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APRIL 1988

AN ECONOMIC ANALYSIS OF LOBSTER FISHING VESSEL PERFORMANCE IN THE NORTHWESTERN HAWAIIAN ISLANDS

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NOAA-TM-NMFS-SWFC-106

U.S. DEPARTMENT OF COMMERCE
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NOAA Technical Memorandum NMFS

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ABSTRACT

The economic and operational performance of three classes of lobster fishing vessels in the Northwestern Hawaiian Islands was examined. Operational information came from logbook catch and effort data required by law since the fishery came under Federal management in 1983. Economic information, with emphasis on cost-earnings data, was supplied by 12 vessels active during the 1985 and 1986 seasons. Only the Class II, midsized vessels were clearly profitable, whereas the larger Class I vessels faced a variety of cost constraints, and the Class III vessels faced a number of operational problems. Return on investment was estimated to be -4.0, 36.0, and -8.5% on Classes I-III, respectively. Sensitivity analysis indicated several factors can significantly affect net returns; however, the mid-1987 conditions in the fishery appeared to have had a balanced effect on vessel returns.

CONTENTS

INTRODUCTION

During the last 4 yr (1983-86), the lobster fishery in the Northwestern Hawaiian Islands (NWHI) (Fig. 1) has expanded into one of Hawaii's most important commercial fisheries. Approximately 1,000 metric tons (t) of lobster--worth over $6 million in ex-vessel revenue--were caught in 1986 (Clarke et al. 1987[1]). Spiny lobster, Panulirus marginatus, and the common slipper lobster, Scyllarides squammosus, have been the targets of this trap fishery. The fishery has been under Federal management through the Spiny Lobster Fishery Management Plan (FMP) implemented in March 1983 (Western Pacific Regional Fishery Management Council 1983[2]). Regulation is based on biological criteria adjusted for commercial operating feasibility. However, conclusions on the natural state of the lobster stocks are complicated by a number of changes in fishing operations over the course of the fishery.

One particular problem has been the rapid turnover of vessels participating in the NWHI lobster fishery. This may be explained by the high ex-vessel price for lobster tails and the resulting **appearance** of high profitability, both of which promote **entry** into the fleet, and by the often equally high costs of entering and staying in the fishery, which often cause **exit** from the fleet. Only one class of vessels, the Class II, midsized, high capacity vessels, is clearly profitable, whereas the larger, Class I vessels have faced a variety of cost constraints, and the lower capacity, Class III vessels have faced a number of operational problems.

This study was undertaken to analyze the economic performance of commercial lobster fishing vessels operating in the NWHI. This report, which is the third in a cooperative research project on the economics of commercial lobster trapping in the NWHI, describes the fleet, reviews fishing operations, and presents cost and income information on three classes of NWHI commercial lobster fishing vessels active in 1983-86. The economic analysis of this report concentrates on the behavior of the fleet in 1985 and 1986.

The agencies cooperating in this study are the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service (NMFS), NOAA; the Department of Agricultural and Resource Economics of the University of Hawaii; and the Western Pacific Regional Fishery Management Council. The first two reports in this project considered the operating patterns of the NWHI lobster fleet and the marketing practices of the industry (Gates and

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NOTE: Most values are expressed in English units, i.e., pounds, gallons, and feet, which are the industry standard.

[1]Clarke, R. P., P. A. Milone, and H. E. Witham. 1987. Annual report of the 1986 western Pacific lobster fishery. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-87-6, 47 p.

[2]Western Pacific Regional Fishery Management Council. 1983. Final combined fishery management plan, environmental impact statement, regulatory analysis and draft regulation for the spiny lobster fisheries of the western Pacific region, Honolulu, Hawaii.

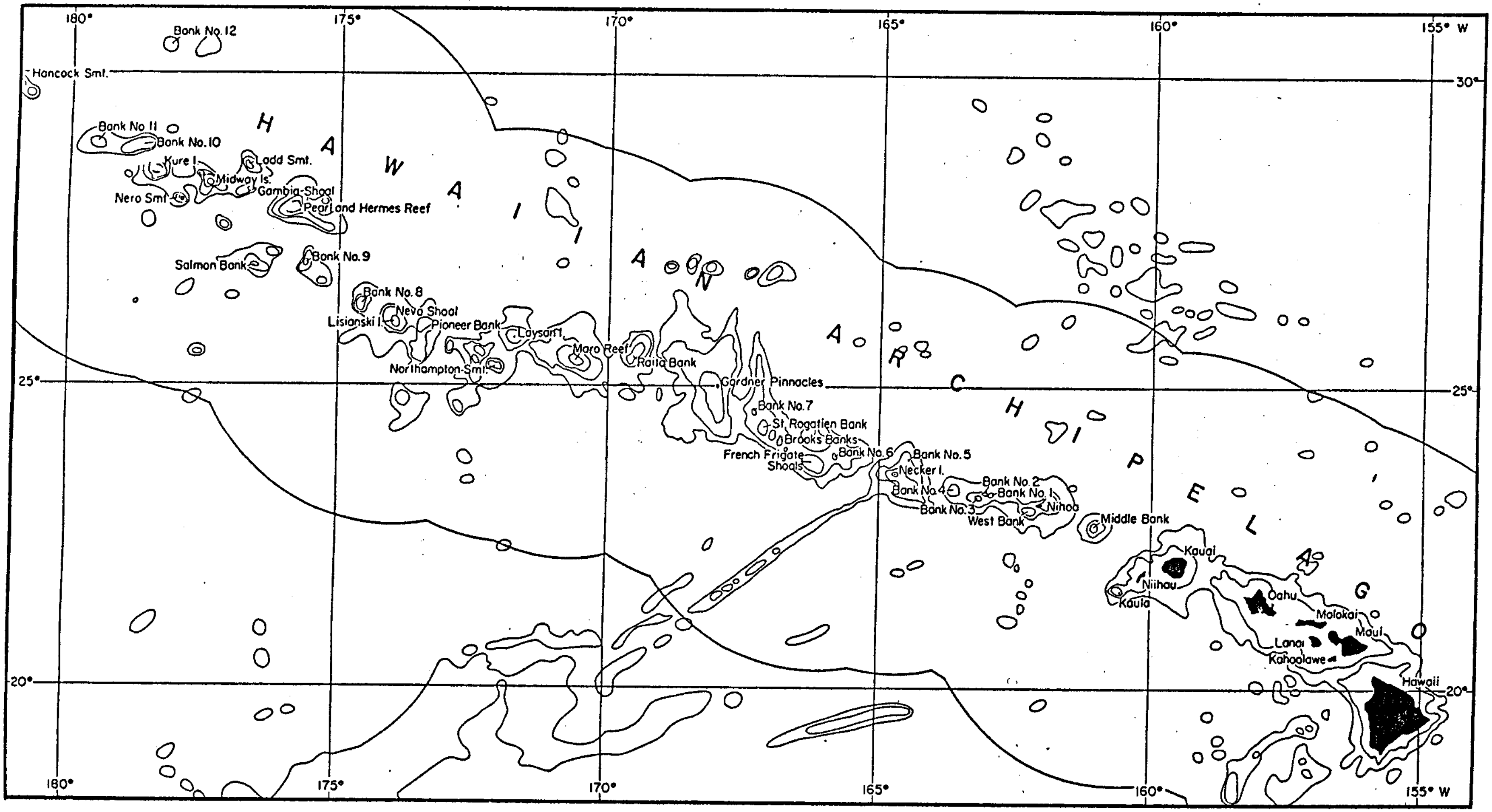


Figure 1.--The Hawaiian Archipelago including the Northwestern Hawaiian Islands (west of long. 160°E).

Samples 1986;[3] Samples and Gates 1987[4]). The fourth report is devoted to the economics of limited entry in the NWHI lobster fishery (Samples and Sproul 1987[5]).

VESSEL CLASSES

Throughout this analysis the NWHI lobster fishing fleet was separated into three classes (Table 1). Classification was based on two major criteria: vessel size (overall length) and vessel operations (average number of traps fished) (Table 2). Class I vessels are easily differentiated from the other vessel classes by their large size, and Class II vessels are differentiated from Class III vessels by the intensity of their fishing operations (i.e., the number of traps fished) (Fig. 2), a feature that may include intangible elements, specifically the characteristics of the captain

Table 1.--Vessel class composition of the lobster fleet in the Northwestern Hawaiian Islands (NWHI), 1983-86. Only vessels that had permits and that actually fished in the NWHI are included.

	No. of vessels by year			
Class	1983	1984	1985	1986
I	0	2	4	5
II	2	3	3	3
III	1	4	5	7
0	1	2	4	1
Total	4	11	16	16

[3] Gates, P. D. and K. C. Samples. 1986. Dynamics of fleet composition and vessel fishing patterns in the Northwestern Hawaiian Islands commercial lobster fishery: 1983-86. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-86-17C, 32 p.

[4] Samples, K. C., and P. D. Gates. 1987. Market situation and outlook for Northwestern Hawaiian Islands spiny and slipper lobsters. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-87-4C, 33 p.

[5] Samples, K. C., and J. T. Sproul. 1987. Potential gains in fleet profitability from limiting entry into the Northwestern Hawaiian Island commercial lobster trap fishery. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-87-17C, 30 p.

Table 2.--Physical and operational characteristics of the lobster fleet and vessel classes in the Northwestern Hawaiian Islands, 1985-86. Data are means unless stated otherwise; ranges are in parentheses.

Characteristics	Fleet average	Class I	Class II	Class III
Physical				
Vessel length (ft)	90 *N* = 17	115 *N* = 7 (99-175)	73 *N* = 3 (62-88)	72 *N* = 7 (63-86)
Fuel capacity (gal)	18,667 *N* = 15	31,400 *N* = 5 (25,000-40,000)	14,200 *N* = 3 (6,000-30,000)	11,500 *N* = 7 (6,500-15,000)
Hull age (yr)	10.8 *N* = 10	9.5 *N* = 2	11.0 *N* = 3	11.2 *N* = 5
Cruising speed (kn)	7.9 *N* = 14	7.8 *N* = 5	8.3 *N* = 3	7.8 *N* = 6
Horsepower	530 *N* = 17	750 *N* = 7 (500-1,400)	370 *N* = 3 (250-530)	380 *N* = 7 (235-520)
Wood-fiberglass (%) Steel (%)	24 76 *N* = 17	0 100 *N* = 7	66 33 *N* = 3	29 71 *N* = 7
Operational				
Crew (No.)	6.4 *N* = 17	7.6 *N* = 7 (6.0-9.0)	6.8 *N* = 3 (5.0-9.0)	5.2 *N* = 7 (4.0-6.0)
Traps (No.)/d	630 *N* = 17	800 *N* = 7 (654-1,089)	726 *N* = 3 (610-820)	423 *N* = 7 (364-499)
Maximum traps (No.)/d	779 *N* = 17	935 *N* = 7 (700-1,200)	880 *N* = 3 (720-1,016)	580 *N* = 7 (500-670)
Trips (No.)/yr	4.6 *N* = 17	4.4 *N* = 7 (3-6)	4.3 *N* = 3 (2-7)	4.9 *N* = 7 (3-13)

