Southwest Fisheries Center Administrative Report H-86-17C

DYNAMICS OF FLEET COMPOSITION AND VESSEL FISHING PATTERNS IN THE NORTHWESTERN HAWAIIAN ISLANDS COMMERCIAL LOBSTER FISHERY: 1983-86

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[NOT FOR PUBLICATION]

PREFACE

This report was prepared by Paul D. Gates under contract to the Western Pacific Regional Fishery Management Council and by Karl C. Samples of the University of Hawaii. It is the result of a cooperative research project on the economics of commercial lobster trapping in the Northwestern Hawaiian Islands (NWHI). The cooperating agencies include WESTPAC, the Southwest Fisheries Center of the National Marine Fisheries Service (NMFS) Honolulu Laboratory, and the University of Hawaii's Department of Agricultural and Resource Economics. Funding for the project was provided by WESTPAC and NMFS.

This report is the first of four which document the research findings of this project. A second report is under preparation which gives the results of a survey of wholesale lobster dealers and brokers on the mainland U.S. A third report will describe the results of a cost and earnings study of the NWHI commercial lobster fishery. A fourth report will be devoted to the economics of limited entry in the lobster fishery.

Karl C. Samples, Associate Professor of Agricultural and Resource Economics, University of Hawaii, is the principal investigator on the project, and Samuel G. Pooley, industry economist, is the liaison with the NMFS.

This report is being released as a Southwest Fisheries Center Administrative Report because the data which form the basis of the analysis were compiled from NMFS logbook and permit files. NMFS staff involved in the preparation of the data summaries include: Joan P. Thomason, computer programmer, and John J. Czyz, computer assistant. Ray F. Sumida, fisheries biologist, and Raymond P. Clarke, biological technician, also contributed to project. The Southwest Region Western Pacific Program Office of NMFS made available the vessel permit files.

Tables in the report that contain confidential information are included as an appendix. This appendix is not included in the general circulation of this report.

This report was prepared under contract to WESTPAC and NMFS. Thus, the statements, findings, and conclusions of this report do not necessarily represent the views of the National Marine Fisheries Service.

Samuel G. Pooley
Industry Economist

October 22, 1986

INTRODUCTION

A decade has now passed since exploitation of lobster stocks in the Northwestern Hawaiian Islands (NWHI) began on a significant commercial scale. Over this time span, the fishery has exhibited considerable dynamism in terms of fleet composition and geographic scope of fishing activities. It has grown to be one of Hawaii's single most important commercial fisheries. During 1985, landings of NWHI lobsters amounted to just under 2 million pounds, with an ex-vessel value of $4.9 million (Skillman, Milone and Witham, 1986). Although the expansion of this fishery has been documented, the dynamics of fleet composition and operations have not been examined in detail.

The purpose of this report is to develop a convenient, complete and accurate description of the operational dynamics of the NWHI commercial lobster fishery. The report documents the entry and exit of vessels from the fishery, identifies the characteristics of active and inactive vessels in the fishery, estimates fleet capacity, and gives a historical profile of the fishery by fishing area. The period under study is from March 1983 through July 1986. This time frame encompasses the total history of the fleet activities under the Spiny Lobster Fishery Management Plan (FMP) for the western Pacific which became effective on March 9, 1983. However, it does not include nearly eight years of commercial lobster fishing in the NWHI that began in 1976 following NMFS surveys of the NWHI.

Two sources of data were used to compile the report: 1) NWHI lobster fishing permit applications, and 2) lobster fishing daily activity reports. These data sources exist because each is mandated under the Spiny Lobster FMP. On an annual basis, participants in the fishery are required to file an application for a permit to take spiny lobsters (Figure 1). It is further required that all such vessels report their fishing activities on a daily basis in logbooks collected for each trip (Figure 2). Access to these two sources of data makes it possible to trace changes in the composition of the NWHI lobster fishing fleet since 1983.

DYNAMICS OF FLEET COMPOSITION

Two different criteria exist for defining the set of vessels that comprise the NWHI lobster fleet. For purposes here a clear distinction is made between the "permit" fleet and the subset of "active" vessels. Permit vessels (or more accurately, permit vessel owners) are those that are permitted to trap lobsters in the NWHI. Active vessels include only those permitted vessels that engage in trapping activities on a commercial scale. Throughout this report, a vessel is labeled as active during any given season if it fishes at least 100 traps during at least one trip. This distinction has not been made in earlier statistical reports on fleet activities. Consequently, there are minor inconsistencies between data reported here and elsewhere by NMFS.

Figure 1. NWHI Lobster Fishing Permit Application Form

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

FOR OFFICE USE ONLY
Date Application Received
Permit Number Assigned

COMMERCIAL LOBSTER FISHING PERMIT APPLICATION

(APPLICANT INFORMATION)

(1) Name of Applicant (Last,First,Middle)

(2) Name of Vessel Owner (Last,First, Middle) | Telephone Number

(3) Mailing Address of Vessel Owner | City and State | Zip Code

(4) Operator's Name (Last,First,Middle) | Telephone Number

(5) Mailing Address of Operator | City and State | Telephone Number

(PERMIT INFORMATION)

(6) Permit Area Applicant Wishes to Fish: (Mark only one box)

(7) Northwest Hawaiian Islands ☐

(8) Main Hawaiian Islands, Guam, American Samoa ☐

(9) Type of Application: (10) New Permit ☐ (11) Renewal Permit ☐

(12) Prior Permit Number: | Expiration Date of Permit:

(VESSEL INFORMATION)

(13) Vessel Name | (14) Official Vessel Number

(15) Radio Call Sign | (16) Home Port | (17) Engine Horsepower

(FISHING INFORMATION)

(18) Vessel Fish Hold Capacity (In Tons)

HOLD #1_____ HOLD #2_____ HOLD #3_____ TOTAL_____

(19) Processing Capacity:

(20) Type of Lobster Fishing Gear:

(21) Quantity of Lobster Fishing Gear:

APPLICANT'S SIGNATURE_____ DATE_____

Figure 2. NWHI Lobster Fishing Daily Catch Report

NAME OF VESSEL: _____ LOBSTER PERMIT NO.: _____

SIZE OF CREW: _____ RADIO CALL SIGN: _____

NUMBER OF TRAPS: _____ STATISTICAL AREA OF FISHING: _____

SET GEAR: Date _____ Time (begin): _____ No. of Traps _____

HAUL GEAR: Date _____ Time (finished): _____ No. of Traps _____

SPECIES	NO. OF LEGALS	NO. OF SUBLEGALS	NO. OF BERRIED	TOTAL NO.	REMARKS
Spiny Lobster (red/two-spined)					
Spiny Lobster (green/four spined)					
Slipper Lobster					
Kona Crab					
Others:					

Endangered Species observations (write numbers in pertinent blocks):

	Monk Seal	Turtle
Observed in statistical area		
Observed in vicinity of gear		
Interfering with fishing operations		
Preying on released lobsters		
Entangled and released alive		
Entangled and released dead		

Comments: _____

LOGGED BY: _____ DATE: _____
(Signature)

The description of fleet composition presented below is based on changes that occur over a fishing "season". A season is a 365-day period that corresponds to the permit year which extends from July 1 of one year through June 30 of the following calendar year. By considering the permit data in this manner, the greatest number of complete annual periods exist. Also, the most recent permit season, that of 1986, is represented as a complete season.

Permit Vessel Entry and Exit

Vessels entering the NWHI lobster fishery are obliged to obtain a numbered, non-transferable permit. Permits are issued throughout the year free of charge. However, regardless of the date of issue, all permits expire on June 30. In order for permits to be effective continuously, renewal applications must be submitted to the Regional Director, NMFS, by the 15th of June. Permits also are renewed during a single season because of: 1) a change in vessel operator; 2) a change in the number of traps declared; 3) a shift in fishing areas, or 4) a change in vessel ownership. Only one vessel in the active fleet changed ownership during a fishing season, and this only involved the establishment of a partnership. The events that precipitated this ownership change were not related to the lobster fishery. The time series of permit activity is given in Figure 3.

Eleven vessels obtained fishing permits for the remainder of the 1983 season (through June 30, 1983) following the implementation of the Spiny Lobster FMP in March 1983. Nine permits were issued for the NWHI, and 2 were issued for the Main Hawaiian Islands (MHI).

