl and Hermes Reef, and Midway.

Table 6.--Annualized mean number of vessels, trips, and sea days, by vessel class, for the lobster fleet in the Northwestern Hawaiian Islands, 1989. Unadjusted figures include incomplete trips, whereas adjusted figures are on an annualized basis. Standard deviations are in parentheses; data are from vessel logbooks.

Vessels		Trips	Sea	Mean number of sea days by activity						
Class	No.	(No.)	days	Fishing	Traveling	Running	Weather	Breakdown	Rest/deck work	Missing
				Unadjusted						
1 and 1-S	3	9	180.7 (33.9)	138.3 (33.9)	5.0 (4.6)	21.3 (1.5)	2.7 (3.8)	0.0 (0.0)	12.7 (2.5)	0.7 (1.2)
2	5	16	164.8 (31.5)	129.6 (31.5)	8.2 (4.8)	21.4 (4.7)	0.2 (0.4)	2.0 (4.5)	2.2 (1.5)	1.2 (1.3)
3	3	8	112.3 (32.3)	85.7 (32.3)	0.7 (1.2)	17.7 (8.7)	1.3 (1.5)	4.3 (6.7)	2.7 (2.9)	0.0 (0.0)
Total fleet	11	33	154.8 (40.3)	120.0 (31.6)	5.3 (4.9)	20.4 (5.3)	1.2 (2.1)	2.1 (4.4)	5.2 (5.2)	0.7 (1.1)
				Adjusted						
1 and 1-S	3	13	249.3 (38.5)	190.7 (38.5)	7.3 (6.0)	30.3 (8.7)	2.7 (3.8)	0.0 (0.0)	17.3 (2.5)	1.0 (1.7)
2	5	19	193.0 (10.0)	152.0 (10.0)	9.6 (5.4)	25.2 (3.9)	0.2 (0.4)	2.0 (4.5)	2.6 (1.9)	1.4 (1.5)
3	3	12	157.0 (33.7)	120.0 (21.4)	1.7 (2.1)	26.3 (9.1)	4.7 (4.2)	0.7 (1.2)	2.0 (2.6)	1.7 (2.9)
Total fleet	11	44	200.5 (49.8)	154.5 (35.7)	6.7 (5.7)	27.1 (9.1)	1.3 (2.2)	3.2 (7.5)	6.9 (7.1)	0.9 (1.4)

Table 7.--Entry and exit patterns of individual lobster fishing vessels in the Northwestern Hawaiian Islands, 1983-89. Vessels are coded for purposes of confidentiality. X's indicate fishing in a particular quarter; elipses indicate vessels that changed class. Data are from vessel logbooks.

Vessel code	Entry and exit by quarters																											
	1983				1984				1985				1986				1987				1988				1989			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Class I-S																												
Vessel U																							X	X	X	X	X[a]	
Class I																												
Vessel A					X	X	X	X	X	X	X	X																
Vessel C								X	X	X	X	X	X	X	X	X											X	X
Vessel CC								X	X	X	X	X	X	X	X	X												
Vessel N										X	X																	
Vessel V												X	X	X	X	X												
Vessel E													X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vessel W														X														
Vessel X														X	X	X	X											
Vessel AA														X	X	X												
Vessel J																		X	X	X								
Class II																												
Vessel S	X	X	X	X	X	X	X	X	X	X	X	X																
Vessel F	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Vessel D								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Vessel Z																		X	X	X	X	X	X	X				
Vessel O																							X	X	X	X	X	X
Vessel K																												X
Vessel T																							X	X	X	X	X	X
Class III																												
Vessel R	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Vessel L	X								X																			
Vessel BB					X																							
Vessel B							X																					
Vessel I							X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	.	.	.	
Vessel M								X	X	X	X	X	X	X	X	X												
Vessel P								X	X	X	X	X	X															
Vessel Y									X																			
Vessel EE									X	X	X	X	X	X	X	X	X											
Vessel G										X																		
Vessel DD											X	X																
Vessel O													X	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.
Vessel Q																		X	X	X	X	X	X			X	X	X
Vessel H																										X	X	X

Table 8.--Income (in million US$) estimate for the lobster fleet in the Northwestern Hawaiian Islands, 1986-89. Values are estimated from annualized earnings per vessel class and then adjusted to actual gross revenue. Data are revised from previous reports (Clarke et al. 1988; Clarke 1989); all active vessels are included, even if the vessels were active for only part of the year.

	Income			
Fleet income	1986	1987	1988	1989
Gross revenue	6.0	4.0	5.0	6.3
Net revenue	-0.2	0.4	1.2	0.9
Labor income	1.7	1.1	1.4	1.8
Total income	1.5	1.5	2.6	2.7
Fleet configuration				
Class I (includes I-S)	7	3	2	3
Class II	2	3	5	5
Class III	7	5	4	3

Table 9.--Alternative scenarios for future fishing effort levels by the lobster fleet in the Northwestern Hawaiian Islands. Catch per unit effort (CPUE; number of lobster per trap-haul) is based on Clarke et al. (in prep.); revenue per lobster ($5.42) and cost per trap-haul ($5.02) are based on 1989 results. The three scenarios represent alternative effort levels in 1990 and 1991.