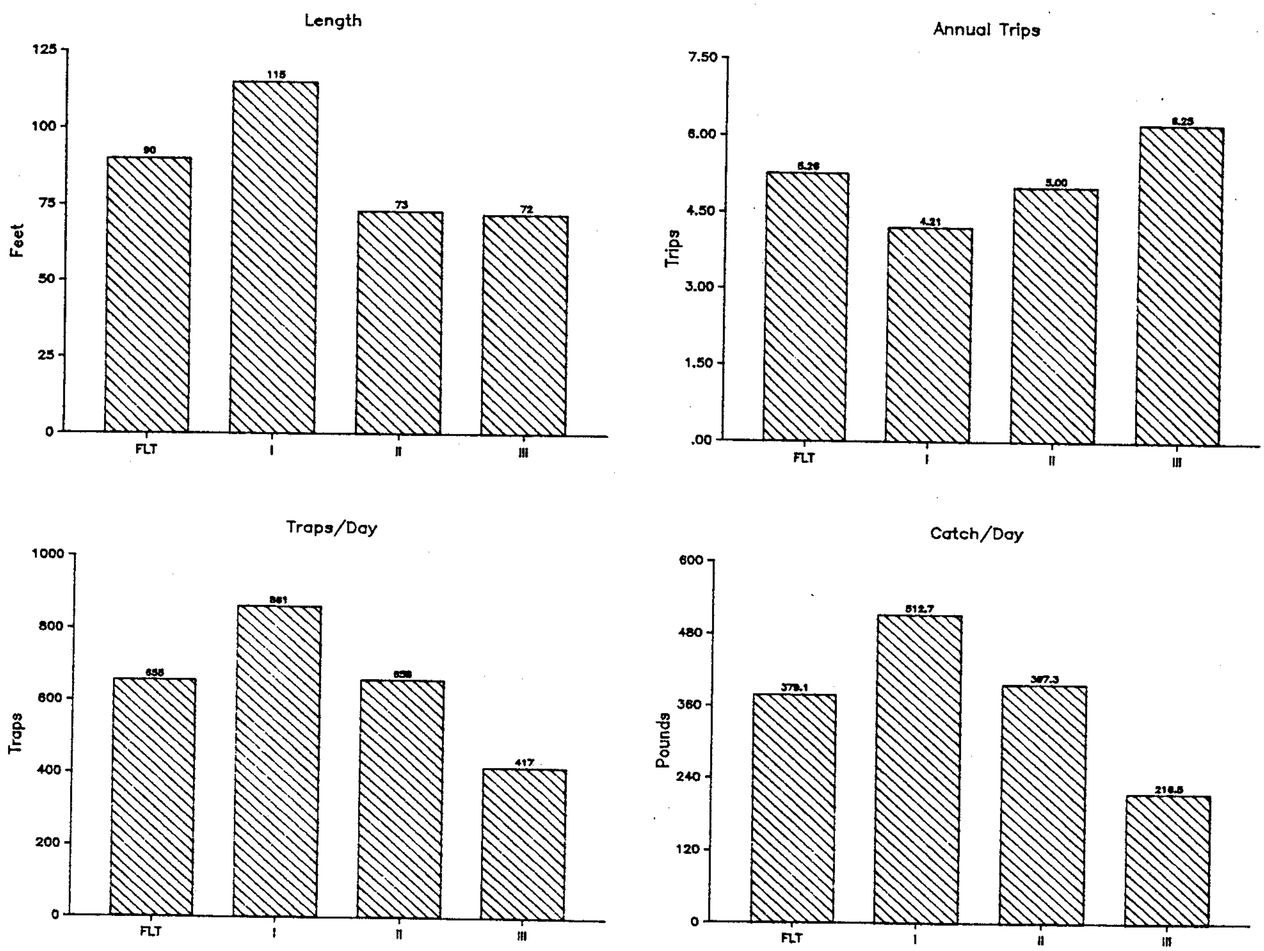


Figure 2.--Fleet class characteristics, 1985-86.

and crew. These two criteria were selected because of their inherent relationship to vessel costs and revenue characteristics. The physical size of the vessel generally plays a key role in its cost structure, but operating characteristics play a more important role in determining revenue characteristics. Only vessels that actively fished in the NWHI were considered. Vessels that had permits but failed to fish were not included. Of the vessels that fished during 1985 or 1986, 17 could be physically categorized as belonging to Classes I-III, and 4 could not be classified because of their sporadic participation in the fishery (from an operational standpoint). They are identified as Class 0 vessels and are omitted from most of the analysis.

Class I vessels (1985-86 fleet) averaged 115 ft overall, had an average fuel capacity of 31,400 gal, and were powered with 750 hp (includes only engine horsepower; does not include auxiliaries and generators). All these vessels were steel-hulled. Their average maximum number of traps fished was 935 (traps fished meaning traps hauled), while their average number per day was 800. Class I vessels carried six to nine crew members, including the captain. These vessels were primarily converted Pacific Northwest or Bering Sea crab vessels (Fig. 3), and many underwent extensive refitting for the NWHI lobster fishery.

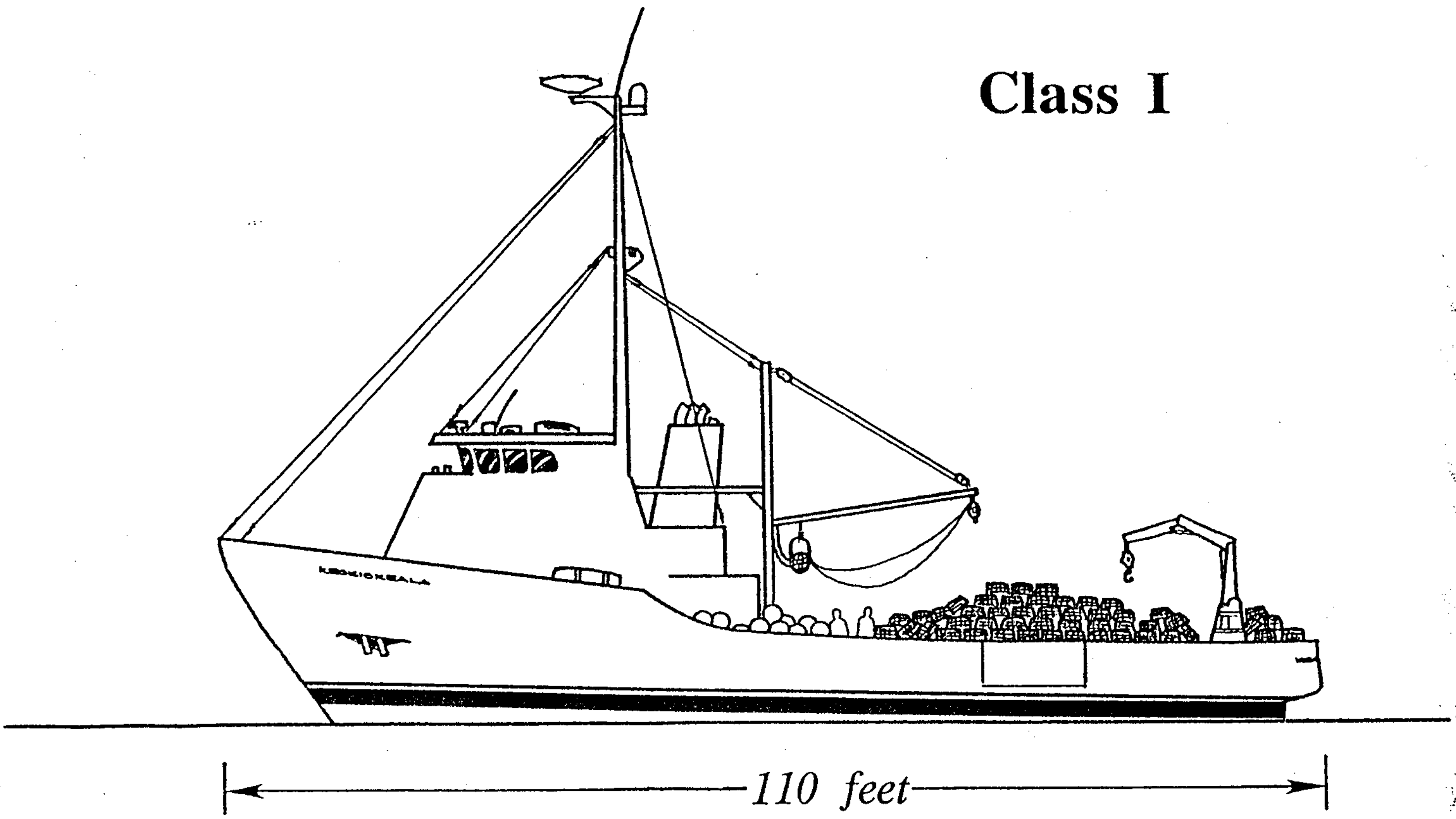


Figure 3.--Drawing of a typical Class I vessel.

Class II vessels (1985-86 fleet) averaged 73 ft overall, with a fuel capacity of 14,200 gal and 370 hp. One vessel was steel-hulled, and two were composed of fiberglass and wood. The average maximum number of traps fished was 880 while the average was 726. Class II vessels carried five to nine crew members. The vessels in this class originally were constructed for trolling, shrimping, or lobstering (Fig. 4).

Class III vessels (1985-86 fleet) were similar to Class II vessels in overall length (mean, 72 ft) and horsepower (mean, 380 hp) but had a lower fuel capacity (11,500 gal). Most of the vessels are steel-hulled, but not all. The average maximum number of traps fished was 580, but the average number per day was only 423. Class III vessels carried four to six crew members. These vessels can be characterized as small west coast draggers, pot vessels, or trollers. Some Class III vessels underwent extensive refitting for this fishery. They have the same basic configuration as the Class II vessels (Fig. 4).

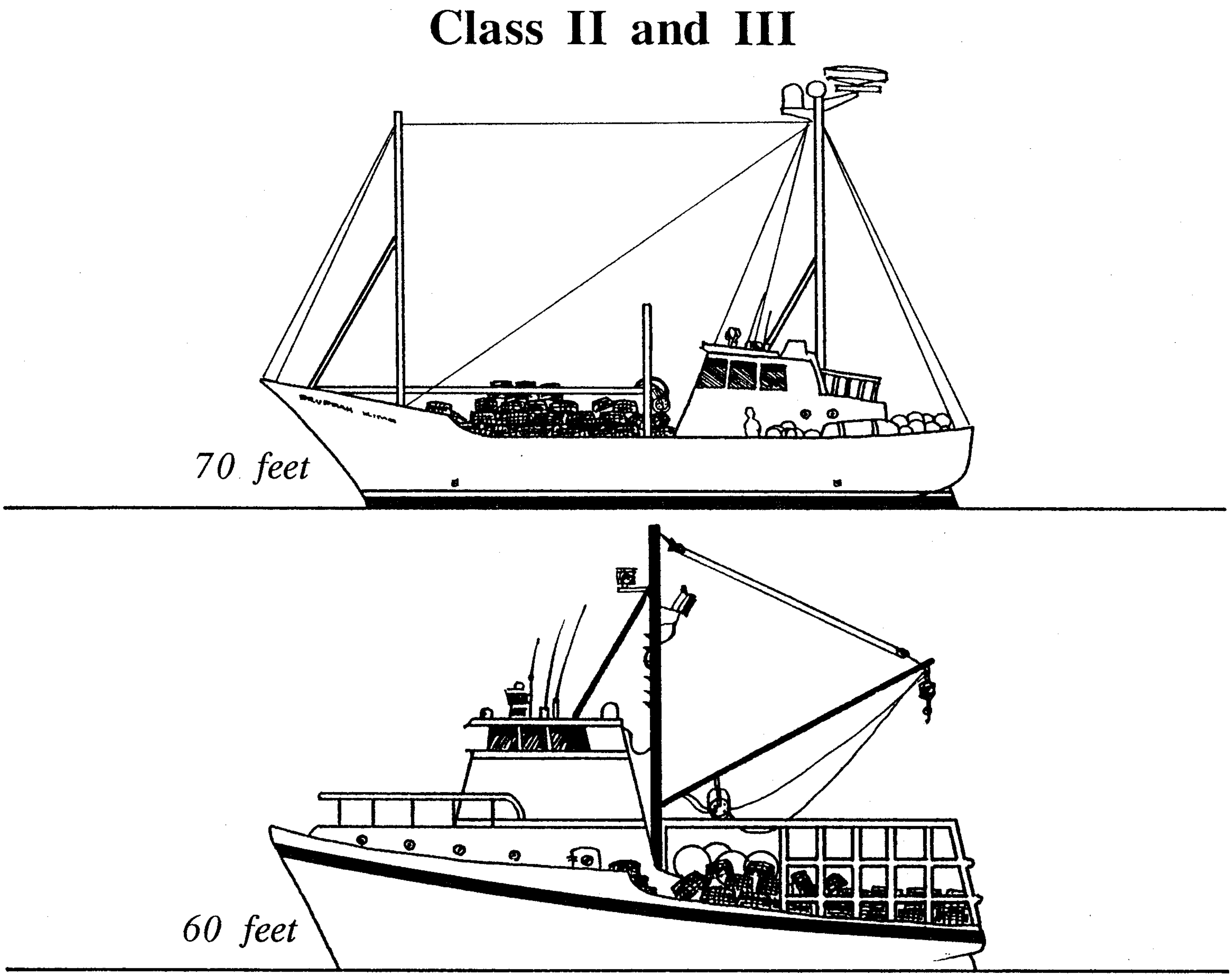


Figure 4.--Drawings of typical Class II and Class III vessels.