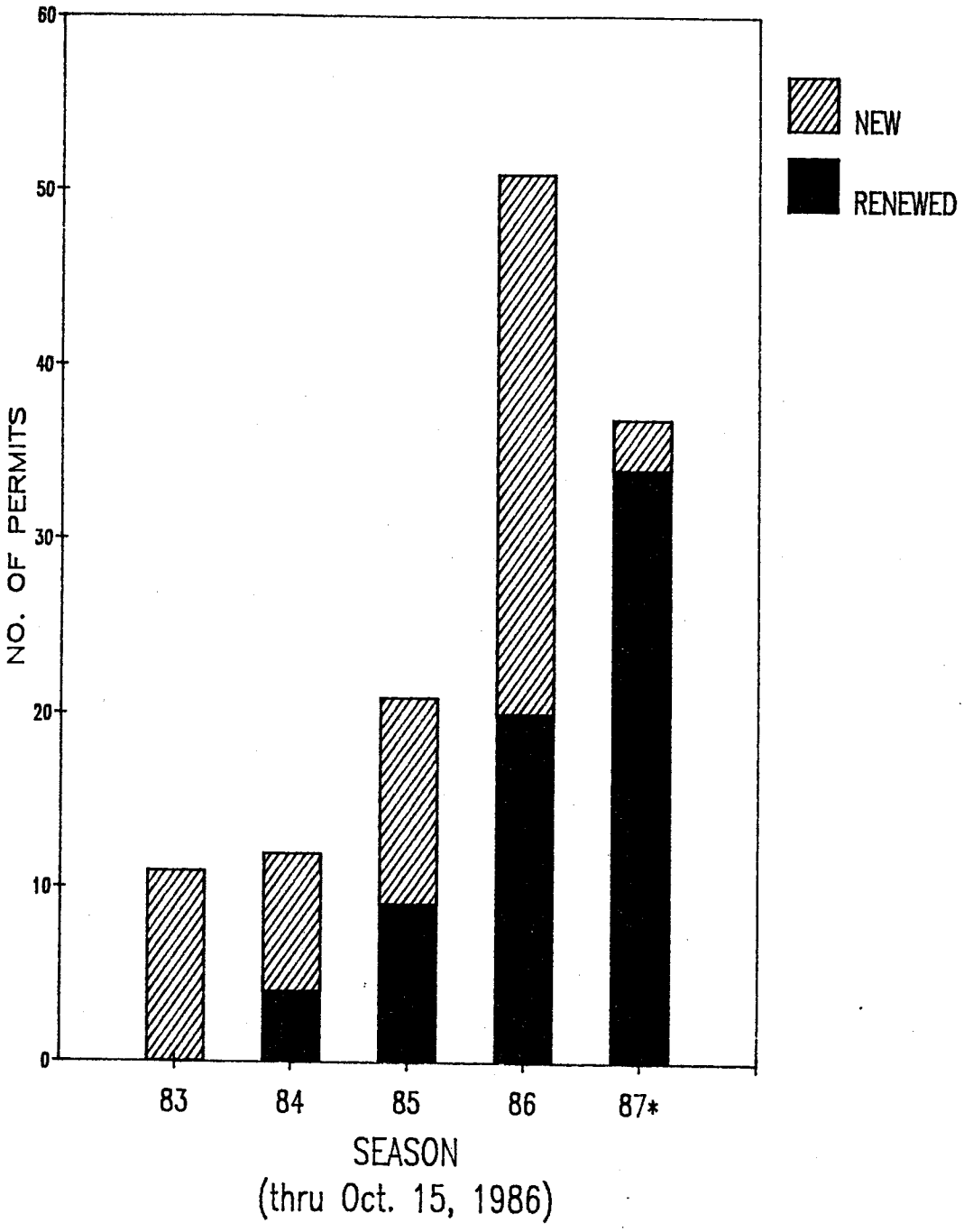
During the 1984 permit season (July 1, 1983 - June 30, 1984), 12 permits were issued. These permits included 8 new permits and 4 renewals from the 1983 season. The 4 vessels that renewed permits had been lobster fishing prior to 1983, and 3 of them had made trips during the 1983 season. The remaining 7 permit holders from the 1983 season allowed their permits to expire.

The number of valid permits nearly doubled between the 1984 and 1985 seasons. Over the course of the 1985 season, 21 were issued. Twelve were new and 9 were renewals. Three permits which had been valid through the 1984 season were not renewed.

During the 1986 season, 51 permits were issued. Of these, 20 were renewals from the 1985 season and 31 were issued for the first time. Thus, only one permit from the previous season was allowed to lapse.

An important factor affecting the number of permits issued early during the 1986 season was the September 1985 announcement of a 90-day moratorium on permit issuance. The moratorium, which commenced on October 1, 1985, was passed by the Western Pacific

Figure 3. NWHI Lobster Fishing Permit Profile



Regional Fishery Management Council as an interim means to control effort in the fishery until more permanent management options could be developed. Passage of the permit moratorium prompted fishermen to obtain permits before the moratorium took effect, regardless of whether or not they seriously intended to participate in the fishery during the 1986 season. Quite likely fishermen perceived that by obtaining a permit, they would have a better chance of being "grandfathered" into the fishery if a limited entry scheme was later adopted. However, the moratorium was not extended, and it expired on December 29, 1986.

In response to the expiration of the moratorium, the number of total permits issued for the 1987 season dropped to 37. This reduction is the net result of 3 new permits being issued, combined with the fact that 17 fishermen failed to renew their permits.

Since March 1983, 61 separate fishing vessels have been issued permits to trap lobsters in the NWHI. Due to transfer of ownership of 4 vessels, the total number of new permits issued is 66 (Table 1). Of this group, 28 permit holders (42 percent) failed to renew their permits for various reasons. With just one exception, these vessels held a permit for no longer than 2 years. In all cases, the departing vessels had never engaged in commercial-scale lobster trapping in the NWHI.

Active Vessel Entry and Exit

Out of 61 permitted vessels, only 21 vessels (34 percent) have become active participants in the fishery since 1983. With the exception of 1985, this ratio has been fairly constant. In 1986, the ratio of active to permitted vessels rose to 37 percent. The difference between the number of permit holders and active vessels is illustrated in Figure 4 for the 1983-86 fishing seasons and the first 3 months of the 1987 season.

Out of the 21 active vessels, 76 percent began fishing during the first year they were issued a permit. The remaining active vessels began trapping operations by the end of their second permit year.

Three of the 11 permitted vessels actively fished on a commercial scale before the close of the 1983 season (June 30, 1983). All fishing was conducted in the NWHI permit area and a total of 8 individual trips were taken.

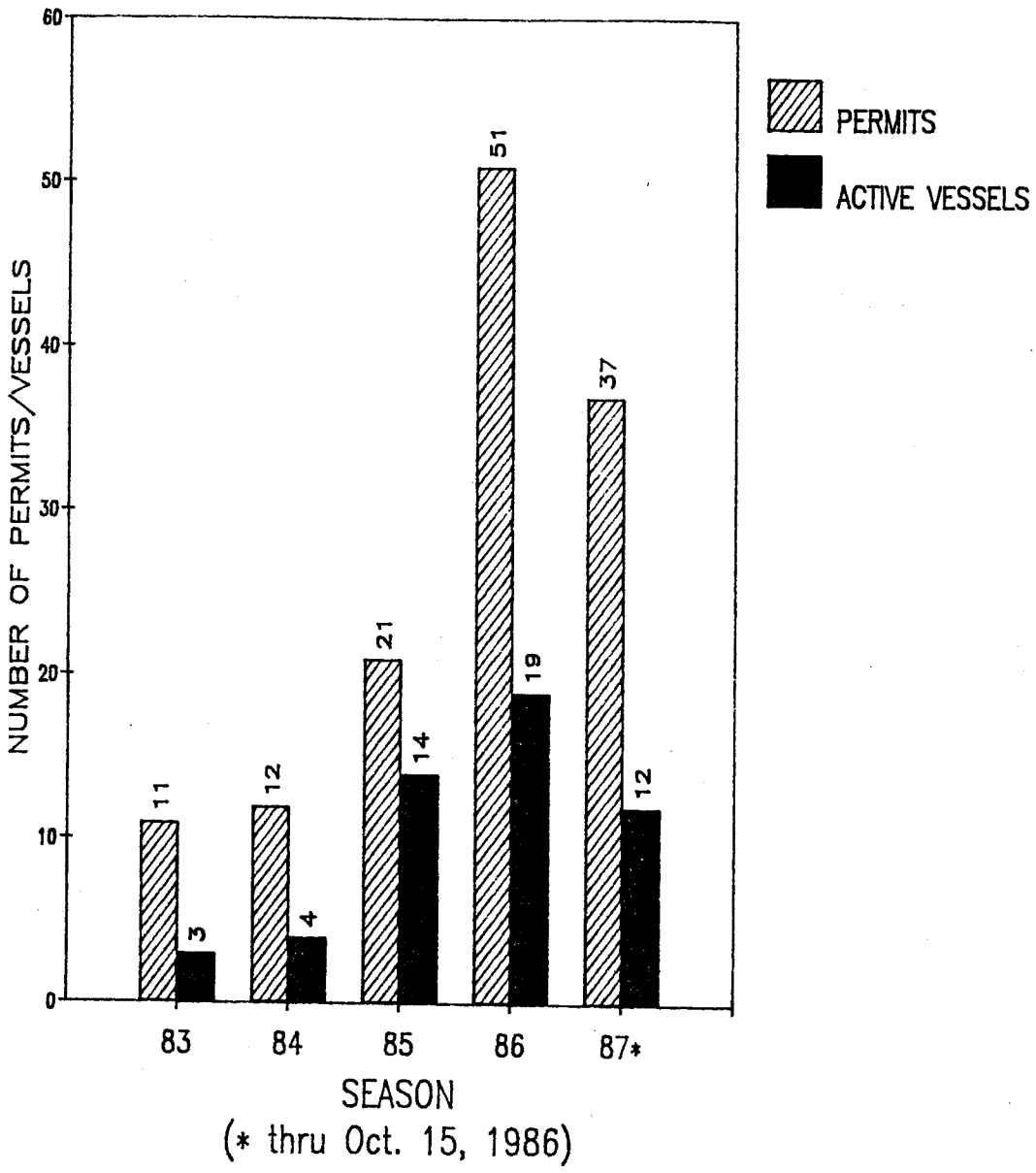
During the 1984 season, the active fleet consisted of 4 vessels which together recorded 21 separate fishing trips. Two of the boats had fished during the 1983 season and 2 vessels had not previously fished under the Spiny Lobster FMP. Of the 2 new vessels, 1 was first permitted in the 1984 season, while the other was a renewal from the previous season. Thus, in the 1984 season, only 1 out of 8 newly permitted vessels participated in the fishery.