Year	CPUE	Yield	Effort	Total revenue	Total cost	Net revenue
			Baseline			
1989	1.08	1,160,283	1,071,538	6,288,734	5,454,128	834,605
			Scenario 1			
1990	1.02	1,092,969	1,071,538	5,923,891	5,454,128	469,762
1991	0.98	1,050,107	1,071,538	5,691,581	5,454,128	237,453
			Scenario 2			
1990	0.93	1,295,489	1,392,999	7,021,551	7,090,365	-68,814
1991	0.79	1,100,469	1,392,999	5,964,543	7,090,365	-1,125,822
			Scenario 3			
1990	0.93	1,295,489	1,392,999	7,021,551	7,090,365	-68,814
1991	1.08	295,920	274,000	1,603,886	1,394,660	209,226

Table 10.--Reported sightings of or interactions with endangered or threatened species by the lobster fleet in the Northwestern Hawaiian Islands, 1989. Data are from the vessel logbooks.

Area	No. of sightings by No. of individuals	
	One individual	Two individuals
Monk seals observed in statistical area		
Maro Reef	3	
Necker Island	28	4
St. Rogatien Bank	3	1
Gardner Pinnacles	7	1
French Frigate Shoals	2	
Brooks Bank	2	
Monk seals observed in vicinity of fishing gear		
Maro Reef	1	
Necker Island	5	
French Frigate Shoals	1	
Brooks Bank	1	
Turtles observed in statistical area		
Maro Reef	1	
Necker Island	3	

Table 11.--Permit and vessel activity in the lobster fishery in the Northwestern Hawaiian Islands, 1983-89, as reported on the permit applications to the National Marine Fisheries Service, Southwest Region.

Year	Permits issued (No.)	Active vessels		
		No.	Trap carrying capacity	Average trap carrying capacity
1983	14	4	1,200	300
1984	19	11	5,240	476
1985	45	16	12,250	703
1986	54	16	13,580	849
1987	41	11	9,150	832
1988	26	9	9,420	1,047
1989	17	11	12,382	1,126

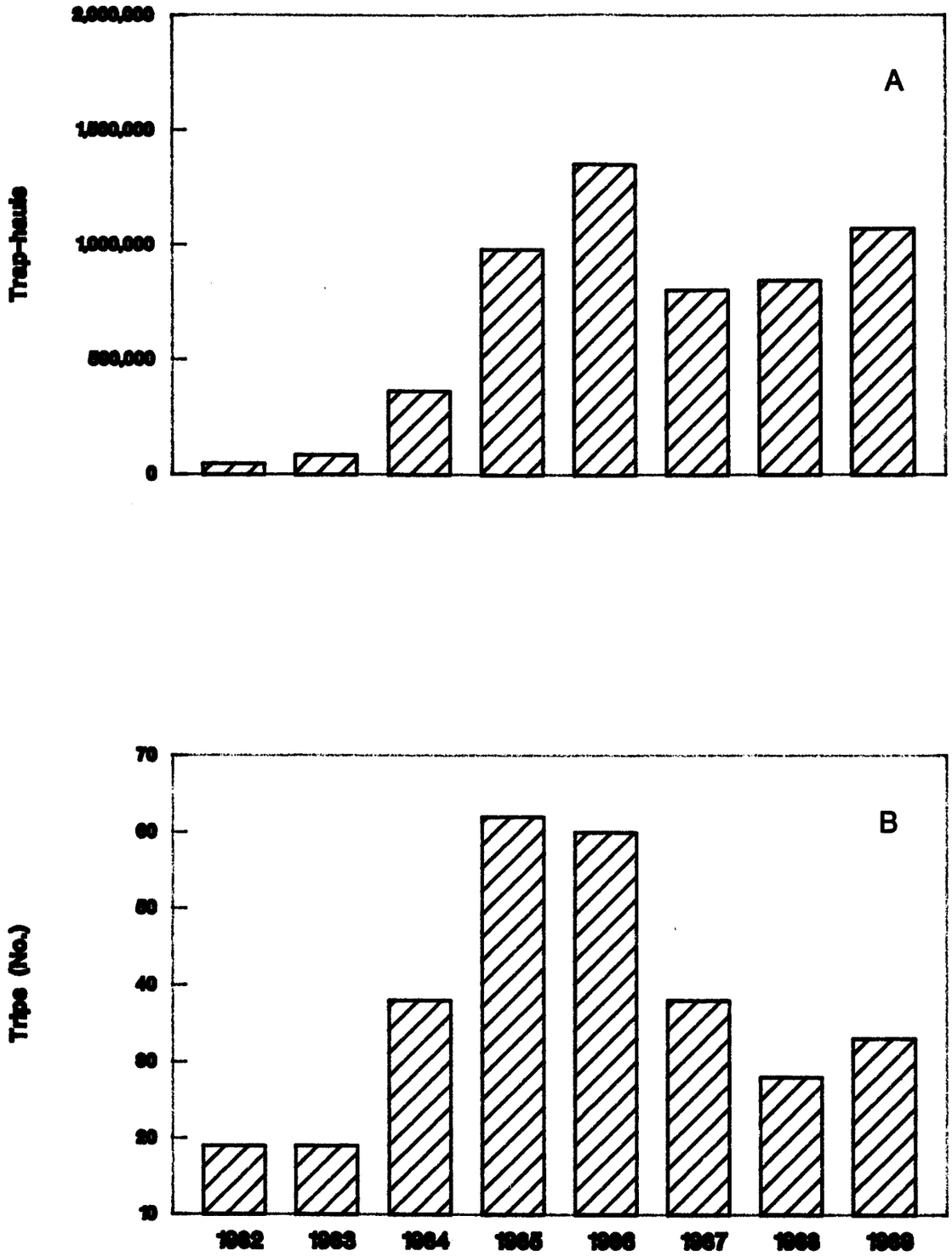


Figure 1.--Fishing effort by the lobster fleet in the Northwestern Hawaiian Islands, 1982-89: A) Trap-hauls, and B) trips.