Turnover of participation in the fishery since Federal management began in 1983 has been substantial (Table 3). There were 65 individually licensed vessels over the period, but only 24 vessels actually fished. Of these, seven fished only experimentally or intermittently. Table 3 presents information on entry, participation, and exit of all vessels that fished during 1983-87. The number of vessels participating in the fishery steadily increased from 4 in 1983 to 16 vessels in 1986 (Table 1), but only 7 vessels that fished during 1983-86 were still fishing in 1987.

Table 3.--Entry and exit patterns of individual lobster fishing vessels in the Northwestern Hawaiian Islands (NWHI), 1983-87. Vessels are coded for purposes of confidentiality.

Vessel code	Entry and exit by month				
	1983	1984	1985	1986	
	JFMAMJJASOND	JFMAMJJASOND	JFMAMJJASOND	JFMAMJJASOND	1987
			Class I		
A		XXXXXXXXXXXX	XXXXXXXXXXXX		
B			XXXXXXXXXXXX	XXXXXXXXXXX	
C		XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	
D			XXXXXXXXXX	XXXXXXXXXXXX	
E			XXXXX		
F				XXXXXXXXX	
G				XXXXXXXXXX	X
H				XXXXXXXXXXXX	X
			Class II		
A	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX		
B	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	X
C		XXX	XXXXXXXXXXXX	XXXXXXXXXXXX	X
			Class III		
A	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	X
B		XXXXXX	XXXXXXXXXXXX	XXXXXXXXXXXX	X
C		XXX	XXXXXXXXXXXX	XXXXXXXXXX	
D		XX	XXXXXXXXXXXX	XX	
E			XXXXXXXXXXXX	XXXXXXXXXXXX	X
F			XXXXXXXX		
G			XXXXXXX	XXXXXXXXXXXX	X

Class II vessels had the longest average participation in the fishery, with an average duration of 35 mo (Fig. 5). Of the three Class II vessels, two were in the fishery when it came under Federal regulation in March 1983, and two vessels were still active in 1987. Class I vessel participation was concentrated during 1985 and 1986, with only one of the vessels which fished during the 1983-86 period still active in 1987 (midyear). Average participation for Class I vessels was 14 mo (Fig. 5). Their entry seems to have been prompted by problems in the Gulf of Alaska and Bering Sea crab fisheries. Participation of Class III vessels has been of mixed duration and averaged 21 mo (Fig. 5) (excluding vessels and periods in which lobster fishing was experimental or patchy). A number of Class III vessels were already in Hawaii when they entered the NWHI lobster fishery.

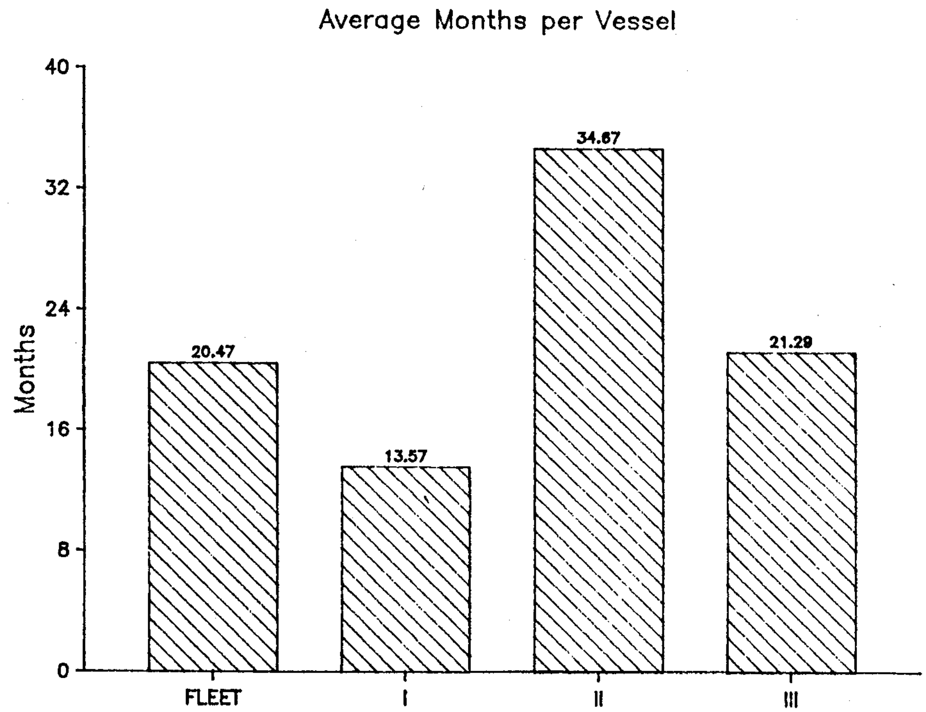


Figure 5.--Participation of the lobster fleet in the Northwestern Hawaiian Islands, by class, 1983-86.

VESSEL DESCRIPTION

The commercial fishing vessels that participate in the NWHI lobster fishery are long-range boats. This extended fishing capacity is necessary because of the long distances between the fishing grounds and the major Hawaii ports (Gates and Samples footnote 3). Vessels also must have sufficient deck space to carry between 500 and 1,200 traps, as well as onboard processing and freezing facilities. These two operational requirements mandate a fairly large vessel compared to other lobster fisheries in the world or to other commercial fisheries in Hawaii. Most of these vessels are from Pacific Northwest or Alaska fisheries, where weather and operational characteristics require similar configurations.

The typical NWHI lobster fishing vessel is steel-hulled, although some fiberglass and wood vessels also participate successfully in the fishery. The afterdeck is normally clear of obstruction to allow for stacking of traps and line. Many operators have built a framework around the stern and afterdeck railing to permit higher stacking of traps. Voids below deck are converted into line bins or holds.

Vessels carry as many traps as can be set and hauled in a single day. The lobster pots now used are collapsible, black, plastic traps, which are relatively light and can be easily stacked. Gear is connected into strings of 50-250 traps, which are attached by gangions to a groundline. Vessels normally fish to their capacity; some run as many as 20 strings of gear at a time.

All of the vessels have line haulers capable of handling 3/8- to 7/8-inch line from depths to 100 fathoms. Some vessels have line coilers to reduce hauling time and facilitate line storage. The diameter of the groundline is largely dependent on these pieces of equipment. The line haulers are usually situated amidship to haul traps from either port or starboard, depending on the location of the wheel in the wheelhouse. Many vessels also have steering stations, which allow the vessel to be controlled from outside the wheelhouse. Next to the line hauler normally is a table or bench where traps are set after being hauled aboard. This is the beginning of the processing area, which also contains a tailing and deveining station and water baths for washing processed tails.

Many vessels have blast freezers with daily freezing capacities in excess of 2,500 lb. The vessels also have freezers that can hold frozen tails at -10° to -40°F. These freezers are usually located on the deck of the larger vessels and in the holds of smaller vessels. The holds must be large enough to carry bait and stores for trips up to 90 d. Some of the larger vessels carry as much as 80,000 lb of bait. Fuel capacity is also dependent on the overall size of the vessel. With the need for storage of traps, bait, and processed products, fuel is often the limiting factor in trip duration. Many vessels have watermakers to reduce the space required for freshwater storage and increase fuel capacity. Processing and packing lobster tails require a large crew, and most skippers take as many crew members as accommodations will support.

DAILY FISHING OPERATIONS

Most vessels operate 12-16 h/d, but workdays lasting 18 to 20 h are not uncommon on some vessels, and the labor is rigorous. Operations usually begin each day with crew members removing frozen tails from freezers, bagging or boxing them, and transferring them to the hold for storage. On average, this takes 1 h. The vessel then begins to haul the gear set the previous day. This usually begins around 0700 (depending on the time of year) and continues for 12-14 h. Some vessels alternate hauling and resetting strings of gear, whereas others haul as much gear as deck space allows before resetting. Normally four crew members are involved in handling the gear: two handle lobsters and rebait traps while two handle the traps and lines. Most vessels process their catch while these operations are under way, although on smaller vessels processing may await resetting the gear. Tailing and deveining the catch requires one or two crew members. The day usually ends between 2100 and 0100. Vessels anchor or drift at night.

All of the vessels participating in the NWHI lobster fishery are full-time lobster operations, over 95% of their revenue coming from lobster fishing. Many attempts have been made to fish simultaneously for lobster and bottom fish or troll species (e.g., tuna, mahimahi, and wahoo), but success in the lobster fishery apparently requires full-time effort during individual trips. Some effort has also been made to fish seasonally for different species, but too little information is available to judge the success of this strategy.

ANNUAL VESSEL OPERATIONS

The annual operations of the vessels participating in the NWHI lobster fishery were examined in detail because of the fundamental relationship between vessel operations and variable costs, catch, and revenue. The time that goes into generating revenue from lobster fishing consists of a number of different stages. Fishermen allocate time for preparing to harvest lobsters and actively pursuing them. Although the preparation time is a necessary factor before active pursuit, it normally does not involve the generation of any revenue. In fact, this nonfishing time may be considered an investment in future income, a time when much more money is going out than coming in. Preparation time is not explicitly counted as a cost of production in this analysis, but it clearly serves as a constraint on operations and as a contribution to the earning capabilities of the vessel. The time spent in preparation not only involves dockside vessel and gear work but also all aspects involved with managing and running a small business.

The annual operations of lobster vessels were traced through the logs the fishermen submit to the NMFS at the completion of each fishing trip. These logs (Daily Lobster Catch per Statistical Area Form) are a daily accounting of lobster catch and fishing effort. The normal operation of the lobster vessel involves setting and hauling traps every day; therefore, the vessel normally indicates a catch every day.

Most operational data in this report are on an "annualized" basis: The original logbook data base was modified to account for trip activity in which vessels returned early because of breakdown or other anomaly, and to adjust for vessels entering the fishery after the beginning of the year or leaving the fishery before the end of the year. There is essentially no difference in average or fleetwide values in the adjusted (annualized) and unadjusted modes.

The annualized statistics are based on the 1983-86 lobster fishing seasons and are categorized by vessel class. A lobster season is a calendar year (Clarke et al. footnote 1). Trip operations and revenue data are compiled from the daily logbook reports mentioned earlier and from the trip revenue reports also required under the FMP. Trip duration and activities are calculated from information obtained from personal interviews on dates of departure and arrival.

Our report presents new information on the operations of lobster vessels fishing in the NWHI. Gates and Samples (footnote 3) provided a thorough analysis of the geographic area of vessel operations, which will not be repeated here. However, their data did not cover the entire 1986 season, they were required to use assumptions on travel time to calculate trip duration, and they did not categorize operations by vessel class. We attempted to take full advantage of our expanded data set, and our analysis concentrates on operating characteristics important for the economic analysis of each class of NWHI lobster fishing vessel.

Criteria were established to determine whether all vessels that submitted logs should be included in the scope of this analysis. Only vessels that took more than one "legitimate" trip to the NWHI in any year were included in the analysis. Legitimate trips were defined as those **excluding** experimental or breakdown trips (trips in which <500 lb of product were landed). Vessels that fished primarily in the main Hawaiian Islands also were excluded. Some discretion was exercised in determining whether a vessel or a trip should be included in the analysis, but only three trips taken by two vessels in 1986 were excluded.