Table 1. Status of Permits for the Hawaiian Lobster Fishery

	SEASON				
	1983	1984	1985	1986	1987(a)
Permit Profile:					
New	11	8	12	31	3
Renewals	NA	4	9	20	34
Total	11	12	21	51	37
Dropouts From Previous Season	NA	7	3	1	17
Renewal Profile:					
Number of Renewed Permits/Number of Seasons it has Been Renewed)	NA	4/1	4/2 5/1	4/3 4/2 12/1	4/4 3/3 7/2 20/1
Dropout Profile:					
Number of Dropouts/ Number of Seasons With Permit	NA	7/1	3/1	1/2	1/3 5/2 11/1

(a) Data through October 15, 1987

Figure 4. Profile of Permited and Active Vessels in the NWHI Lobster Fishery



Fourteen vessels fished commercially during the 1985 season taking a total of 57 separate trips. Eight out of the 9 vessels with renewed permits from the 1984 season fished throughout the 1985 season, 3 of them for the first time. The other 6 participants in the fishery during the 1985 season came from the set of 12 newly permitted vessels.

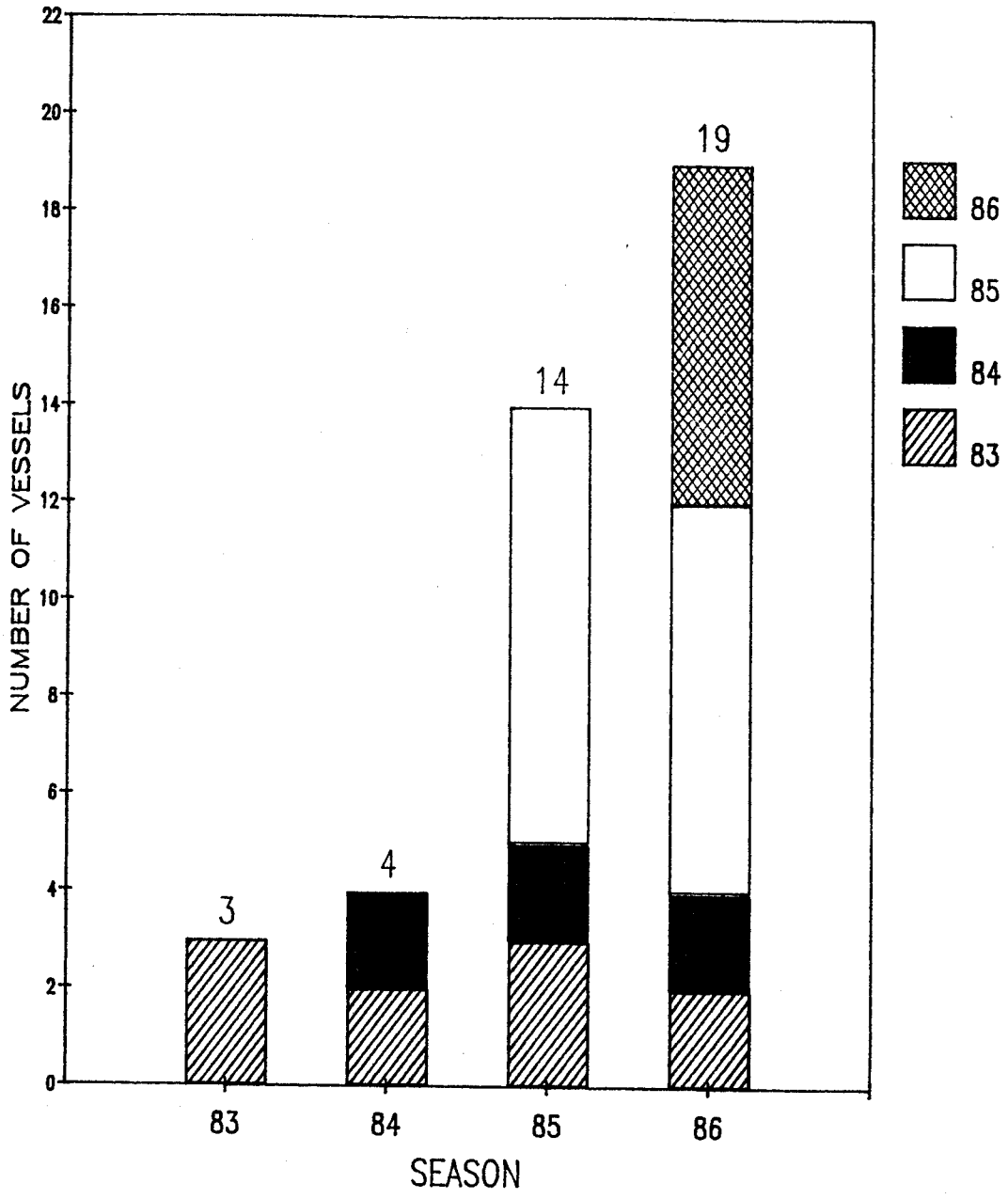
The number of vessels active in the fishery reached a record high of 19 during the 1986 season. Twelve of these vessels had fished previously, and 7 were newcomers. Out of these, 6 represented newly permitted vessels. The other newcomer had acquired a permit the previous season but had not fished. By the end of the 1986 season (June 30, 1986), 4 boats had dropped out of the active fleet. Fifteen participants remained. Of the 4 vessels that terminated fishing efforts, only 1 can be conclusively linked with low catches and poor production.

During the period of March 1983 through June 1986, 21 vessels actively engaged in commercial lobster trapping during at least 1 season. By June 1986, the profile of years of experience in the fishery was as follows: 8 vessels had fished 1 season; 9 vessels had fished 2 seasons; 2 vessels had fished 3 seasons; and 2 vessels had fished all 4 seasons (Figure 5). The greatest number of active vessels during a single fishing season was 19 in 1986, but by the end of that season the number of active participants had fallen to 15 boats. During each of the past 4 seasons, 4 vessels comprised the nucleus of the active fleet. Three of these had commercially fished for lobster before 1983. During the past two seasons, 14 new boats have become active in the fishery, and several have done quite well in terms of total catch, and landing revenues.

Since 1983, 4 out of 21 active vessels (19 percent) have exited the NWHI lobster fishery. This turnover occurred during the 1986 season. Of these 4 boats, 1 had fished consistently since the fishery began (although it did not make a fishing trip during the permitted portion of the 1983 season, it had fished prior to that). Another exiting vessel had fished a total of about two years (1 full season and parts of 2 others). The third boat was active for 16 months during parts of 1985 and 1986, while the last vessel was active for only about 5 months during the end of 1985 and the beginning of 1986.

These 4 vessels exited the fishery for several different reasons. The first vessel, which had been part of the active fleet nucleus even before 1983, left for reasons unrelated to the economic conditions of the fishery. Two of the other 3 departing boats were sold, and their new owners had intentions other than to continue to utilize the vessels for lobstering. Both of these vessels had been for sale for quite sometime and one had only made two short trips to the NWHI. One boat went into service in a fishery outside of Hawaii. The previous owner of the other vessel that was sold and dropped out of the fishery still owns a vessel which is currently active in the fishery. Sources at NMFS indicate that the vessel which was not sold because of marginal

Figure 5. Profile of the Active NWHI Lobster Fishing Fleet



profitability of the fishery.

The fourth vessel that dropped out of the fishery in the 1986 season might represent the only one of the few vessels which have fished with commercial-scale intensity, which still had to leave the fishery due to directly associated economic reasons. Many of the problems that prevented the vessel from catching profitable amounts of lobster were mechanical in nature. A succession of breakdowns reportedly seemed to set the tone for each cruise. Therefore, it seems that in the end, only one vessel exited the fishery because it truly was an unprofitable venture. However, this unprofitability may have been more closely associated with the ship itself than with the state of the fishery.

Dynamics of Fleet Capacity

Total industry capacity to harvest lobsters depends on fleet size, fishing frequency, and fishing power. Since 1983, there has been significant upward trends in all three factors. The previous discussion supports this claim both in terms of fleet size, and in fishing frequency as measured in terms of aggregate trips taken per season.

Data extracted from vessel permit applications and logbook records suggests that the third capacity factor, fishing power, has also increased significantly since implementation of the Spiny Lobster FMP. Fishing power refers to the catching capabilities of an individual vessel. Three different measures of fishing power were adopted here. Each has its limitations.

The first measure is the number of traps declared on permit applications. The problems with this measure are fourfold. First, the number of traps listed on a permit is not necessarily even close to the number of traps that are actually fished under normal circumstances. Inexperienced applicants may have difficulty accurately making this assessment. Secondly, a vessel's fishing operations generally become more efficient over time. The more experienced the skipper and crew become, the greater the number of traps they will be able to turn over in a day. Consequently, the number of traps actually fished may increase while the total number of traps on board does not change. The skipper may have a greater impact on efficiency than the crew in most cases because there is an extremely high turnover of crew on lobster boats. Thirdly, there may be a conscientious inflation in the number of traps listed on permit applications. Although there is no clear evidence in this regard, the number of reported traps may be artificially high to offset the effect of potential ceilings on effort.

A fourth problem associated with using traps as a measure of fishing power over time is the fact that traps used by fishermen have undergone considerable technological development since 1983. At least three basic trap designs have been used. In 1983, vessels were using a combination of wire mesh, wooden slat and

black plastic traps. By 1986, the changeover to black plastic traps was complete. This was motivated by the fact that, unlike wire mesh and wooden slat traps, black plastic traps can be disassembled into halves and nested when not in use. Consequently, fishermen can carry more traps than previously.

In view of these four shortcomings, a second measure of fishing power which avoids some of these problems is the maximum number of traps hauled per 24-hour period. This trap measure, termed "maximum" or "actual" traps fished here, is derived from daily fishing activity reports. As such, it is based on actual trap use rather than permit applicants' projections about expected trap use and carrying capacity. Furthermore, there are fewer incentives for fishermen to inflate this value. However, there remains the influence of technical developments on trap productivity over time.