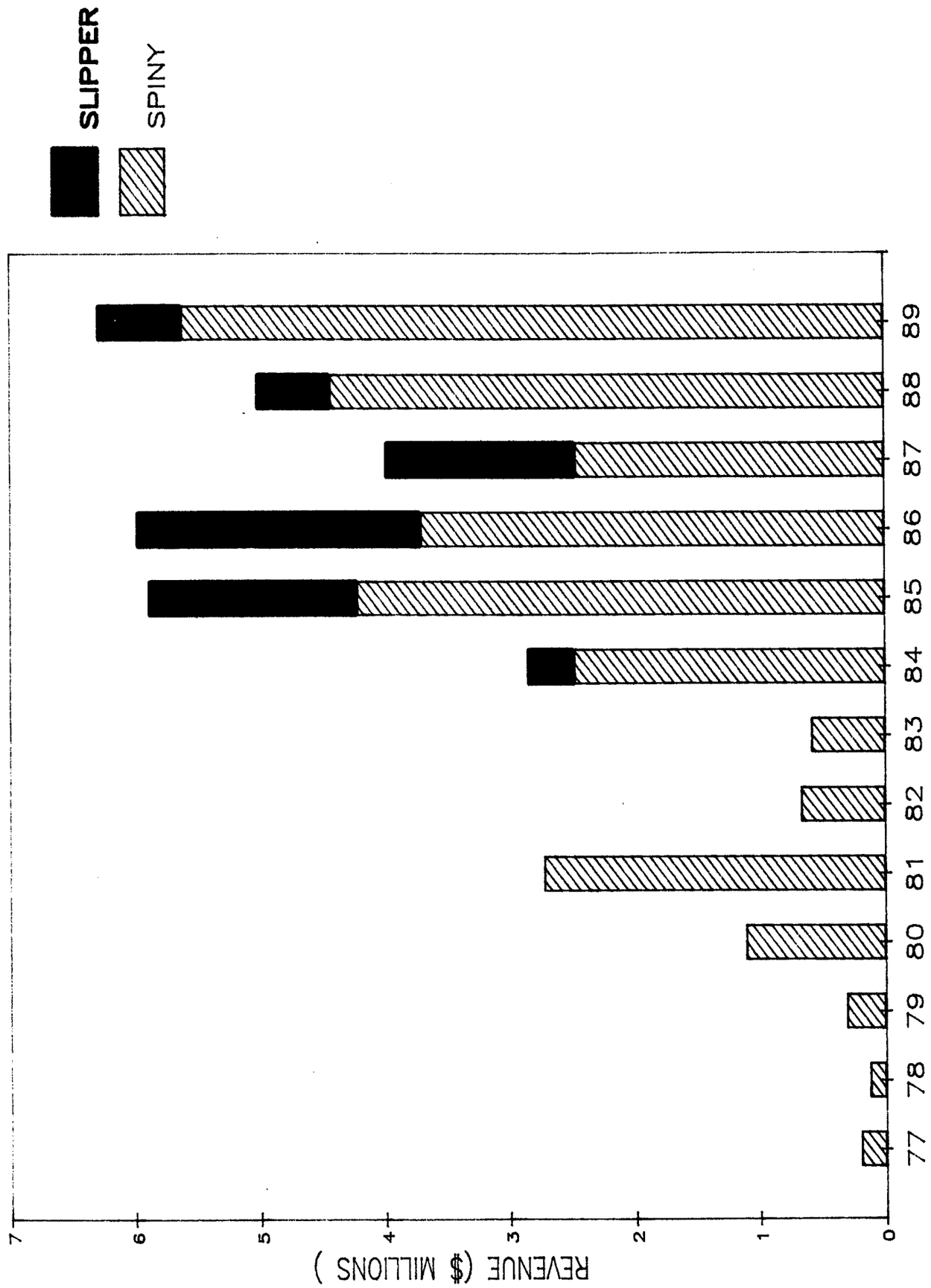


Figure 2.--Revenue for spiny and slipper lobsters from the Northwestern Hawaiian Islands, 1977-89.