The analysis of sea-day activity was based on active commercial-scale participation in the NWHI lobster fishery. The distances traveled by the vessels that trap lobster in the NWHI are such that they preclude any noncommercial trapping of lobster (i.e., recreational fishing or trapping). This analysis involved the determination of total trip length in days for each of the trips logged by active commercial vessels. **Total trip length** was defined as the total number of days the vessel spent at sea, i.e., the time it left Honolulu until it returned. All vessels departed from Honolulu, Hawaii, and, except for one trip, landed their product in Honolulu. The sum of all total trip lengths for each vessel yielded **annual sea days** which were analyzed by fleet and class if more than three vessels participated (Table 4). (Federal statutes require three or more sources of information before confidential data can be aggregated and reported publicly.)

Total trip length included running days, traveling days, fishing days, rest or deck-work days, weather days, breakdown days, and missing days. These categories represent the general operational activities of most of the NWHI lobster fleet, although they may not fully include every activity of a particular vessel.

Running days equaled the time it took the lobster vessel to travel from Honolulu to the first bank, where gear was set, and from the last bank fished (gear hauled) to Honolulu. This figure was determined by asking the skippers of each vessel for the actual number of running days to a particular bank under average conditions or for the vessel's cruising speed. In most instances, the responses given for travel to a particular bank were in whole days. In a few instances, no specific information was known about the cruising speed. In these cases, running days were estimated by dividing the distance from Honolulu to the first and last bank fished, by an average cruising speed of 8 kn (as adapted from Gates and Samples (footnote 3)). This figure was rounded off to whole days.

Traveling days equaled the time required for movement between banks by the vessels that reduced the potentially available fishing time. Some banks are close enough, and some vessels were large and fast enough that gear could be hauled on 1 d: The vessels travel to another bank, set their gear,

Table 4.--Annualized sea-day activity of the lobster fleet in the Northwestern Hawaiian Islands, 1983-86. (Standard deviations are in parentheses.) See Appendixes A and B for complete analysis.

Class	Vessels (No.)	Trips (No.)	Annual sea days/vessel	Fishing days/vessel	Annual sea days/ trip	Fishing days/trip
			1983			
Combined	3	23	171.7 (37.6)	123.3 (43.8)	22.4	16.1
			1984			
I	--	--	-- --	-- --	--	--
II	3	12	173.0 (15.7)	138.7 (13.6)	43.3	34.7
III	4	22	114.0 (18.1)	79.3 (11.5)	20.7	14.4
Total	9	41	149.1 (39.9)	113.1 (36.0)	32.7	24.8
			1985			
I	4	17	213.8 (72.0)	163.0 (65.9)	50.3	38.4
II	3	13	166.0 (26.1)	130.7 (22.4)	38.3	30.2
III	5	27	173.2 (61.6)	122.2 (42.4)	32.1	22.6
Total	12	57	184.9 (58.2)	137.9 (47.8)	38.9	29.0
			1986			
I	5	20	247.0 (56.6)	199.0 (55.0)	61.8	49.8
II	3	15	191.5 (72.8)	151.0 (62.2)	38.3	30.2
III	7	35	188.0 (54.9)	138.4 (55.7)	37.6	27.7
Total	15	70	209.6 (60.2)	161.9 (59.2)	45.1	34.9

and hauled it the following day without interruption in their operation. This, however, was the exception. Movement between banks usually incurred lost fishing time. The days on which lobster gear was hauled and a catch was recorded in the daily catch logs were labeled as fishing days, which usually equaled the number of daily catch reports submitted after each trip.

Rest or deck-work days were days on which the vessel did not haul gear, but it was unclear whether the crew rested or performed other nonfishing activities e.g., deck work. **Weather days** were those days on which no fishing took place because of high winds or rough seas, but they did not include days on which hauling may have been partially curtailed because of weather. Similarly, on **breakdown days**, lobster gear was not hauled because of mechanical breakdown rather than poor weather. Finally, **missing days** were those in which no catch was recorded, and the reason was not attributable to any of the above categories.

Only 2 active vessels fished in all four seasons (1983-86), 1 vessel fished in three seasons, and the remaining 14 vessels fished in two or less seasons. Some of these 17 vessels did not fish a complete season (they either entered or left the fishery before a complete season of participation). In these cases, the sea days were extrapolated to an annualized basis by the vessel's historical performance.

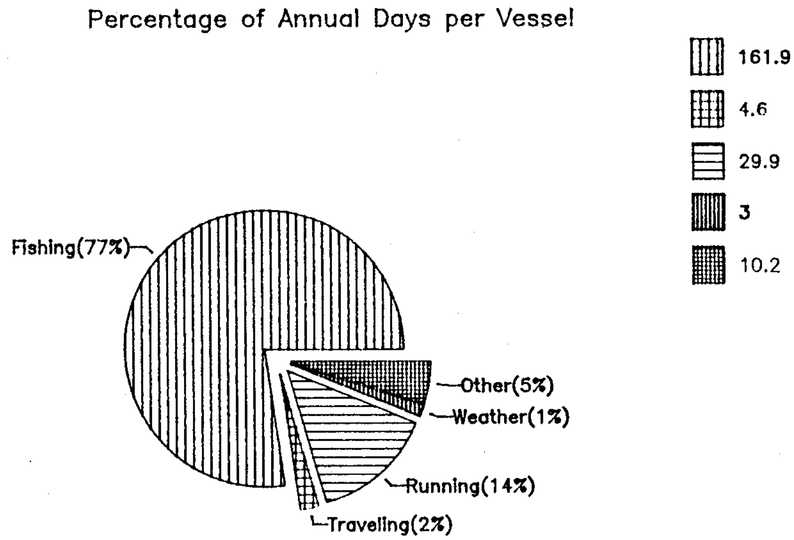
Table 4 presents annualized sea days and total trip length activity for each class of vessel for 1983-86 and includes fleet summaries for each year. Figure 6 shows average trip length (total trip length) and fishing time (fishing days) by class for 1986. Table 4 represents the entire year's activity of all three vessels examined for 1983 even though the FMP went into effect in March. Pre-FMP data were obtained from information provided by the vessels or by extrapolating from the activity of the following months in 1983. Appendixes A and B present the entire breakdown of mean sea days and total trip length by vessel class and for the fleet for 1983 through 1986.

The data on sea days show that in the 1984-86 period, vessels averaged 4.6 trips per year (Table 4). Although the overall duration (total trip length) of the average trip increased from 33 d in 1984 to over 45 d in 1986 (Table 4), the relative time spent in each major subset of operations (e.g., fishing days, traveling days, running days) remained relatively constant (Fig. 6).

The fishing days remained constant between 75 and 77% of total trip length for the fleet (Fig. 6) as a whole during 1984 and 1986. The amount of time spent fishing was similar for Class I and II vessels, ranging between 76 and 81% of the overall trip duration (total trip length), but slightly lower for Class III vessels ranging between 70 and 74%.

The running days, which increased in terms of absolute number during 1983 and 1986, also remained relatively constant at 15% of total sea days for the fleet as a whole. Traveling days accounted for a constant but relatively small amount of the overall trip length, between 2 and 4%. There was no clear trend in traveling days; however, Class II vessels apparently spent slightly more time moving from bank to bank than did the Class I or III vessels.

The weather days were greatest in 1984 for all classes of vessels, perhaps reflecting bad weather conditions for that particular year. The weather days declined significantly in 1985 and 1986; Class III vessels always had the greatest proportion of lost fishing time due to inclement weather. Surprisingly, the Class II vessels lost the same or less days to weather that did the larger Class I vessels, and significantly less than the Class III.



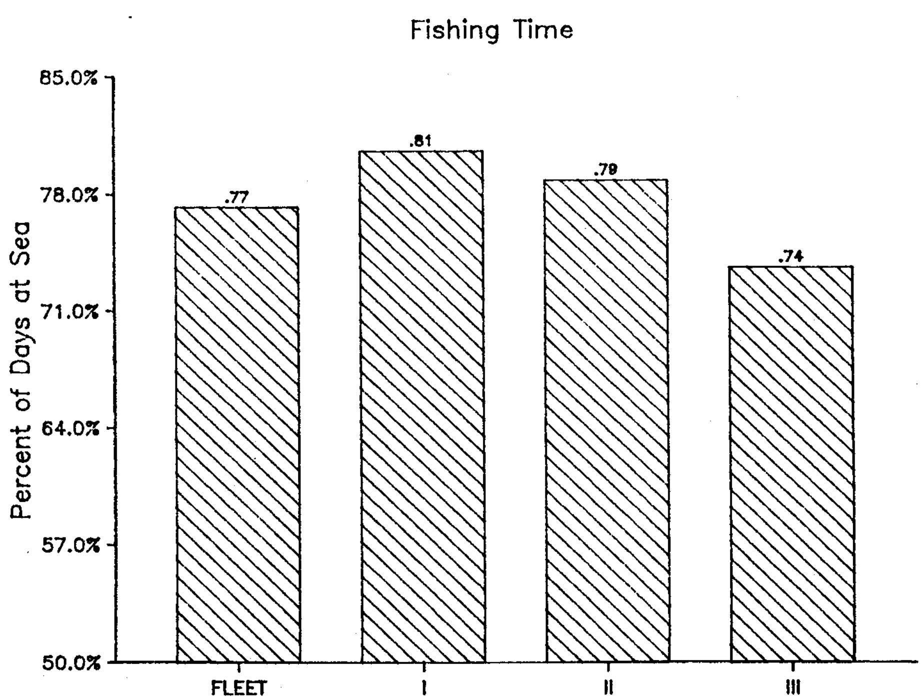


Figure 6.--Average trip time by class, 1986.

The breakdown days were relatively few, although this result could be due to their inclusion in rest or deck-work days or the missing days. The overall trend for rest or deck-work days is relatively constant, between 2 and 3% of total trip length.

It appears that while trip duration in days has increased between 1983 and 1986, the relative time spent in each of the major subsets of operations has remained constant across the whole fleet. Fishing days accounted for 75% of the total trip length; running, 15%; and traveling, 4%. Traveling, which is differentiated from searching or "prospecting" while on the bank, probably constituted a significant part of every fishing day but was impossible to determine from logbooks. The remaining time (4-6%) was spread among weather, rest and deck work, breakdown, and missing days. The weather days, although affecting some classes more than others, apparently affected all classes in years of especially poor weather. The fleet also had very few fishing days lost to breakdowns; this result may be related to high preventive maintenance costs.

Operational differences existed mainly between the first two classes and the Class III vessels. The Class II vessels, although of the same approximate size as the Class III vessels, were less affected by weather. The Class I and II vessels spent a little more time fishing than did the Class III vessels, with the difference spread among breakdown days, rest or deck-work days, and weather days. The Class I vessels had the highest number and percentage of missing days, as expected because of their relatively new entrance into the fishery.

Part of the change in trip duration was explained by the changing composition of the fleet over the 4-yr period. For example, the Class II vessels actually decreased in average annual sea days from 1983 to 1985, but then increased in 1986 (Fig. 7). But most of this change was caused by changes in the number of trips, rather than in per trip activity. Some changes were the result of vessels learning the fishery, as shown by the increase in fishing days per trip by the Class III vessels.

The major differentiation in trip activity within a year was between the Class I vessels and the Class II and III vessels. The Class I vessels were at sea for more days during the year and for more days per trip, and their fishing time was substantially greater, compared to that of the other two classes (Table 4, Fig. 6). These differences were directly related to the larger size and capacity of the Class I vessels.

The trends shown here are in general agreement with Gates and Samples (footnote 3). However, total trip length, as well as its components, tended to significantly differ in respect to absolute value as well in relative importance of each component.