The third measure of fishing power is main engine break horsepower or simply "vessel horsepower." Horsepower is one of the few physical characteristics requested on permit applications. No data are provided on vessel length or net tonnage. However, information on horsepower is complete and appears to be reliable based on comparisons between reported values and knowledge about the fishing vessels themselves.

A chronology of number of traps declared, maximum traps fished, and vessel horsepower is given in Table 2 for calendar years 1983 through 1986. Calendar years were selected rather than seasons because data on traps actually fished are compiled by NMFS on a calendar year basis only. For each year, the fleet is separated into active and inactive segments. This distinction is based on whether the vessel fished on a commercial scale (i.e. greater than 100 traps hauled) during the calendar year. Information on maximum traps fished is available only for the active fleet.

Looking first at annual trends in number of traps declared, the total has grown from 6,600 in 1983 to 36,090 in 1986. This represents an annual average increase of 110 percent. Part of this growth is due to the increase in number of permit vessels which has grown at an annual rate of 66 percent. Also a factor is the early wholesale conversion of the fleet to plastic traps which allowed the average vessel to carry more traps. In 1983, vessels declared 471 traps, on the average. In 1986, the average vessel declared 708 traps, a 50 percent increase over 1983 levels.

The most rapid growth in number of declared traps is by the active fleet which grew by an annual average rate of 200 percent. The average growth rate in maximum traps fished by the active fleet is somewhat lower at 160 percent. The growth rate in both cases is due to: 1) an increased number of traps carried per vessel (the plastic trap effect), and 2) an increased average size of vessel entering the fleet.

Table 2. Fleet Capacity Indicators: 1983-86

CAPACITY INDICATOR	1983 ACTIVE	1983 INACTIVE	1983 TOTAL	1984 ACTIVE	1984 INACTIVE	1984 TOTAL	1985 ACTIVE	1985 INACTIVE	1985 TOTAL	1986(a) ACTIVE	1986(a) INACTIVE	1986(a) TOTAL
Vessel Numbers	4	10	14	9	12	21	15	36	51	15	36	51
Traps Declared on Permit Application	1350	5250	6600	5790	4600	10390	11350	18040	29390	11850	24240	36090
Maximum Traps Fished Per Day	1145	NA	1145	4733	NA	4733	9359	NA	9359	8747	NA	8747
Vessel Horsepower	1345	5636	6980	3615	4715	8330	7435	11225	18660	7150	16515	23665

(a) Data through June 1986

Total horsepower in the permit fleet (active and inactive vessels combined) increased by an annual average rate of 60 percent between 1983 and 1986. This largely reflects a similar increase in fleet size. Once again, the active fleet registered the fastest growth in horsepower relative to inactive boats, indicating larger vessels were entering the fleet.

In terms of vessel numbers, the active fleet represents a third of the total permitted fleet. This proportion carries over to declared traps and vessel horsepower (Table 3).

Taken together, these data suggest that capacity in the lobster fishing fleet has expanded at an average annual rate between 100 and 200 percent since 1983. This is true for the active, inactive, and combined fleet. It also holds for horsepower, traps declared and traps actually fished. The peak year for almost all capacity indicators is 1986.

The data also suggest that there is a close relationship between the various capacity measures: fleet size, horsepower, traps declared and traps fished. Traps declared seems to be a reasonably good proxy for maximum traps fished, although both trap measures have possible problems in terms of accuracy.

DYNAMICS OF VESSEL FISHING ACTIVITIES

The history of the NWHI lobster fishery since 1983 is characterized by a steady increase in active participants and trip frequency (Figure 6). This growth is associated with the northwest extension of fishing activities farther from the fishery logistic center in Honolulu. In addition, increased fishing pressure has been exerted at more locations throughout the NWHI. Banks that were largely ignored in the past, perhaps due to their small size, are now being fished. Both of these trends, are graphically portrayed in Figure 7 (arrows indicate areas where vessels fished on return trips to Oahu).

Expansion in Fishing Range

From the inception of the fishery in 1976, through 1982, the primary fishing grounds were located around Necker Island. Necker is the nearest major fishing ground to Honolulu (Table 4). During 1983, the fleet explored more distant waters with a boat making 2 trips to Gardner Pinnacles. In addition, a single vessel made a 36-day trip to Maro Reef (776 miles from Honolulu), which represented the most distant fishing effort (Table 5).

In 1984, fishing effort did not range into waters more distant than the Maro Reef grounds, but fishing activity around Maro Reef increased considerably. Expansion of the fishing range during 1984 occurred through greater dispersion of vessels. Effort was expanded so that smaller banks within the existing range were now being exploited. These included Nihoa Island, French Frigate Shoals, and Raita Bank. Additionally, 1 vessel fished for 2 days in waters of the Main Hawaiian Islands.

Table 3. Percentage Relationships For Horsepower and Traps.

	CALENDAR YEAR			
	1983	1984	1985	1986(a)
Total Vessel Horsepower:				
Percent in Active Fleet	19.3	56.6	39.8	30.2
Percent in Inactive Fleet	80.7	43.4	60.2	69.8
Total Declared Traps:				
Percent in Active Fleet	17.4	55.7	38.6	32.8
Percent in Inactive Fleet	82.6	44.3	61.4	67.2
Percent in Active Fleet Actually Fished	84.8	81.7	82.5	73.8

(a) Data through June 1986

Figure 6. Profile of the Active Fleet Size and Trips

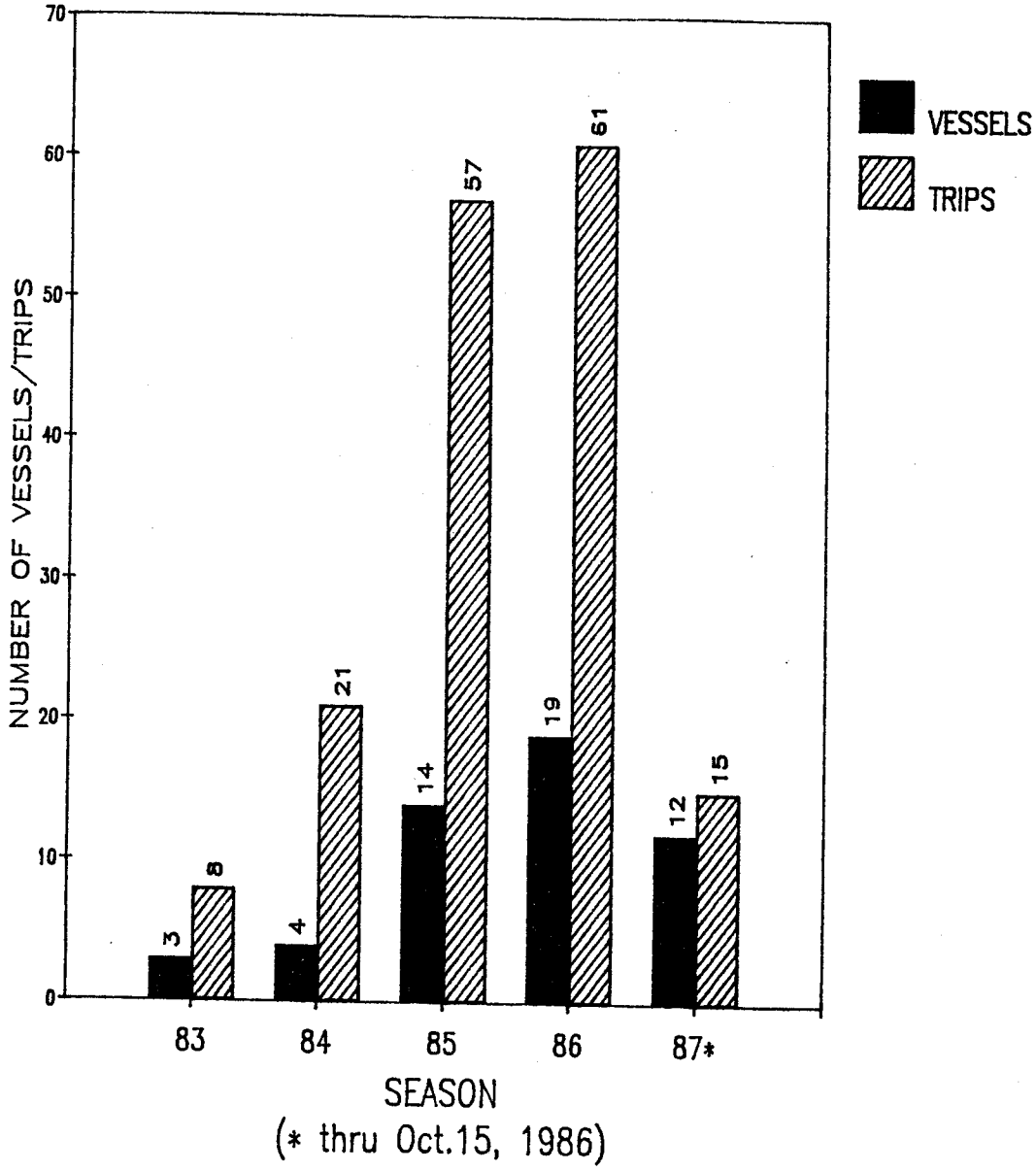
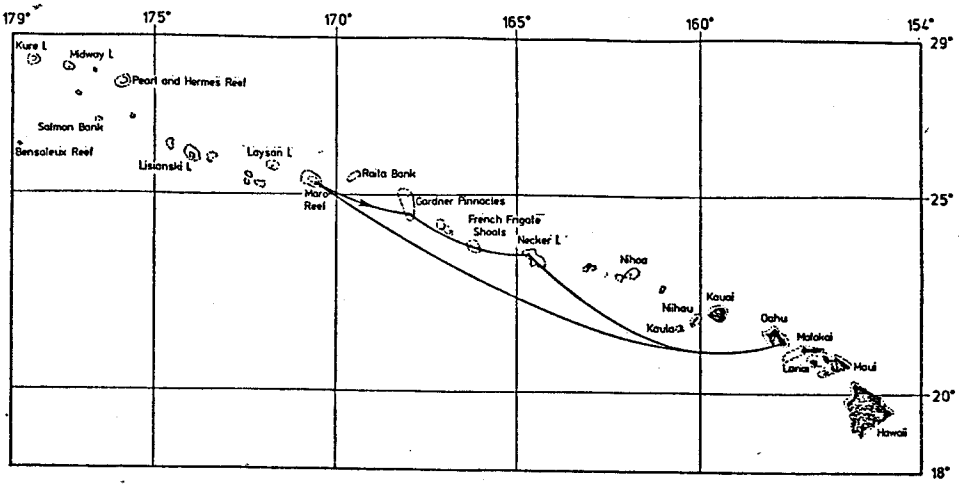
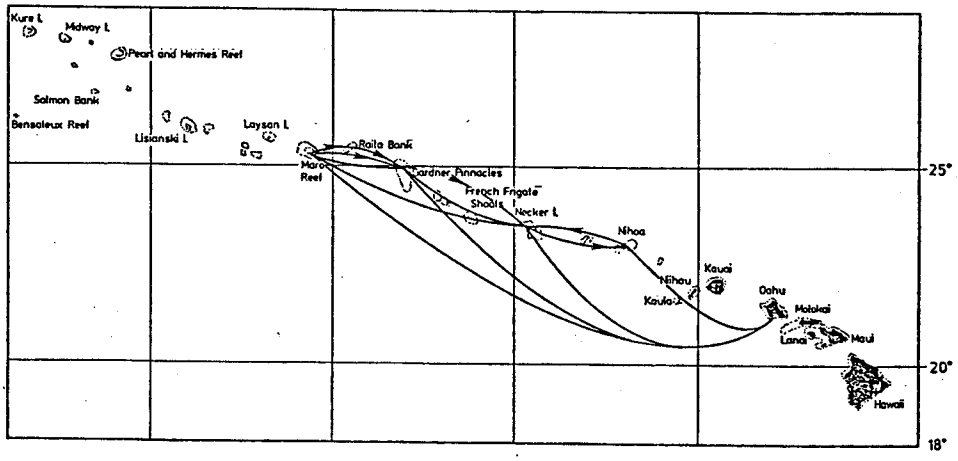