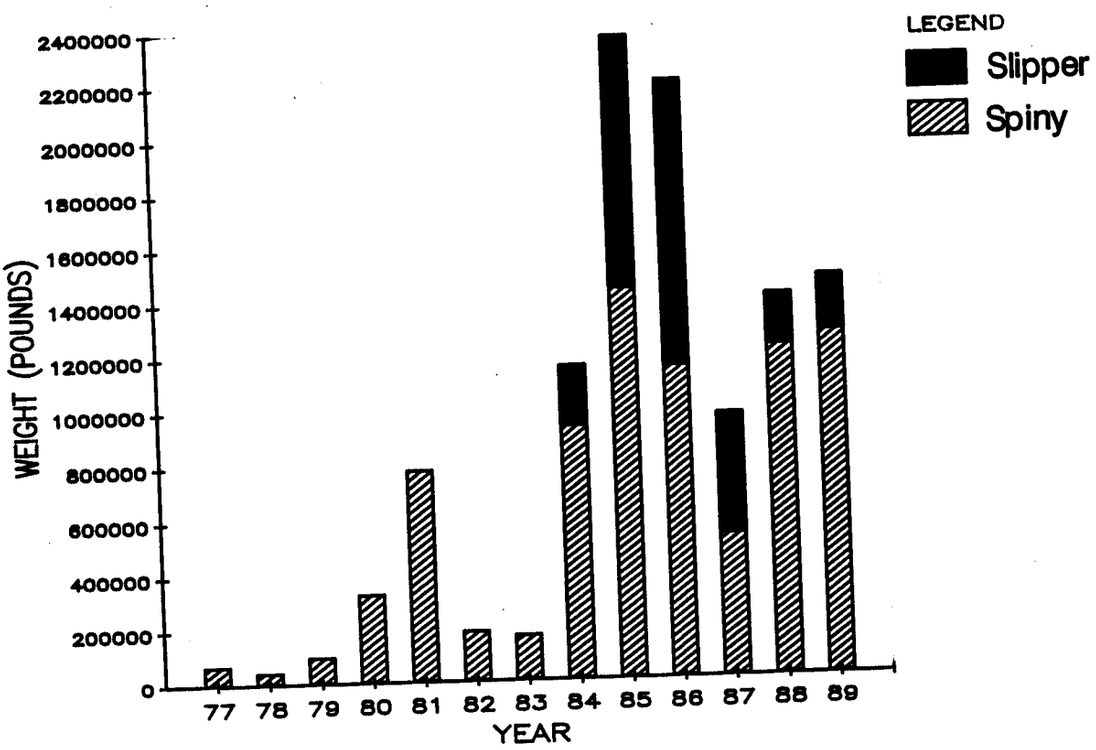


Figure 3.--Estimated annual landings (wet weight) of spiny and slipper lobsters in the Northwestern Hawaiian Islands, 1977-89.