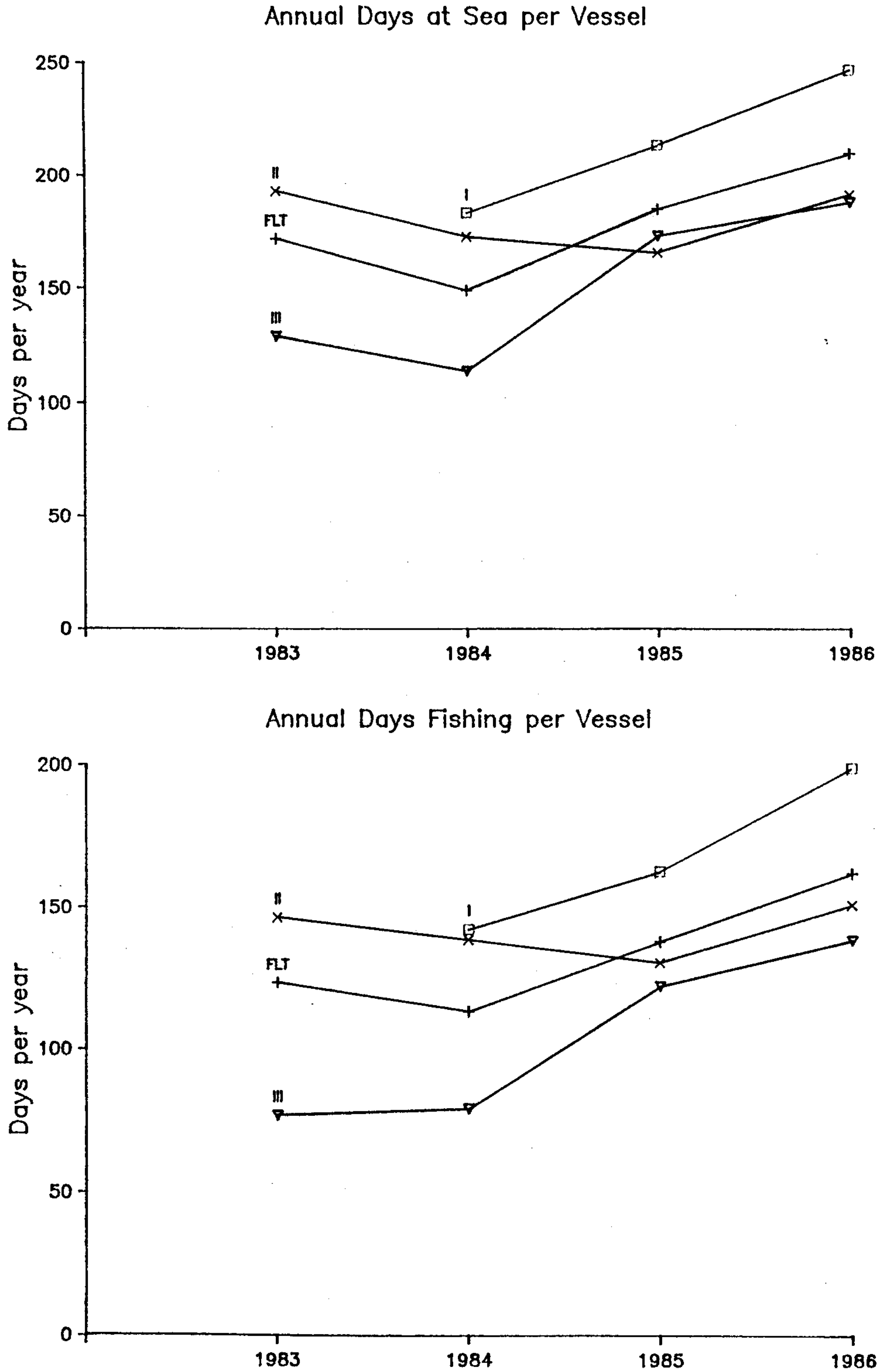


Figure 7.--Average annual days at sea and fishing per vessel, by class, 1983-86.

CATCH RATES

Overall catch rate figures for the fishery are reproduced in Table 5 from the annual report (Clarke et al. footnote 1). Polovina et al. (1987[6]) argue that both the spiny and slipper lobster stocks have been fished down toward their maximum sustainable yield, and the catch rate per trap-night reflect this process. However, catch rate between the classes of vessels for 1986 (Table 6 and Fig. 8) significantly differed.

Table 5.--Annual catch per unit effort (CPUE) of the lobster fleet in the Northwestern Hawaiian Islands, 1983-86.[a]

Year	Days (No.)	Trap-nights (No.)	Legal spiny lobster (CPUE)	Total slipper lobster (CPUE)
1983	274	76,857	2.05	0.33
1984	822	377,440	1.17	0.75
1985	1,653	1,089,462	0.88	1.09
1986	2,166	1,455,790	0.62	0.85

[a]Data are from Clarke et al. (text footnote 1).

Table 6.--Catch and catch rates by class of the lobster fishery in the Northwestern Hawaiian Islands, 1986. Data in this table may differ from the Clarke et al. (text footnote 1) because of new information and exclusion of data from the main Hawaiian Island trips.

Class	Weight (lb) of landed product			Trips (No.)	Days fished (No.)	Weight (lb) of landed product/day			Traps ($\bar{x}$ No.)	Catch (lb)/trap
	Spiny	Slipper	Total			Spiny	Slipper	Total		
I	241,404	241,555	482,959	19	942	256.3	256.4	512.7	861	0.60
II	83,872	36,110	119,982	10	302	277.7	119.6	397.3	658	0.60
III	100,807	72,210	173,017	28	799	126.2	90.4	216.5	417	0.52
Total[a]	428,192	353,462	781,654	58	2,062[a]	207.7	171.4	379.1	655	0.58

[a]Includes one trip not categorized by class.

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[6]Polovina, J. J., R. B. Moffitt, and R. P. Clarke. 1987. Status of stocks of spiny and slipper lobsters in the Northwestern Hawaiian Islands, 1986. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-87-2, 12 p.

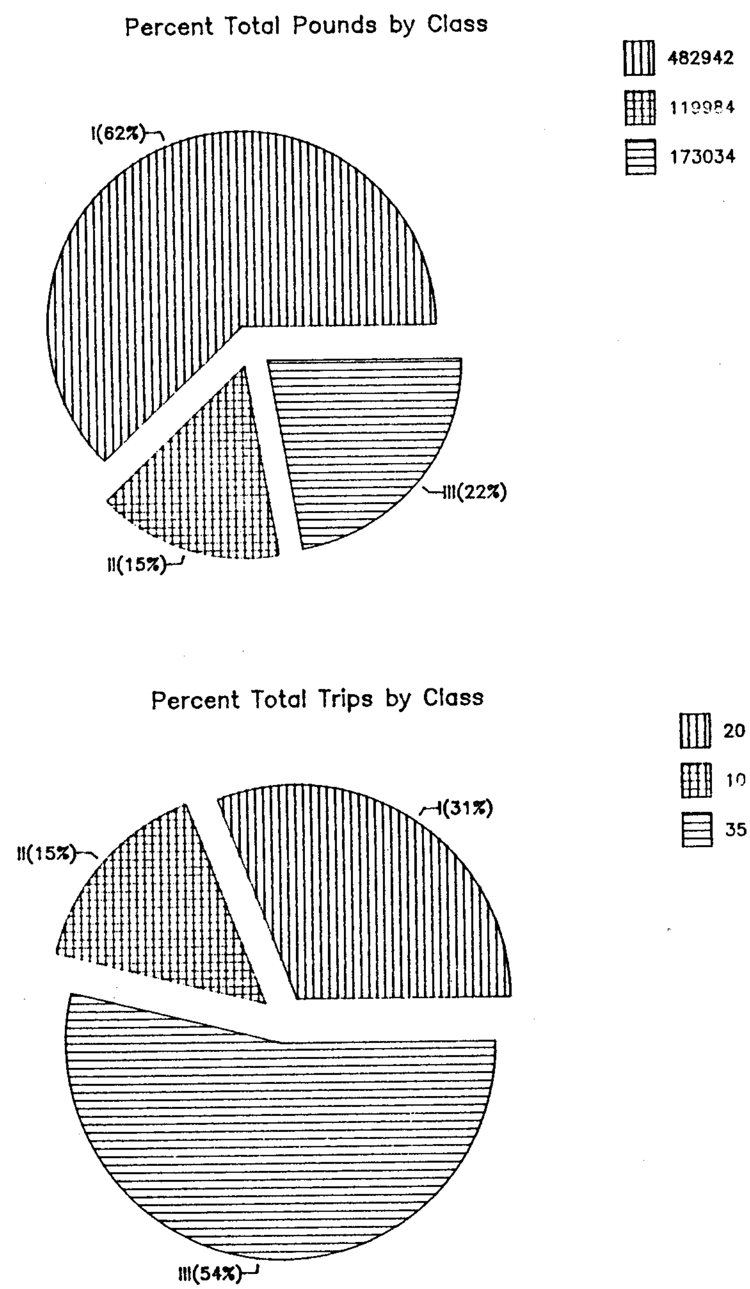

Figure 8.--Total catch and trips by class, 1986.

Class I vessels had the highest catch per day fishing (510 lb of landed lobster product, i.e., frozen tails), but they also hauled, on average, the most traps per day (861) in 1986. This result indicated a higher operating intensity by these boats in 1986 compared to 1985 when fewer traps were hauled on average. Their catch per trap hauled was 0.60 lb of lobster product. Class I vessels had a higher percentage of slipper lobsters (which have a lower value) than spiny lobsters; slipper lobsters constituted 50% of their catch (by landed weight). They landed more slipper lobsters than spiny lobsters (by product weight) in 58% of their trips in 1986.

Class I vessels caught 241,000 lb of spiny lobsters (product weight) and 242,000 lb of slipper lobsters in 1986 (Table 6). This amounts to 62% of total fleetwide lobster landed weight (Fig. 8), 56% of spiny lobster and 68% of slipper lobster. The average Class I vessel landed 51,000 lb of processed spiny lobster (product weight) in 1986 and 51,000 lb of processed slipper lobster on an annualized basis. It is important to note that the catch logbooks reported lobsters by **number** while the revenue data, used in this analysis, reported landings by **weight**.

Class II vessels had a lower average daily catch rate (397 lb/d) than did the Class I vessels. But with a lower number of traps fished, they caught the same product weight per trap (0.60 lb) and had a greater percentage (70% by weight) of highly valued spiny lobster in 1986. Class II vessels caught 84,000 lb of spiny lobsters and 36,000 lb of slipper lobsters in 1986 (Table 6). This amounts to 15% of total lobster landings (Fig. 8), 20% of spiny lobster landings, but only 10% of slipper lobster landings. In 1986, the average Class II vessel landed 42,000 lb of processed spiny lobster product and 18,000 lb of processed slipper lobsters.

Class III vessels had a slightly lower catch per trap (0.52 lb product weight per trap), and with fewer traps fished, (417 traps), they landed less weight per day (216.5 lb) (Table 6). A large percentage (42% by weight) of Class III landings was slipper lobster in 1986. Class III vessels caught 101,000 lb of spiny lobster and 72,000 lb of slipper lobster in 1986 (Table 6). They caught 22% of all lobster landings (Fig. 8), 24% of the spiny lobster, and 20% of the slipper lobster landed. The average Class III vessel landed 18,000 lb of processed spiny lobster product and 13,000 lb of processed slipper lobster in 1986.

REVENUE

Revenue characteristics are a composite of vessel operations (fishing days and catch rates) and marketing practices that determine prices. Clarke et al. (footnote 1) presented revised estimates of total lobster revenue from the fishery. Our estimates of total lobster revenue were further refined on a trip-by-trip basis for a more complete estimation of missing revenues from 1983 to 1986 (Table 7) and revenue information by class is provided for 1986 (Table 8).

Class I vessels landed $3.76 million in lobster products in 1986 or 63% of total industry revenue. Revenue per trip was $198,000, and average

Table 7.-- Revenue (US$) for spiny and slipper lobsters in the Northwestern Hawaiian Islands.[a]

Year	Spiny lobster				Slipper lobster				Spiny and slipper lobster total
	Live	Whole	Tails	Total	Live	Whole	Tails	Total	
1983	—	—	—	559,624	—	—	—	—	589,801
1984	156,568	13,831	2,302,419	2,472,818	—	4,077	328,696	332,773	2,805,591
1985	160,723	11,356	4,043,425	4,215,504	105	1,615	1,630,052	1,631,772	5,847,276
1986	84,880	59,468	3,550,178	3,694,526	593	8,735	2,265,549	2,274,877	5,969,403

[a]Data (in pounds) were revised from Clarke et al. (text footnote 1).