Figure 7. Expansion of Lobster Fishing Activities in the NWHI

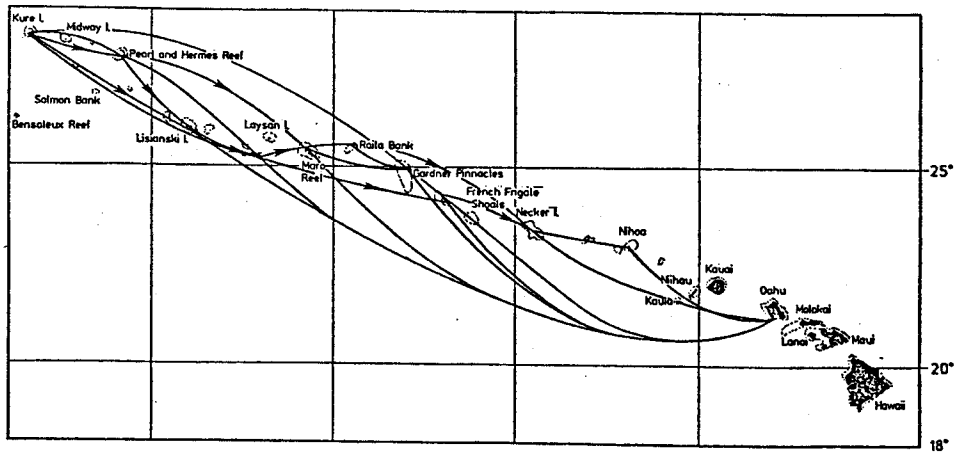
1983 19 TRIPS
3 AREAS



1984 33 TRIPS
6 AREAS



1985 62 TRIPS
14 AREAS



1986 33 TRIPS
15 AREAS
(preliminary)

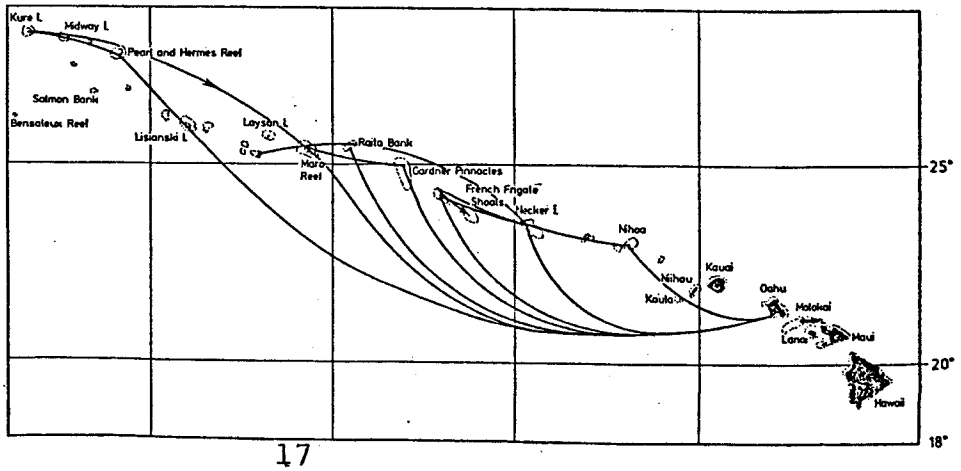


Table 4. Distance and Running Time to NWHI Fishing Areas From Honolulu

AREA	DISTANCE (NAUTICAL MILES)	RUNNING TIME (HRS)(a)
Main Hawaiian Islands (just north of Kauai)	128	16
Nihoa	216	27
Necker	384	48
French Frigate Shoals	480	60
Brooks Bank	520	65
St. Rogatien	544	68
Gardner Pinnacles	616	77
Raita	712	89
Maro Reef	776	97
Laysan	843	105
Northhampton Banks	864	108
Pioneer	944	118
Lisianski	976	122
Pearl and Hermes Reef	1128	141
Midway	1232	154
Kure	1280	160

(a) Based on an average running speed of 8 knots per hour

Table 5. Summary of Fishing Activities: 1976-86

YEAR	NO. OF VESSELS	NO. OF TRIPS	NO. OF AREAS FISHED	MOST DISTANT AREA	DISTANCE FROM OAHU
1976!	1				
1977	5	14			
1978	2	12			
1979	2	6			
1980	3	12			
1981	10	25			
1982	7	19			
1983+	4	19	3	MARO	776
1984	9	33	6	MARO	776
1985	15	62	14	KURE	1280
1986*	16	33	15	KURE	1280

! 76-82 data is from NMFS Administrative Report H-86-6.
+ Detailed data is available only since the FMP went into effect in 1983.
* Data through July 1986

In 1985, fishing effort was expanded to include 14 different fishing grounds compared to 6 different areas fished in 1984. Five of the new fishing grounds were the result of a range extension into more distant waters, while the other three new fishing grounds became part of the fishery through a greater dispersion of effort within the already existing range of activity. The waters around Kure Atoll, 1280 miles from Honolulu and just west-northwest of Midway Islands, became the most distant fishing ground visited by the 1985 fleet. The other areas added to the fishery via range extension beyond Maro Reef were Northhampton Banks, Lisianski Island, and Pearl and Hermes Reef. The identified fishing grounds added by dispersion of the fleet throughout its prior existing range were Brooks and St. Rogatien Banks. During 1985, 2 vessels also made a total of three fishing trips in Main Hawaiian Island waters. By the end of 1985, nearly all of the known fishing grounds in the NWHI had been exploited.

Through the first 7 months of 1986, 16 vessels completed 33 fishing trips. Fishing operations have once again extended to Kure Atoll. Fishing effort has been dispersed among 15 fishing grounds. Pioneer Bank and Laysan Island have been fished in addition to the areas which had also been fished during 1985.

Expansion of fishing effort throughout the NWHI has not been uniform in terms of intensity. In 1983, all fishing was conducted in 3 areas: Necker Island, Maro Reef, and Gardner Pinnacles (Table 6). Fishing around Necker Island alone accounted for 62.2 percent of that year's trapnights. During 1984, when several new areas were fished, the combination of effort at Necker, Maro and Gardner still represented 90.8 percent of the year's total trapnights. In 1985, the fleet dispersed more widely and ranged further than ever before. Fourteen grounds were fished in 1985, but fishing around Necker, Maro and Gardner still accounted for 68.2 percent of the year's effort measured in terms of trapnights. Within this group however, Maro Reef replaced Necker Island as the most heavily fished area by a factor of 1.8 (371,854 trapnights at Maro as compared to 211,208 trapnights at Necker Island). The 1985 pattern of effort has been reflected thus far through 1986. Maro Reef, Necker Island and Gardner Pinnacles account for 66.1 percent of the fishing effort, with Maro Reef being fished nearly twice as heavily as Necker Island.