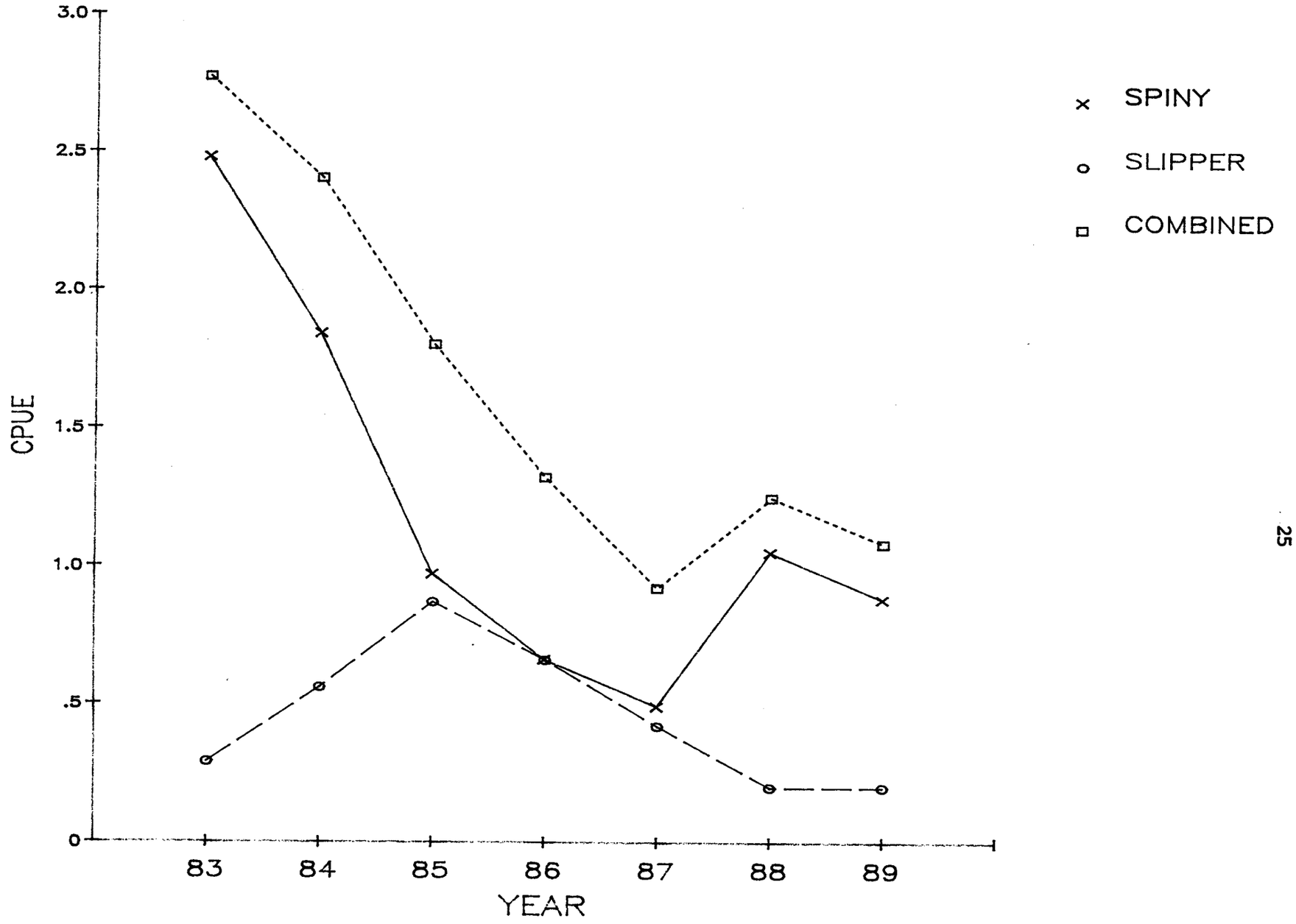
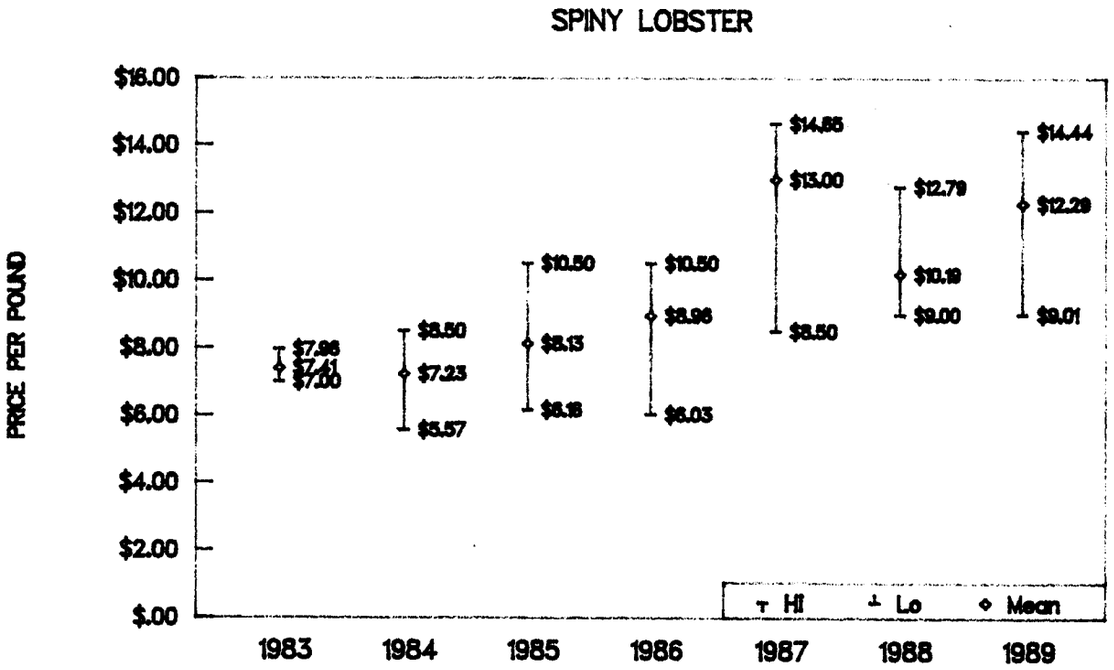


Figure 4.--Catch per unit effort (CPUE) for spiny and slipper lobsters from the Northwestern Hawaiian Islands, 1983-89. (CPUE for slipper lobster is calculated as 0.72 * number retained before 1988.)