Table 8.--Revenue (in million US$) by class of the lobster fleet in the Northwestern Hawaiian Islands, 1986.

Class	Revenue by species			Spiny lobster		Slipper lobster		Total	
	Spiny lobster	Slipper lobster	Total	Revenue/ trip	Price/ lb	Revenue/ trip	Price/ lb	Revenue/ trip	Price/ lb
I	2.19	1.56	3.76	115,425	9.08	82,272	6.47	197,697	7.78
II	0.72	0.23	0.95	71,872	8.57	23,116	6.40	94,989	7.92
III	0.77	0.46	1.23	27,617	7.67	16,429	6.37	44,046	7.12
Total	3.68	2.25	5.97[a]	63,699	8.63	39,222	6.44	102,921	7.64

[a]Includes one trip not categorized by class.

price was $7.78 per lb. Although Class I vessels' catch of slipper lobsters equaled that of spiny lobsters, the higher average price for spiny lobsters meant that spiny lobsters amounted to 58% of the revenue by class. The higher average prices received by Class I vessels for both product types reflected their superior freezing capabilities, product handling practices, and strong linkages to mainland U.S. buyers.

Class II vessels landed $950,000 worth of lobster products during 1986 or 16% of the total industry revenue. Revenue per trip totaled $95,000, and average price received was $7.92 per lb. Although this average price was higher than for Class I vessels, it reflects the higher composition of spiny lobsters in Class II landings. Spiny lobster comprised 76% of Class II revenue. Average prices for Class II landings of spiny and slipper lobsters individually were lower than those for Class I vessels. Like Class I vessels, most Class II vessels sell their lobsters to the mainland United States, but because they are sold in smaller lots, their handling charges are substantially lower than those of Class I vessels (many sell to local wholesalers and as a result do not pay fees such as cold storage costs, brokerage fees, and associated insurance).

Class III vessels landed $1.23 million worth of lobster products in 1986 or 21% of the total industry revenue. Revenue per trip was $44,000, and average price was $7.12 per lb. Many of their lobsters were sold in Hawaii, so handling charges were negligible. However, for Class III vessels that did sell products to the mainland U.S. buyers, their handling charges were substantial (on a per pound basis). Figure 9 shows the relative prices of spiny and slipper lobsters by class, and the relative composition of spiny lobsters in the catch by class.

OPERATING RELATIONSHIPS

Categorization of vessels by class is based on the presumption that the characteristics of the vessels and their captains and crews affect economic performance. Simple correlation analysis shows the relationship between vessel characteristics (Table 9a) and vessel operations (Table 10a). Class identification is related to these variables through the chi-squared test (Tables 9b and 10b). Classification of vessels was first by vessel length; therefore, the high chi-squared statistic between class and vessel length, fuel capacity, and vessel cost was not surprising (Table 9b).

Table 9a.--Correlations between vessel characteristics. *N* = 17 in most cases but was less if paired vessel characteristics and operating characteristics were not available.

Vessel	Fuel	Speed	Cost	Age	Horsepower
Length	79.7*	-29.0	85.9*	2.3	53.2*
Fuel	--	21.7	76.2*	-0.4	81.9*
Speed		--	38.8	-38.2	41.5
Cost			--	0.8	86.2*
Age				--	7.1

*$P \leq 0.05$ that r <> 0.00.

Table 9b.--Chi-squared relationship with vessel class. Chi-square table was calculated as a threeway table. The program proportionally spaced the nonclass variables, except in the case of cost where an outlier required adjustment.

	Length	Fuel	Speed	Cost	Age	Horsepower
χ^2	17.0*	12.89*	3.15	8.00	5.80	3.24
P	0.00	0.01	0.53	0.09	0.21	0.52

*$P \leq 0.05$.

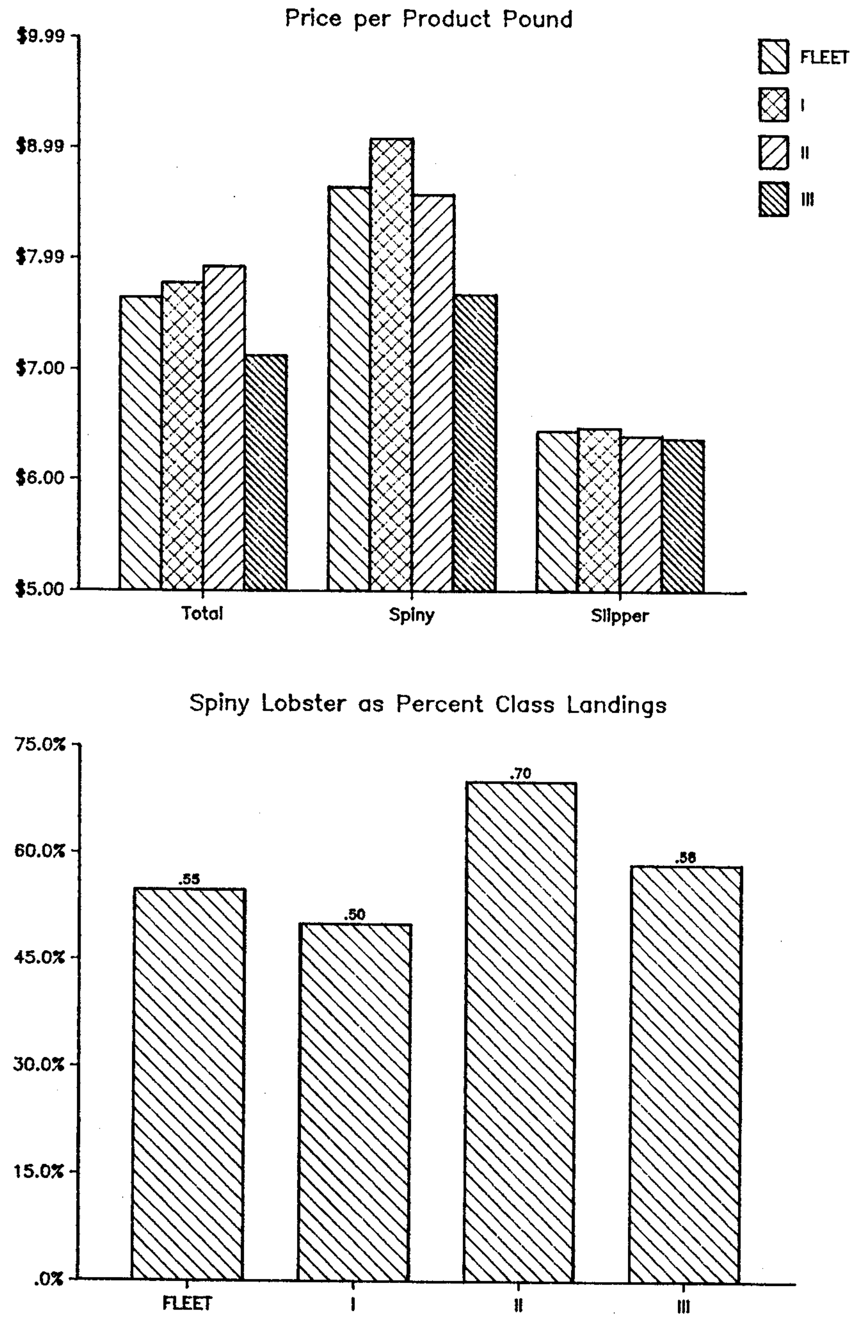

Figure 9.--Product price and composition by class, 1986.

Table 10a.--Correlations between vessel operations (CPUE = catch per unit effort). *N* = 17 in most cases but was less if paired vessel characteristics and operating characteristics were not available.

	Traps	Crew	Days at sea	Trips	Price	CPUE
Length	37.7	64.8	0.2	-1.4	5.5	24.0
Average No. of traps	--	82.9*	53.8*	-41.6	60.2*	24.5
Crew	--	--	35.6	-44.2	37.5	48.5
Days at sea per trip	--	--	--	-61.5*	25.5	0.0
Trips per year	--	--	--	--	-4.2	-34.7
Product price	--	--	--	--	--	40.4

* = $P \leq 0.05$ that r <> 0.00.

Table 10b.--Chi-squared relationship with vessel class. Chi-square table was calculated as a threeway table. The program proportionally spaced the nonclass variables.

	Average number of traps	Sea days/ trip	Trip/ year	Product price	Catch per unit of effort
χ^2	18.80*	6.47	2.00	3.08	5.38
P	0.00	0.17	0.73	0.54	0.25

*$P \leq 0.05$.

The secondary level of classification was by traps fished, which also was highly related to class (via chi-squared) and highly correlated with sea days per trip and price (Table 10b). It would take a partial correlation analysis to investigate the differences and similarities between groups of vessel classes. Interestingly, neither the speed nor the age of the vessel was significantly correlated with any other vessel characteristic.

There were significant correlations within vessel operations, but there were also insignificant, although interesting, correlations: The number of sea days was not correlated with the size of the vessel, nor was the number of trips; catch per trap was not significantly correlated with any of the operation variables, although it had a weak negative correlation with the number of trips per year and a weak positive correlation with the number of crew members and price.

VESSEL PROFITABILITY

Sample Size and Data Sources

Vessel operating and fixed costs for 12 NWHI commercial lobster fishing vessels active in 1985 or 1986 were obtained through interviews with the owner, operator, or crew members. The sample included four Class I, three Class II, and five Class III vessels. The information was of mixed detail, but we believe that, for each vessel, the data are reliable. The data are strictly confidential. Data on some vessels were available for only 1985 and were adjusted to 1986 price levels. The Honolulu Consumer Price Index was used for 1985 cost adjustments except fuel, which was adjusted by a constructed index from the Honolulu refinery sales price for diesel fuel.

The cost data represent annualized estimates of fixed and operating costs for a vessel operating full time in the NWHI lobster fishery. Data on vessel operations were taken from the sources indicated previously in this report. The cost data presented represented the average values given by respondents for their respective vessel classes. Engineering data were used to validate various cost information provided by respondents. If large variations were found, the respondents were recontacted to confirm the data. Cost per unit varied substantially in many instances.

Cost-Earnings Spreadsheets

Data for each vessel were first entered into a simple cost-earnings spreadsheet, which makes minor adjustments to ensure that all subtotals add up to totals and all rates are consistent. These spreadsheets are not shown. The vessel cost-earnings sample data were then compiled into fleet-class averages with their standard deviations and coefficients of variation (Tables 11-13). Catch per trip, crew share percentages, prices, and other rates are not necessarily consistent with total figures (such as total catch, labor income, and revenue) in previous tables because rates were unweighted averages.

The class averages were then re-entered into a cost-earnings simulator format to ensure that all rates were consistent. The annualized fleet operating and revenue characteristics (Tables 4-8) were summarized (Table 14) and divided into cost percentages, cost per fishing day, and cost per product weight (Tables 15-17).

Cost-Earnings Methodology

Although cost-earnings analysis is relatively straightforward, a number of methodological issues are important to clarify. Fixed costs represent annual costs that a fishing vessel must incur to fish and are considered independent of fishing activity. Annual repairs and insurance are not strictly fixed because they may depend on the level of anticipated operations, but in this analysis, they are considered fixed for marginal changes in vessel operation.

Table 11.--Class I sample means, standard deviations (SD's) and coefficients of variation (COV's) (N = 4), 1986 price levels.