Even though fishing effort is encompassing more distant and widely scattered areas, the three areas fished in 1983 continue to attract the majority of fishing effort. Thus, historically fishing effort has been and continues to be trimodally distributed. Even though more areas have been fished each year, approximately two thirds of the total fishing effort is concentrated around three areas (Figures 8 and 9). Necker Island and Maro Reef are established as the two most heavily fished areas in terms of effort measured in trapnights. However, the greatest concentration of effort has shifted from Necker Island, which is the nearest major fishing ground to Oahu, to Maro Reef, which is an additional two days running time from Honolulu. The

Table 6. Distribution of Fishing Effort By Area

YEAR AND AREA	TRAPNIGHTS	PERCENT OF EFFORT
1983		
Necker	47791	62.2
Maro	16150	21.0
Gardner	12916	16.8
TOTAL	76857	100.0
1984		
Maro	142973	37.9
Gardner	102099	27.1
Necker	97367	25.8
Nihoa	23871	6.3
Raita&French Frig.Sho.	10938	2.9
TOTAL	377248	100.0
1985		
Maro	371854	34.1
Necker	211208	19.4
Gardner	163038	15.0
St. Rogatien	180711	16.6
Pearl&Hermes Reef	65907	6.0
Brooks	30428	2.8
Kure	15728	1.5
French Frig. Sho.	15026	1.4
Nihoa	13405	1.2
Raita	11869	1.1
Main Haw. Is.	7160	.7
Northhampton Banks	1330	.1
Lisianski	1265	.1
Midway	498	-
TOTAL	1089427	100.0
1986(a)		
Maro	234813	35.4
Necker	125105	18.9
Gardner	78220	11.8
St. Rogatien	49429	7.5
Laysan	38850	5.9
Brooks	37451	5.6
Raita	34601	5.2
Pearl&Hermes Reef	22808	3.4
French Frig. Sho.	15278	2.3
Nihoa	10792	1.6
Kure	4666	.7
Main Haw. Is.	3914	.6
Northhampton Banks	3974	.6
Midway	2146	.3
Lisianski Island	1198	.2
Pioneer	223	-

(a) Data through July 1986

Figure 8. Fishing Frequency by Area in Terms of Trips

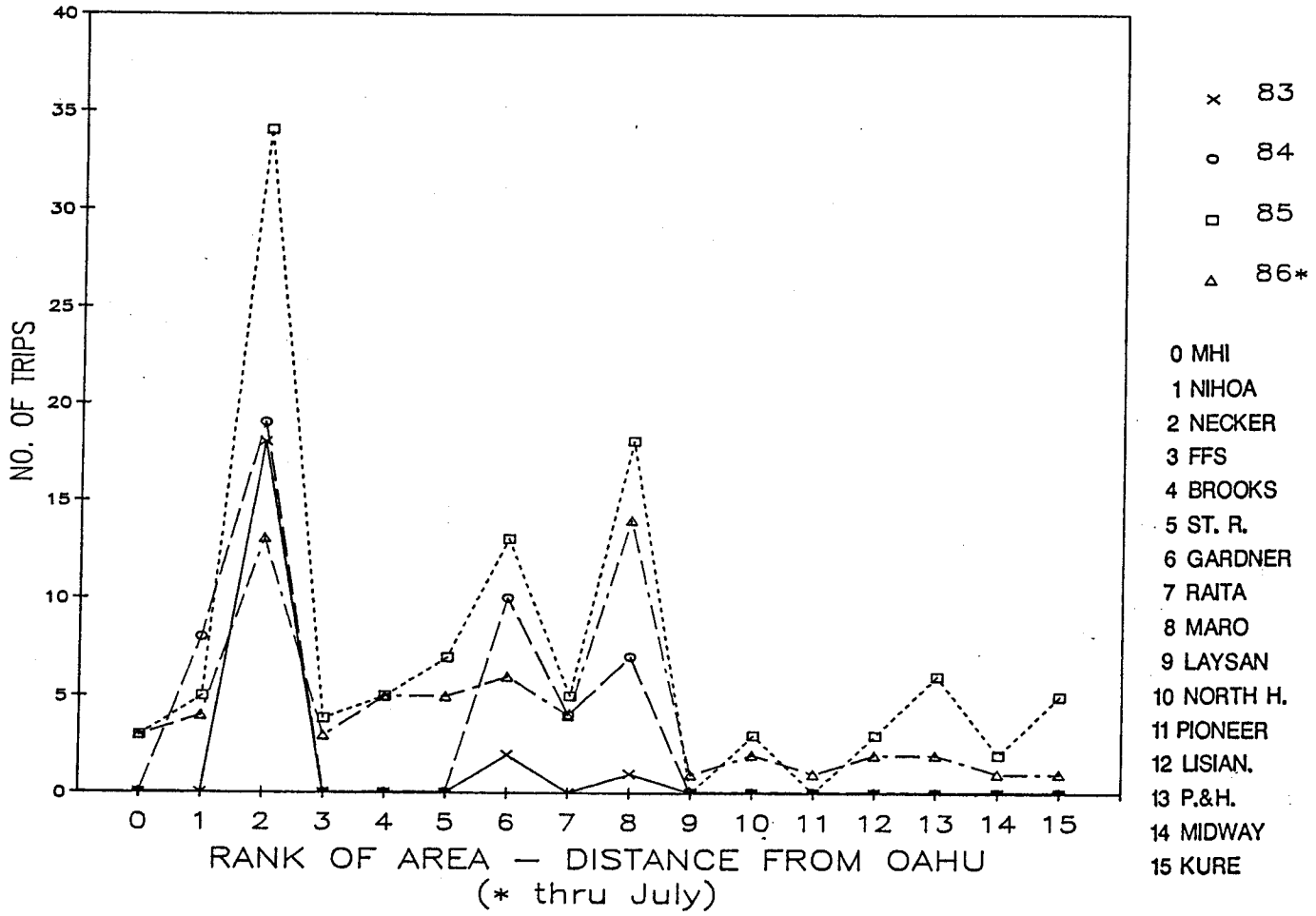
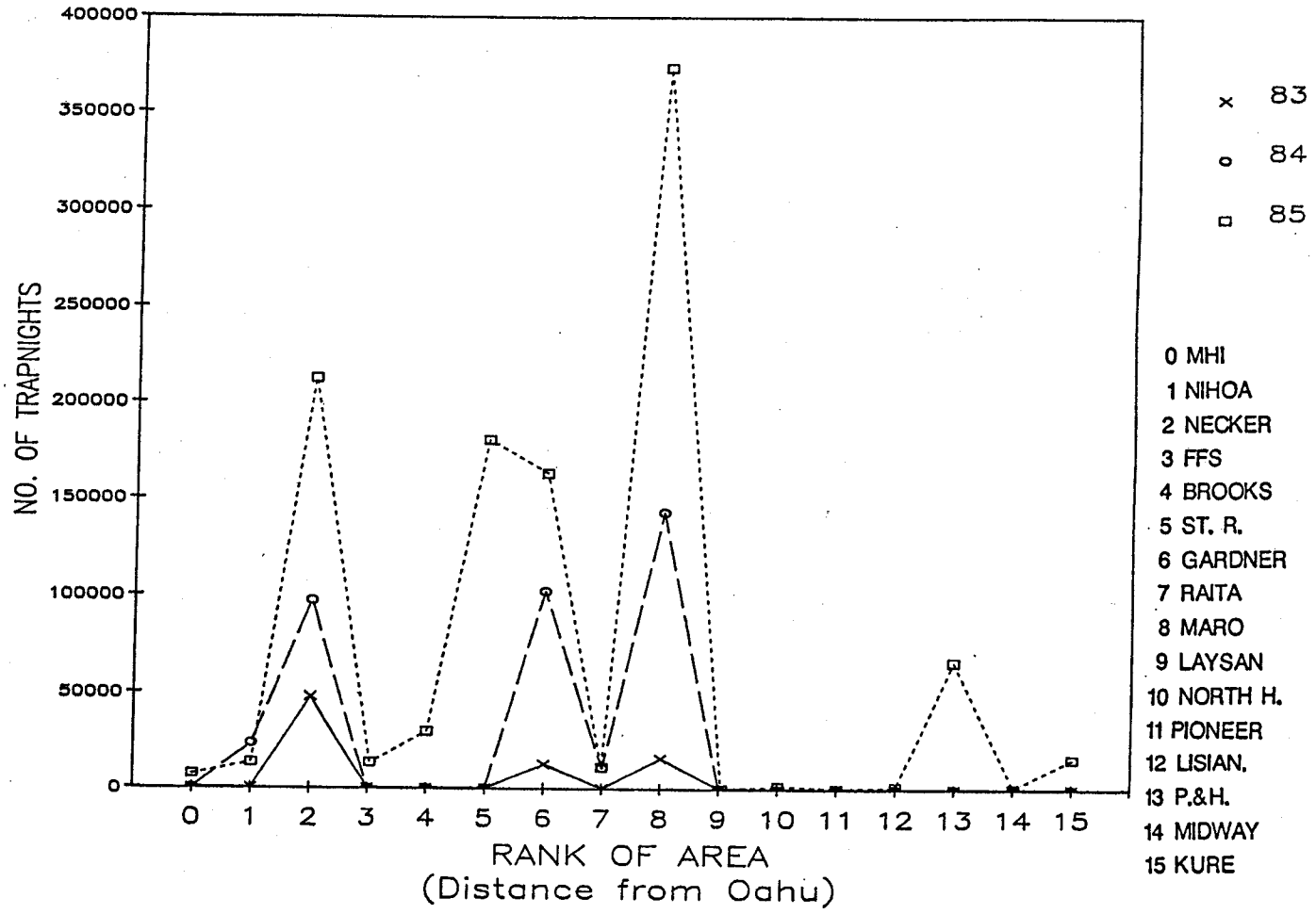


Figure 9. Fishing Frequency by Area in Terms of Trapnights



third principal fishing area has been Gardner Pinnacles through 1983, 1984, and thus far in 1986. St. Rogatien replaced Gardner as the number three fishing area in 1985.