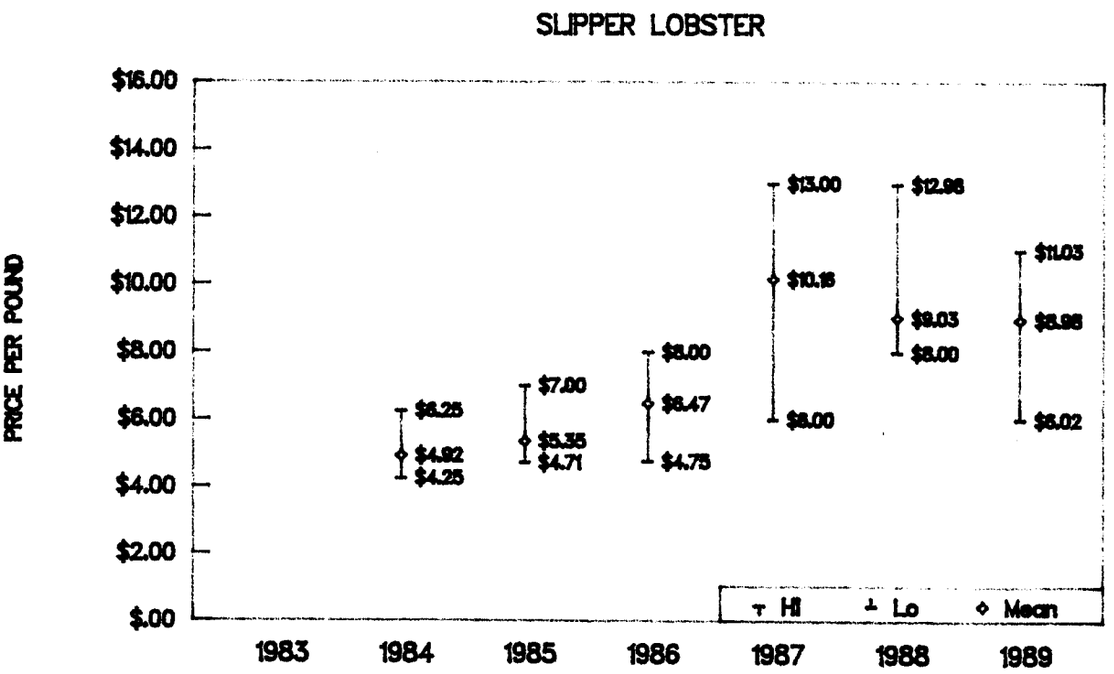


Figure 5.--Low, mean, and high ex-vessel prices of frozen spiny and slipper lobster tails from the Northwestern Hawaiian Islands, 1983-89.

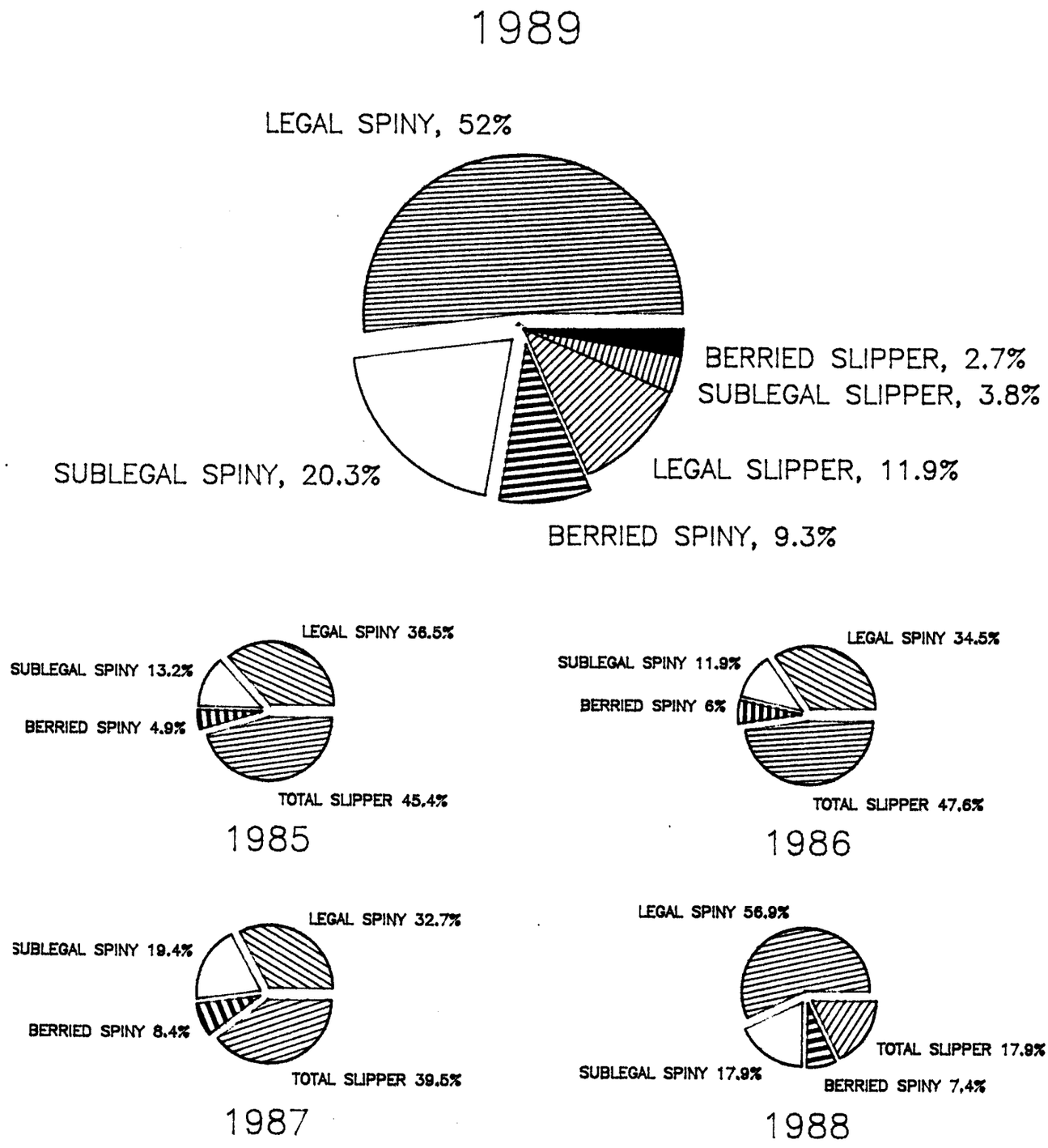


Figure 6.--Composition of catches of spiny and slipper lobsters from the Northwestern Hawaiian Islands, 1985-89.