Income statement	$\bar{x}$ (US$)	SD (US$)	COV (%)
Revenue	**1,003,692**	457,677	46
Fixed costs	**368,846**	135,437	37
Capital costs	121,618	25,435	21
Annual repair	57,982	60,689	105
Vessel insurance	81,302	7,377	9
Administrative	10,102	11,665	115
Loan costs	97,842	95,100	97
Operating costs	**609,400**	289,647	48
Fuel and oil	77,562	26,091	34
Bait	55,706	35,047	63
Handling	100,158	74,094	74
Provisions	26,755	16,900	63
Medical	896	915	102
Supplies	4,851	8,510	175
Gear	29,520	15,809	54
Other	3,420	3,582	105
Crew share	273,912	109,798	40
Captain's share	32,219	64,437	200
Not enumerated separately	4,402	8,805	NA
Total cost before depreciation	978,246	408,559	42
Revenue minus cost	25,446	89,131	350
Supplemental depreciation	16,396	24,841	152
Total cost	**994,642**	574,257	58
Net revenue	**9,050**	108,839	1,203
	Operating Characteristics		
Investment ($)	1,216,179	806,230	66
Trips (No.)	4.50	1.00	22
Catch per day (lb)	625	130	21
Trip days (No.)	264	46	17
Fishing days (No.)	210	55	26
Crew share (%)	40.00	3.8	9
Crew (No.)	8.00	0.00	0.00
Shared costs ($)	298,867	147,731	49
Revenue ($)	1,003,692	457,677	46
Product price ($/lb)	7.30	0.68	9
Total catch (lb)	135,289	57,165	42
Inflation factor	1.01		
Fuel price factor	0.80		
Capital factor	0.10		
Depreciation factor	0.04		

Table 12.--Class II sample means, standard deviations (SD), and coefficients of variation (COV's) (N = 3), 1986 price levels.

Income statement	$\bar{x}$ (US$)	SD (US$)	COV (%)
Revenue	**590,136**	209,132	35
Fixed costs	**101,497**	39,156	39
Capital costs	37,367	24,067	64
Annual repair	16,541	12,203	74
Vessel insurance	24,032	6,175	26
Administrative	18,049	19,565	108
Loan costs	5,509	9,541	173
Operating costs	**262,050**	88,614	34
Fuel and oil	25,489	14,589	57
Bait	19,932	10,802	54
Handling	4,299	4,010	93
Provisions	12,021	6,371	53
Medical	0	0	NA
Supplies	4,894	4,824	99
Gear	16,216	2,996	18
Other	4,116	2,159	52
Crew share	158,236	67,992	43
Captain's share	16,847	10,123	60
Not enumerated separately	0	0	NA
Total cost before depreciation	363,547	120,784	33
Revenue minus cost	226,589	113,026	50
Supplemental depreciation	543	23,950	4,413
Total cost	**364,090**	257,450	71
Net revenue	**226,047**	101,840	45
Operating Characteristics			
Investment ($)	373,667	240,666	64
Trips (No.)	4.33	2.31	53
Catch per day (lb)	560	244	44
Trip days (No.)	186	54	29
Fishing days (No.)	147	45	31
Crew share (%)	31.00	3.38	10
Crew (No.)	6.67	2.08	31
Shared costs ($)	86,966	37,771	43
Revenue ($)	590,136	209,132	35
Product price per pound ($)	7.71	0.34	4
Total catch (lb)	76,459	26,763	35
Inflation factor	1.01		
Fuel price factor	0.74		
Capital factor	0.10		
Depreciation factor	0.04		

Table 13.--Class III sample means, standard deviations (SD), and coefficients of variation (COV's) (N = 5), 1986 price levels.

Income statement	$\bar{x}$ (US$)	(US$)	COV(%)
Revenue	**275,240**	94,462	34
Fixed costs	**134,256**	45,674	34
Capital costs	36,920	9,359	25
Annual repair	18,421	18,029	98
Vessel insurance	29,507	8,300	28
Administrative	3,972	4,597	116
Loan costs	45,436	41,275	91
Operating costs	**165,341**	35,788	22
Fuel and oil	26,776	9,241	35
Bait	22,711	3,551	16
Handling	1,785	3,991	224
Provisions	12,286	3,615	29
Medical	541	630	116
Supplies	2,486	3,029	122
Gear	14,299	4,450	31
Other	7,600	9,839	129
Crew share	74,142	40,462	55
Captain's share	2,716	6,072	224
Not enumerated separately	0	0	NA
Total cost before depreciation	299,597	71,231	24
Revenue minus cost	-24,357	48,678	NA
Supplemental depreciation	4,148	5,438	131
Total cost	**303,745**	151,873	50
Net revenue	**-28,505**	51,684	-181
	Operating Characteristics		
Investment ($)	369,200	186,217	50
Trips (No.)	5.20	2.17	42
Catch per day (lb)	256	81	32
Trip days (No.)	204	45	22
Fishing days (No.)	158	47	30
Crew share (%)	39.5	1.16	3
Crew (No.)	5.00	0.71	14
Shared costs ($)	88,483	21,733	25
Revenue ($)	275,240	94,462	34
Product price ($/lb)	7.05	0.50	7
Total catch (lb)	38,790	12,069	31
Inflation factor	1.00		
Fuel price factor	0.92		
Capital factor	0.10		
Depreciation factor	0.04		

Table 14.--Comparison of annualized characteristics for vessel classes and fleet (in US$), 1986 price levels.

Income statement	Fleet N = 15	Class I N = 5	Class II N = 3	Class III N = 7
Revenue	**459,178**	**793,772**	**475,139**	**213,341**
Fixed costs	**188,647**	**341,216**	**117,562**	**110,135**
Capital costs	65,242	121,618	37,367	36,920
Annual repair	31,232	57,982	16,541	18,421
Vessel insurance	45,677	81,302	24,032	29,507
Administrative	8,831	10,102	18,049	3,972
Loan costs	37,666	70,212	21,573	21,315
Operating costs	**275,549**	**505,143**	**221,914**	**134,540**
Fuel and oil	40,972	72,543	26,262	24,726
Bait	31,021	52,828	20,474	19,964
Handling	27,726	79,177	3,500	1,358
Provisions	16,113	25,024	12,385	11,345
Medical	512	838	0	500
Supplies	3,592	4,537	5,043	2,295
Gear	18,529	27,995	16,657	12,569
Other	5,189	3,199	4,240	7,018
Crew share	118,906	210,636	120,428	52,732
Captain's share	11,616	24,248	12,925	2,033
Not enumerated separately	1,373	4,118	0	0
Total cost before depreciation	464,196	846,358	339,476	244,675
Revenue minus cost	-5,019	-52,586	135,663	-31,334
Supplemental depreciation	0	0	0	0
Total cost	**464,196**	**846,358**	**339,476**	**244,675**
Net revenue	**-5,019**	**-52,586**	**135,663**	**-31,334**
		Operating Characteristics		
Investment ($)	652,420	1,216,179	373,667	369,200
Trips (No.)	4.67	4.00	5.00	5.00
Catch per day (lb)	351	513	397	217
Trip days (No.)	208	247	192	188
Fishing days (No.)	161	199	151	138
Crew share (%)	38	40	31	39
Crew (No.)	6	8	7	5
Shared costs ($)	143,654	266,141	88,561	79,775
Revenue ($)	459,178	793,772	475,139	213,341
Product price ($/lb)	7.50	7.78	7.92	7.12
Total catch (lb)	59,991	102,027	59,992	29,964
Capital factor	0.10	0.10	0.10	0.10
Depreciation factor	0.04	0.04	0.04	0.04
Traps hauled per day	613	861	658	417

[Page corrected 6/30/88. SGP]

Table 15.--Percentage, by vessel class, of total costs (in US$).

	Class I	Class II	Class III
Revenue	**93.79%**	**139.97%**	**87.19%**
Fixed costs	**40.32**	**34.63**	**45.01**
Capital costs	14.37	11.01	15.09
Annual repair	6.85	4.87	7.53
Vessel insurance	9.61	7.08	12.06
Administrative	1.19	5.32	1.62
Loan costs	8.30	6.36	8.71
Operating costs	**59.69**	**65.38**	**54.98**
Fuel and oil	8.57	7.74	10.11
Bait	6.24	6.03	8.16
Handling	9.36	1.03	0.55
Provisions	2.96	3.65	4.64
Medical	0.10	0.00	0.20
Supplies	0.54	1.49	0.94
Gear	3.31	4.91	5.14
Other	0.38	1.25	2.87
Crew share	24.89	35.48	21.55
Captain's share	2.86	3.81	0.83
Not enumerated separately	0.49	0.00	0.00
Total cost before depreciation	100.00	100.00	100.00
Revenue minus cost	-6.21	39.97	-12.81
Supplemental depreciation	0.00	0.00	0.00
Total cost	**100.00**	**100.00**	**100.00**
Net revenue	**-6.21**	**39.97**	**-12.81**

Table 16.--Cost, by vessel class, per fishing day (in US$), 1986 price levels.

	Class I	Class II	Class III
Revenue	**$3,989**	**$3,147**	**$1,541**
Fixed costs	**1,715**	**779**	**796**
Capital costs	611	247	267
Annual repair	291	110	133
Vessel insurance	409	159	213
Administrative	51	120	29
Loan costs	353	143	154
Operating costs	**2,538**	**1,470**	**972**
Fuel and oil	365	174	179
Bait	265	136	144
Handling	398	23	10
Provisions	126	82	82
Medical	4	0	4
Supplies	23	33	17
Gear	141	110	91
Other	16	28	51
Crew share	1,058	798	381
Captain's share	122	86	15
Not enumerated separately	21	0	0
Total cost before depreciation	4,253	2,248	1,768
Revenue minus cost	-264	899	-227
Supplemental depreciation	0	0	0
Total cost	**4,253**	**2,248**	**1,768**
Net revenue	**-264**	**899**	**-227**

Table 17.--Cost, by vessel class, per pound of product (in US$), 1986 price levels.

	Class I	Class II	Class III
Revenue	**$7.78**	**$7.92**	**$7.12**
Fixed costs	**$3.34**	**$1.96**	**$3.68**
Capital costs	1.19	0.62	1.23
Annual repair	0.57	0.28	0.61
Vessel insurance	0.80	0.40	0.98
Administrative	0.10	0.30	0.13
Loan costs	0.69	0.36	0.71
Operating costs	**4.95**	**3.70**	**4.49**
Fuel and oil	0.71	0.44	0.83
Bait	0.52	0.34	0.67
Handling	0.78	0.06	0.05
Provisions	0.25	0.21	0.38
Medical	0.01	0.00	0.02
Supplies	0.04	0.08	0.08
Gear	0.27	0.28	0.42
Other	0.03	0.07	0.23
Crew share	2.06	2.01	1.76
Captain's share	0.24	0.22	0.07
Not enumerated separately	0.04	0.00	0.00
Total cost before depreciation	8.30	5.66	8.17
Revenue minus cost	-0.52	2.26	-1.05
Supplemental depreciation	0.00	0.00	0.00
Total cost	**8.30**	**5.66**	**8.17**
Net revenue	**-0.52**	**2.26**	**-1.05**

A methodological problem arose with our estimation of fixed costs. An analysis by Crutchfield (1986[7]) for fixed costs in comparable west coast fishing vessels stressed the importance of getting 4 to 5 yr of repair and maintenance cost data to smooth out the "bulges" in vessel repair schedules. Our study had two types of "bulges." First, vessels frequently incurred start-up investment costs for entering the fishery. These costs included retooling deck space and improving refrigeration. If these costs were accountable, they were included in the investment value of the vessel and not in annualized fixed costs. Second, many of the Class I vessels hauled out biennially. However, many of the Class II and Class III vessels had not hauled out during the study period, so these costs were estimated.

Capital costs are an approximation for the economic opportunity cost of capital, i.e., the income from the best alternative use for the funds invested in the vessel. From an accounting perspective, accounting costs might be viewed as equivalent to depreciation, but depreciation as an economic cost category is hopelessly confounded by tax law formulas. We calculated capital costs at current market interest rates on total funds invested in the vessel.

Loan costs represent only the interest paid to finance the vessel and vessel operations. From some economic perspectives, loan costs should be excluded from this analysis because financing is a matter of choice for individual owners. However, to maintain the realism of the results, we included loan costs. They are "normalized" for all vessels to limit the impact of different financing mechanisms.