Changes in Trip Length and Distance

Concomitant with the fleet's expanded activities, fishing trips have become longer over time (Table 7). In 1983, the average total trip length was 19.1 days. In 1984, the average total trip length had increased by 12.2 days to 31.3 days. Trips during 1985 were about 5 days longer (36.7) than they had been during 1984. Thus far in 1986, total trip length has averaged 39.6 days, or just about 3 days longer than the 1985 average. Keep in mind that these are average values. Fishing trips have been as short as 5 days and as long as 90 days.

Total trip length is composed of running time and fishing time. As the fleet's fishing activities extend farther northwest from Honolulu, running time necessarily increases. Through the years the fleet has increased fishing time almost in direct proportion to running time, so that since 1983 about 80% of the average total trip length has been spent fishing (Figure 10).

Location and Dispersion Indices

Indices of location and dispersion were developed to summarize the changes in lobster fishing patterns over time. The location index provides information on the northwest expansion of fishing effort and the distance of fishing activities from Honolulu. The index of dispersion summarizes the frequency of visits to different areas throughout the NWHI.

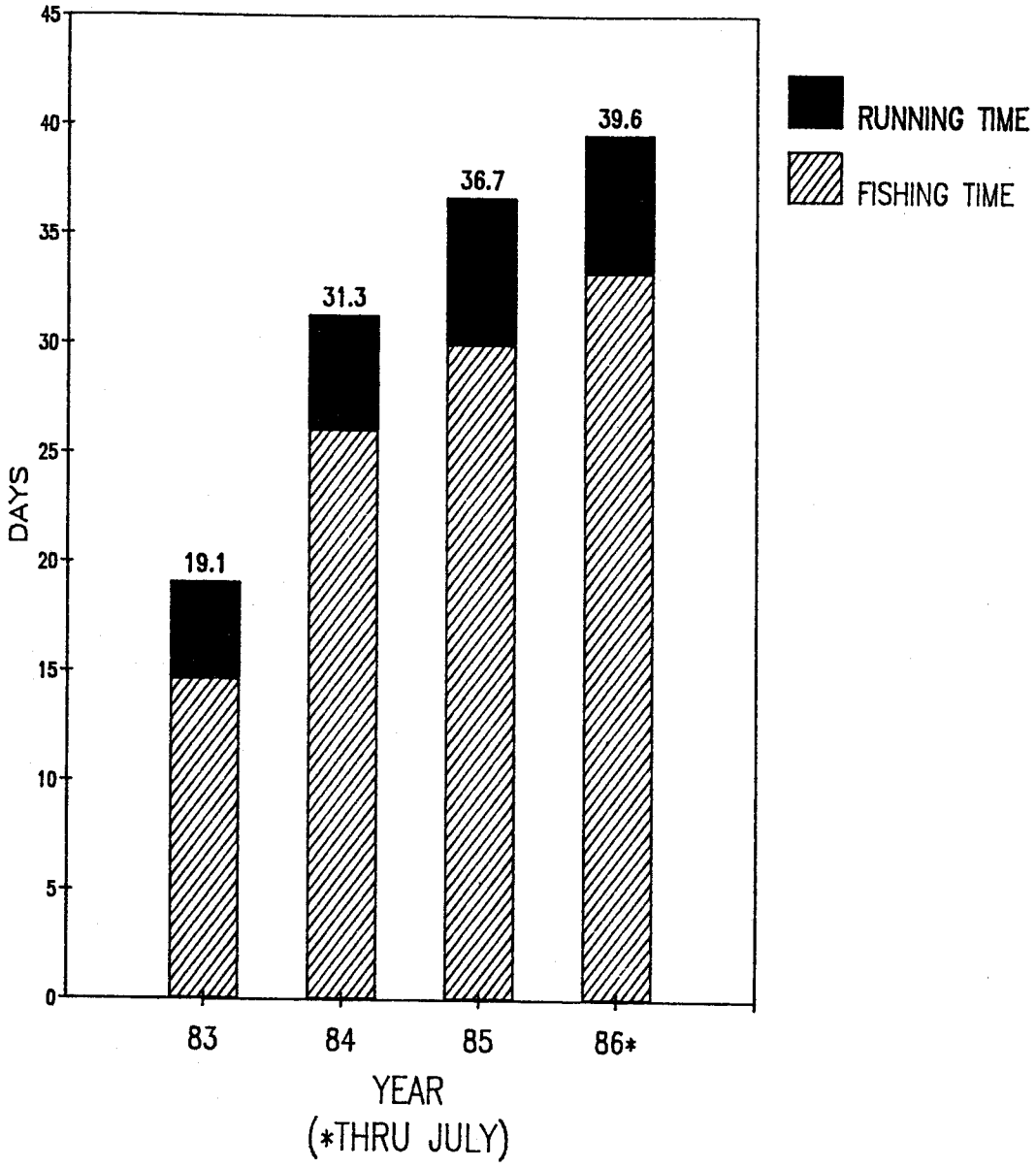
The index of location measures the average running time (from Honolulu) to reach areas fished during any given season. Although the location index does not generate a true measure of the the geographic centroid of fishing activity, it is a trend indicator for extensions in fleet activities. The index is calculated in the following manner. (1) Running time (a surrogate for distance) to each fishing area from Oahu is calculated. (2) For each fishing area visited during the year the number of visits is tallied. (3) The sum of the tallies for individual areas are multiplied by running time to that area. This computation appropriately weights fishing effort at each area visited in terms of distance and is designated "area pressure". (4) The "area pressure" term is summed across all areas visited and then divided by total visits to all areas. The quotient in the index of location for that year. In essence it is the average distance (measured in running time) to reach the areas fished by the fleet during a given year.

The index of dispersion measures the average number of different areas visited per trip during a given fishing season. It is calculated in the following manner. (1) Each trip taken during a year is classified by the number of areas visited by a vessel on that trip. (2) The total number of trips within each

Table 7. Changes in Trip Length, Fishing Time and Running Time

	CALENDAR YEAR			
	1983	1984	1985	1986(a)
Average Trip Length (Days)	19.1	31.3	36.7	39.6
Range of Trip Length (Days)	8 - 57	10 - 72	5 - 90	9 - 83
Standard Deviation of Trip Length (Days)	14.7	19.7	21.2	20.9
Average Fishing Time (Days)	14.7	26.1	30.0	33.3
Range of Fishing Time (Days)	4 - 49	6 - 61	1 - 81	4 - 78
Standard Deviation of Fishing Time (Days)	13.9	17.3	19.4	20.2
Average Running Time (Days)	4.4	5.2	6.7	6.3
Percentage of Total Trip Length Spent Fishing	76.7 %	83.4 %	81.7 %	84.1 %

Figure 10. Profile of Trip Length



classification is multiplied by the number of areas/trip which defines the classification. This yields the total number of areas visited within each classification. (3) The number of areas visited is summed over all classifications to give the total number of areas visited for the year. (4) This total is divided by the number of trips made during the year. The quotient is the index of dispersion. It is an average measure for the fleet as a whole.

The indices of location and dispersion clearly demonstrate the trends of the active fleet to encompass more distant and widely dispersed fishing grounds over time (Table 8 and Figure 11). In 1983, only 2 out of the 19 trips taken that year included more than a single fishing ground, and those trips only included fishing at two areas. The index of dispersion for 1983 was 1.1 areas per trip. Additionally, the fishing trips that were taken to just one area all went to the same area, Necker Island.

The index of location for 1983 falls between Necker Island and French Frigate Shoals which reflects the greater distances and travel times required to reach Gardner Pinnacles and Maro Reef (Figure 12).

Although fishing effort did not extend beyond Maro Reef in 1984, effort became slightly more dispersed than in the previous year. Seventy percent of the year's 33 trips were still just single location trips, and Necker Island remained the principal destination. However, single area trips to Necker Island only accounted for 54 percent of the total single area effort, down from a value of 100 percent in 1983. The index of dispersion in 1984 equalled 1.4 areas per trip as compared to the 1983 value of 1.1 areas per trip.

The index of location increased from 53 hours of running time in 1983 to 60.5 hours of running time in 1984, a shift from between Necker and French Frigate Shoals on out to French Frigate Shoals. Substantial fishing effort targeted Gardner Pinnacles and Maro Reef during 1984. Increased effort at these more distant areas is the primary factor for the outward shift in the index of location.

The indices of dispersion and location for 1985 bring into immediate focus the extension and dispersion of effort that characterized fleet activity throughout that year. In spite of the fact that nearly 60 percent of the 62 trips taken during the year were single area trips, the index of dispersion increased to 2.1 areas visited per trip. On 25 trips, vessels fished at two or more areas, and on 9 of those trips, vessels fished in more than 5 areas per trip. Eight new fishing grounds were added to the 6 different areas fished in 1984.