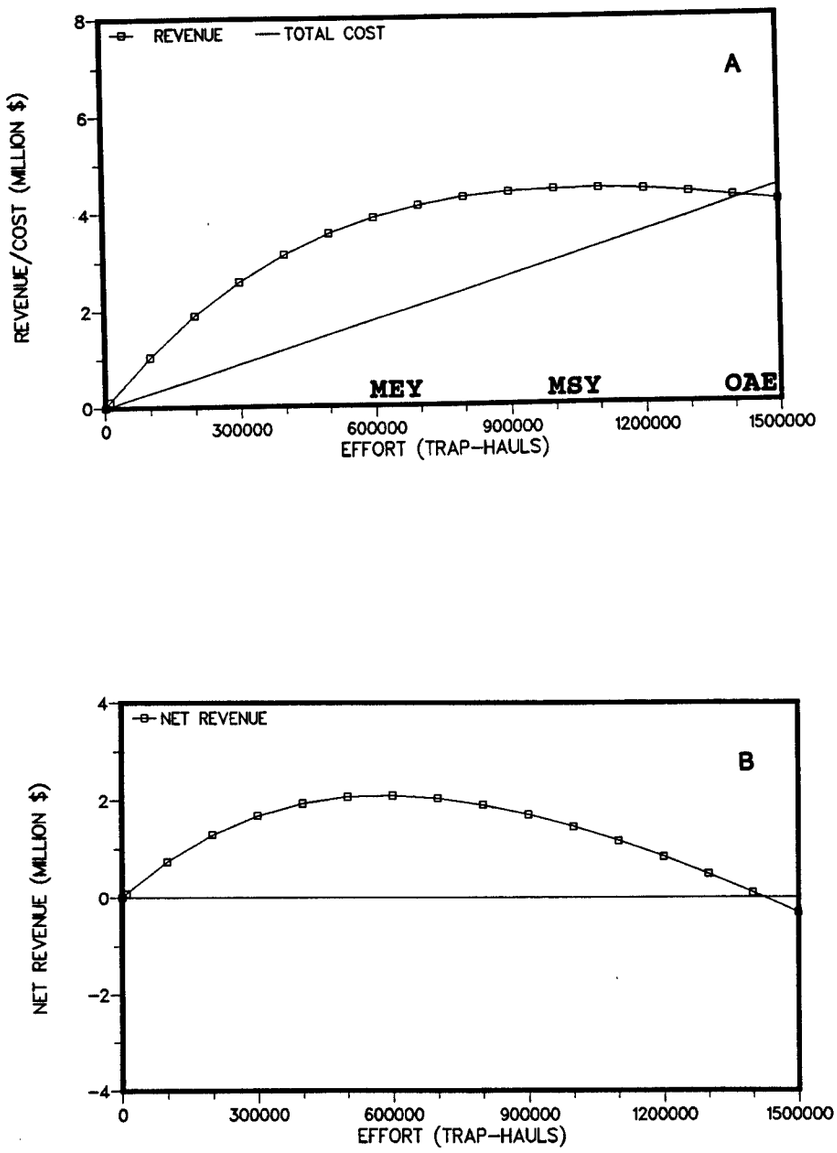


Figure 7.--Bioeconomic equilibrium model for the Northwestern Hawaiian Islands (Clarke et al. in prep.): A) CY&P long-run revenue curve, with effort levels for the maximum economic yield (MEY), maximum sustainable yield (MSY), and open access equilibrium (OAE), and B) CY&P long-run profit curve. $p = 4.055$; $c = 2.97$.