The index of location increased by nearly 17 hours, from an average running time in 1984 of 60.5 hours to a new high of 77.2 hours in 1985. In previous years the most distant area from Oahu that was fished was Maro Reef (97 hours of running time from

Table 8. Summary of Changes in Location and Dispersion

	CALENDAR YEAR			
	1983	1984	1985	1986
Total Trips	19	33	62	33
Index of Location (Running Time from Honolulu in Hours)	53	60.5	77.2	78.6
Approximate Location	Between Necker and French Frigate Shoals	French Frigate Shoals	Gardner Pinnacles	Just North-West of Gardner Pinnacles
Index of Dispersion (Areas)	1.1	1.4	2.1	2.3
Total Areas Fished	3	6	14	15
Percent of Trips to Single Area	85.7	66.7	59.7	51.5
Most Frequently Visited Area	Necker	Necker	Necker	Necker
Visits to Necker	17	12	21	6
Most Distant Area Visited (From Honolulu)	Maro	Maro	Kure	Kure
Running Time Most Distant Area Fished (Hours)	97	97	160	160
Visits to Farthest Area	2	7	6	1

Figure 11. Vessel Activity: Location and Dispersion

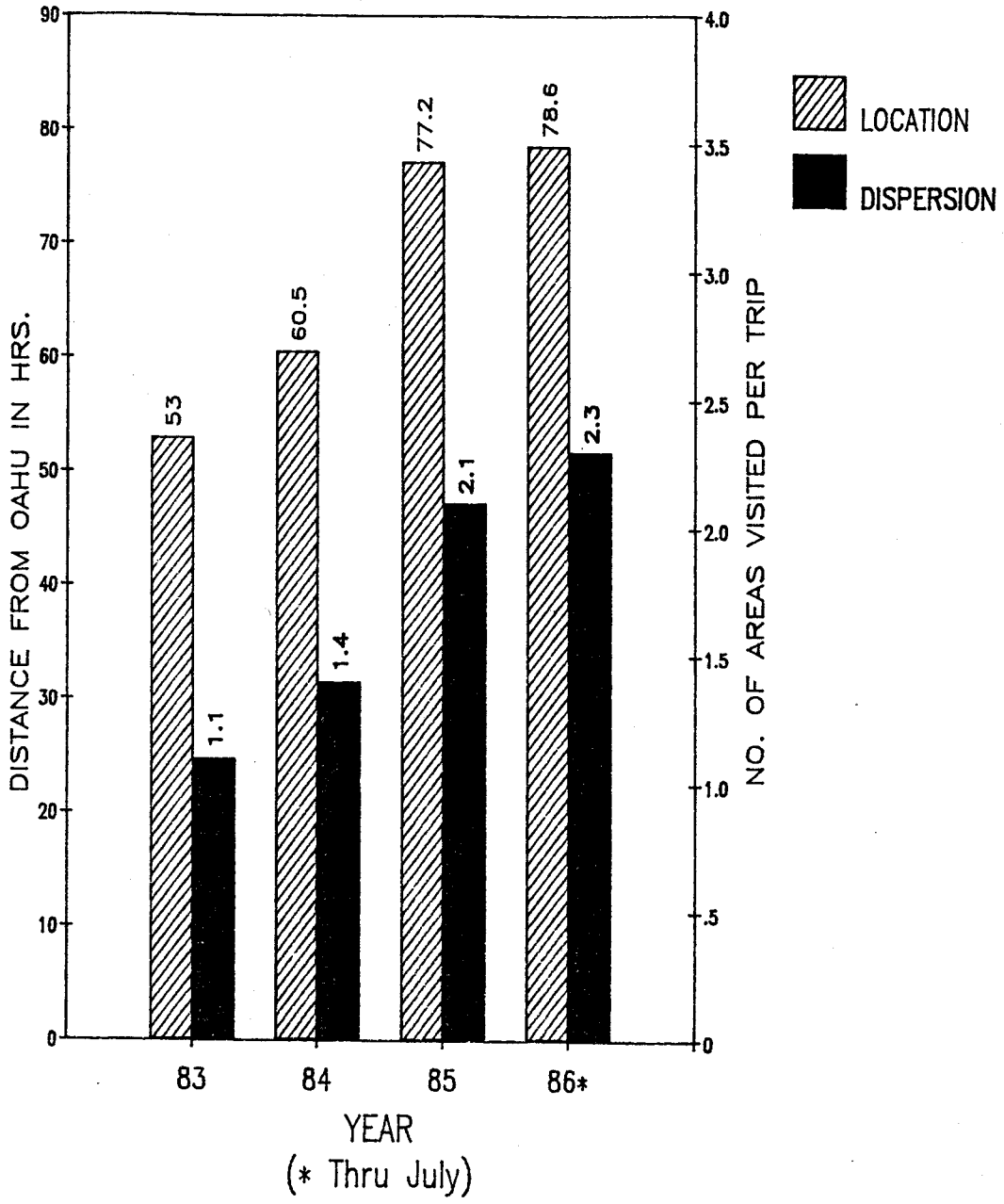
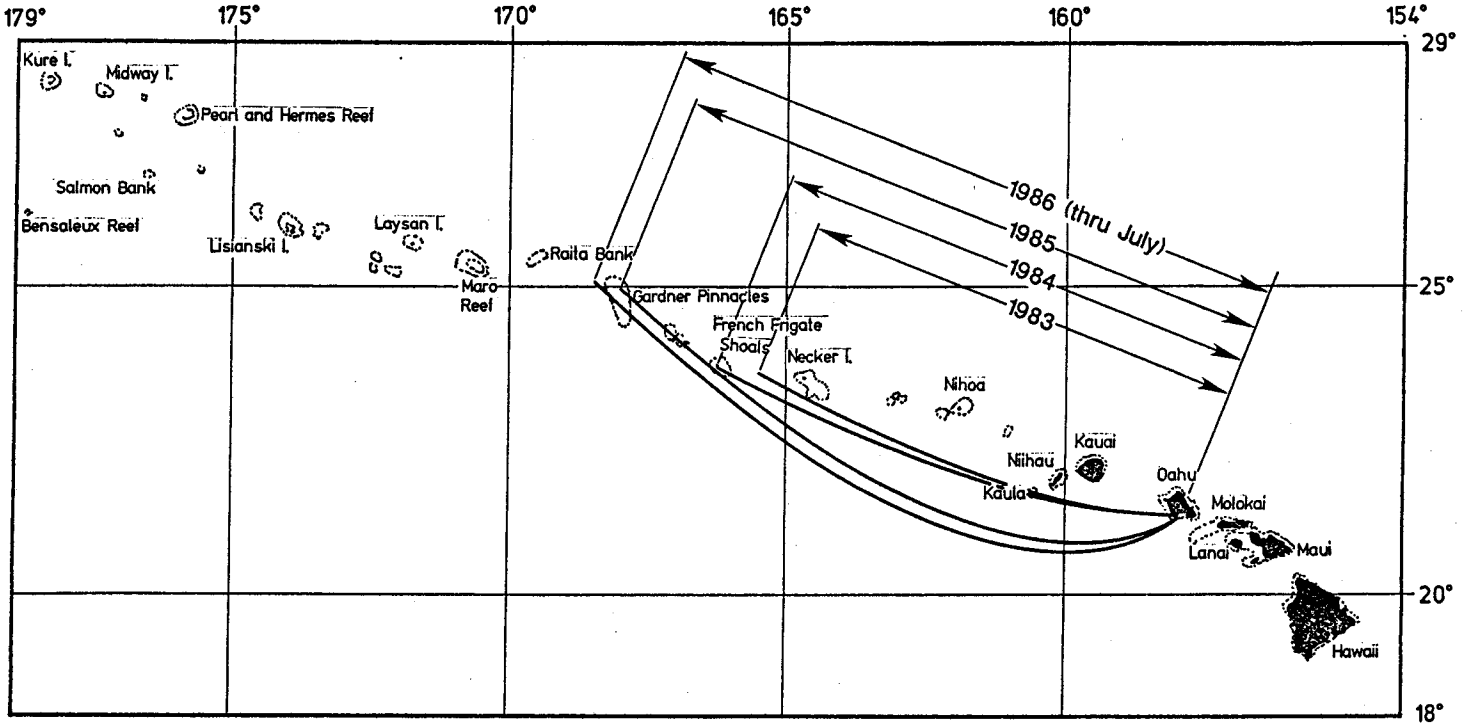


Figure 12. Profile of Average Distance to Areas Fished (Index of Location)



Oahu). In 1985 five fishing grounds beyond Maro Reef were fished, and Kure Atoll, which is the most distant Northwest Hawaiian Island from Oahu (1280 miles, 160 hours of running time based on an 8 knot average), was fished on 6 different occasions.

Through the first seven months of 1986, fishing patterns, in terms of location and dispersion, generally resemble those for 1985. However, one new feature is notable. During the three previous years at least 54 percent of the single-area trips have been to Necker Island. Through July of 1986, Maro Reef was the site of as many single-area trips as Necker Island.

SUMMARY AND CONCLUSIONS

The Northwest Hawaiian Lobster fishery has developed rapidly since the implementation of the Spiny Lobster FMP in 1983. The number of permits issued has increased markedly over time. Eleven permits were issued for the 1983 permit season compared with the 51 that were valid during the 1986 permit season. However, while the number of permits issued for a season reflects interest in the fishery, the number of vessels that fish during a season is a much clearer barometer of the evolution of the fishery. In the shortened 1983 season only 3 vessels fished. In each succeeding season the number of active vessels increased until a peak of 19 was reached during the recently completed 1986 season. This steady stream of new active entrants, combined with the fact that only 4 active boats have exited the fishery since 1983, suggests that in 1986, the NWHI lobster fishery was generating sufficient profits to make it relatively attractive comparted with other commercial fishing alternatives.

Perhaps an active fleet of only 19 vessels does not seem very large, particularly in light of the number of permitted vessels. However, the fleet has exerted substantial fishing effort throughout the NWHI. This has come about through a progressive expansion of fishing effort, and through increased fishing intensity by individual boats. Fishing trips have become longer, more areas are being fished on a single trip, and the number of traps fished per trip has increased dramatically. During 1985, almost all known fishing grounds within the northwestern island chain, which stretches over 1200 miles in length, had been exploited. The mere fact that the physical expansion of fishing areas has come to a end, raises questions about the continue economic viability of the industry.

The dynamics of fleet composition and operations in the NWHI lobster fishery arise from complex economic and biological relationships. This report provides a database that can be used to better understand these relationships. During subsequent stages of this research this information will be integrated with marketing and cost data to more completely address the current and future economic status of the NWHI lobster fishery.

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