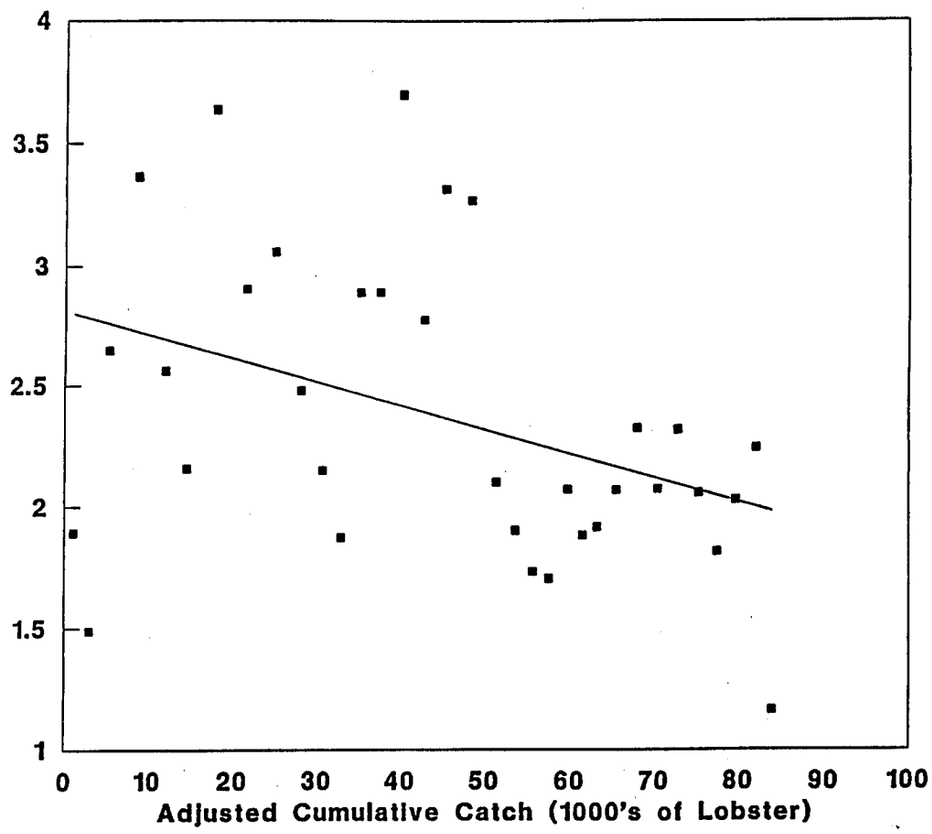


Figure 8.--Leslie model applied to intensive fishing experiment for slipper lobster at Laysan Island in the Northwestern Hawaiian Islands, 1987. Each point represents 1 day of fishing (Clarke and Yoshimoto in press).

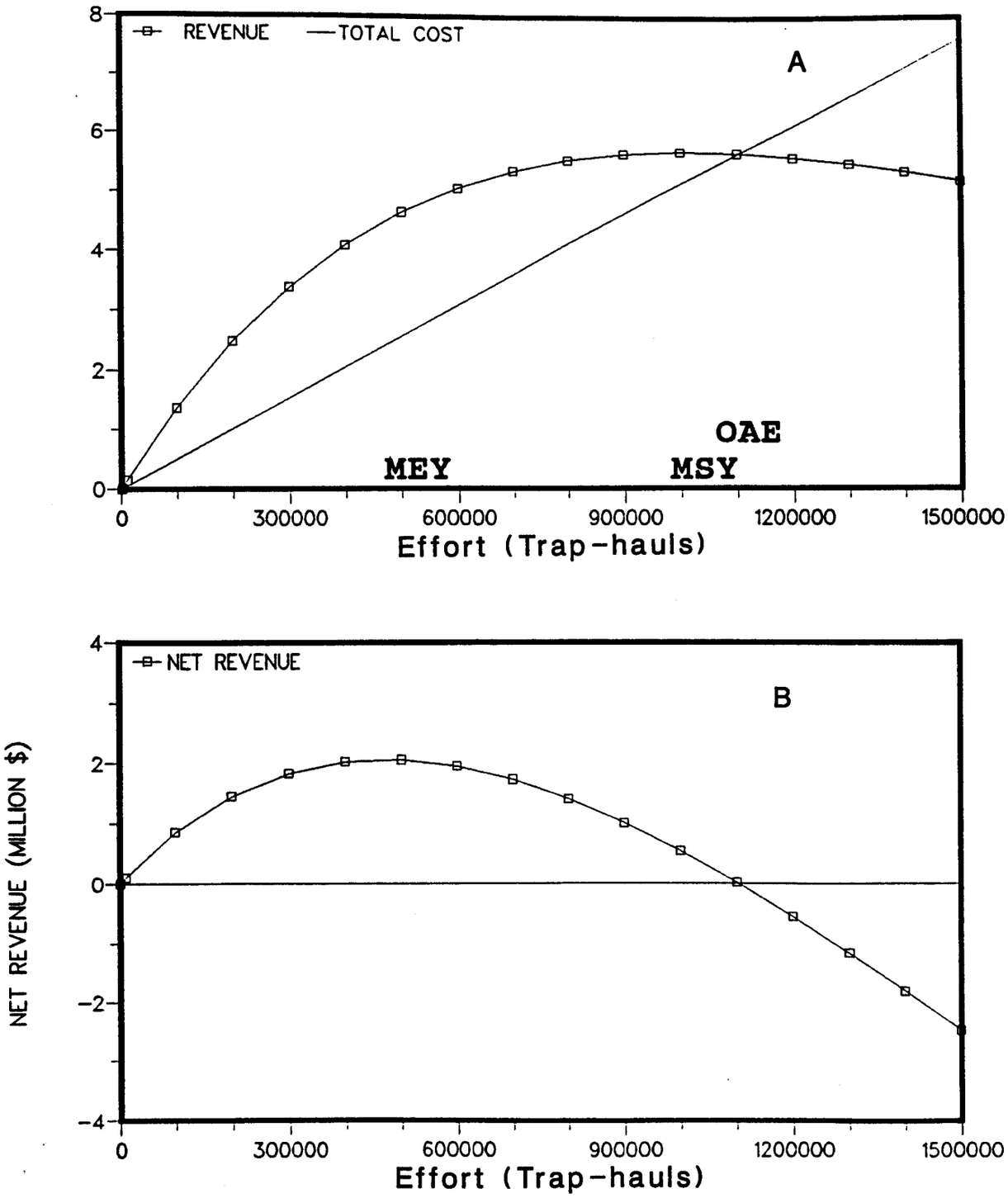


Figure 9.--Bioeconomic model, using 1989 price and cost ratios, for the lobster fishery in the Northwestern Hawaiian Islands (Clarke et al. in prep.). A) CY&P long-run revenue curve, with effort levels for the maximum economic yield (MEY), maximum sustainable yield (MSY), and open access equilibrium (OAE), and B) CY&P long-run profit curve. $p = 5.42$; $c = 5.09$.