Labor, in most industries, also is viewed by economists as an opportunity cost, and several economists use average manufacturing wage rates in fishery studies. However, we are convinced that there is no equivalent to commercial fishing as an occupation. Therefore, labor costs are calculated from shares and incorporated into the analysis as a rate based on net operating revenue. The share system allocates part of the risks, costs, and benefits from operating a fishing vessel among owners, management, and labor, but this, too, is an aspect of commercial fishing that sets it apart from normal business operations. Labor costs include both the crew's share and the captain's share. The captain's share is in addition to his labor share and represents the captain's supplemental role as management.

Typical individual crew member shares are 2-7% each, depending on an individual's experience and the total number in the crew. Skipper shares range from 10 to 17% and include "crew shares." Approximately half the fleet is owner-operated while half uses hired captains.

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[7]Crutchfield, J. A. 1986. Pacific coast trawl vessels: Depreciation, maintenance costs, and capital values. Southwest Fish. Cent, La Jolla Lab., Natl. Mar. Fish. Serv., NOAA, La Jolla, CA 92038. Southwest Fish. Cent. Admin. Rep. LJ-86-03C, 62 p.

Finally, we calculated "supplemental depreciation" to account for the physical deterioration of the vessels. It is calculated as the positive difference between 10% of the value of the vessel and the actual amount spent annually on repairs. The latter represents the direct cost of resisting the forces of nature.

Cost-Earnings Results

The basic results from the cost-earnings analysis which calculates cost per unit are obvious from Table 14 and Tables 15-17. The Class II vessels have the highest level of total profitability and profitability per unit (Fig. 10). The Class I vessels essentially break even overall, with a -4% rate of return on investment (net revenue/investment value). Class II vessels make a 36% rate of return on investment, whereas Class III vessels lose -8.5%.

The Class I and Class II vessels operate almost equally on operations, before labor costs. The larger vessels make $290,000 on operations, and the smaller Class II vessels earn $253,000 on operations. However, with substantially higher fixed costs, the Class I vessels are faced with substantial cash flow problems. The Class III vessels, with essentially the same fixed costs as Class II vessels, make only $79,000 on operations. The shares of fixed, operating, and labor costs are shown in Figure 11.

Many of the vessel owners and skippers stated that the repair and maintenance costs for lobster fishing in the NWHI were substantially higher than they incurred in the Pacific Northwest. Part of this difference is attributable to higher prices in Hawaii, but most of it is due to the extraordinary level of preventive maintenance undertaken by these vessels in order to operate up to 1,500 nmi from Honolulu. Fixed costs by class are shown in Figure 12.

We adjusted Crutchfield's (see footnote 7) figures on west coast trawlers for inflation and compared his findings to our results. Class I lobster vessels are roughly comparable to 90-ft trawlers. The trawler repair and maintenance costs were $46,000, compared to $58,000 for Class I NWHI lobster vessels. Class II and III NWHI lobster vessels were judged to be comparable to 70- to 79-ft trawlers. Trawler costs were $21,000, and Class II and Class III costs averaged $17,500. The lower repair and maintenance costs of these two classes are not easily explained.

Some of the differences in operations are borne by the crew. The Class I and II crew members and captain make similar daily incomes ($147.50/d for Class I and $132.50/d for Class II), but the Class I vessels have a larger crew and fish more days. Average annual income per crew member is $26,000 for Class I crews, $18,000 for Class II crews, and $10,500 for Class III crews. Thus, labor costs are substantially higher for Class I vessels. The Class III crew members and captains receive a smaller income primarily because Class III vessels generate lower revenues.

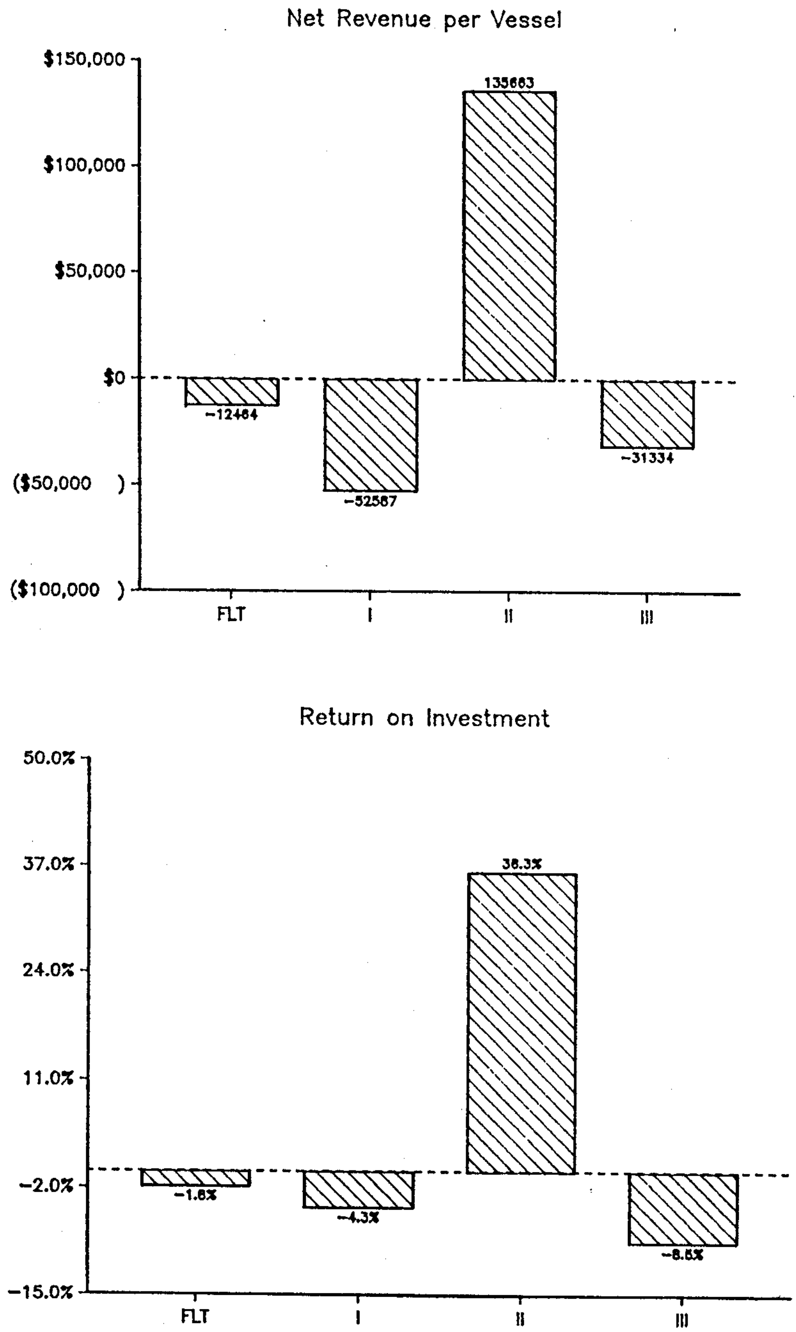


Figure 10.--Economic returns per vessel, by class, 1986.

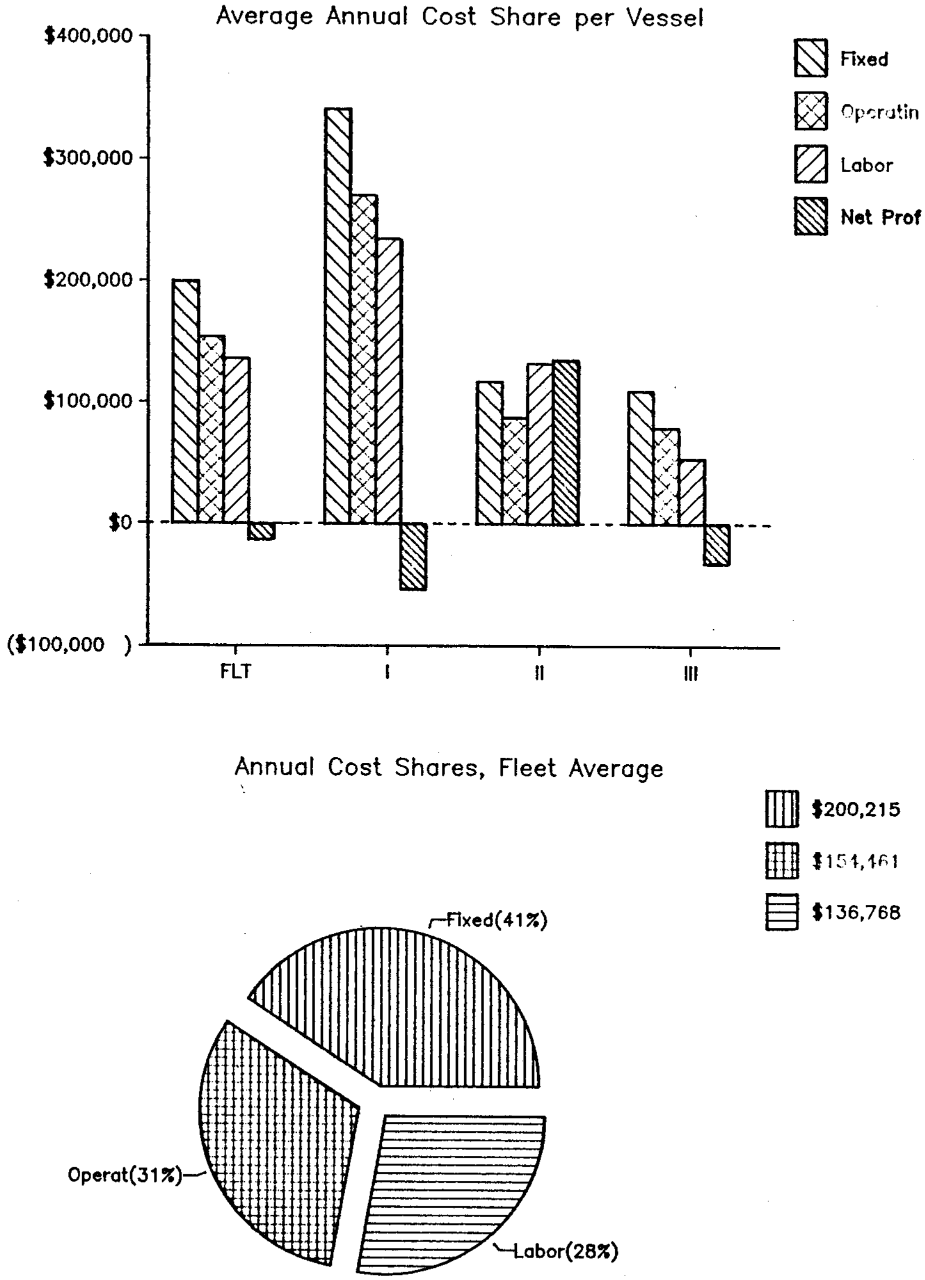
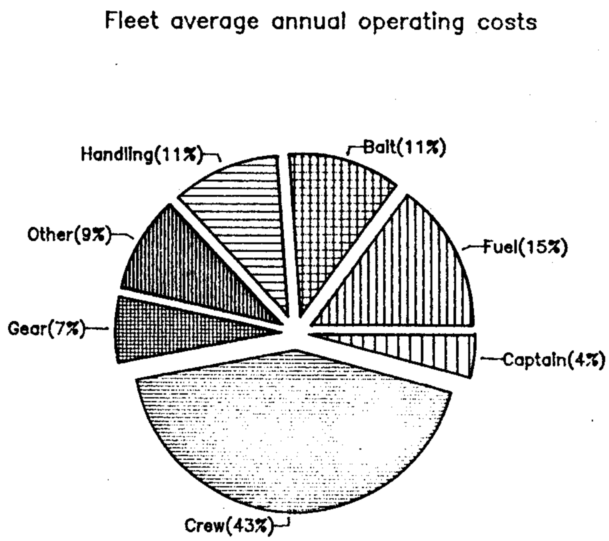


Figure 11.--Major cost categories by class, 1986.



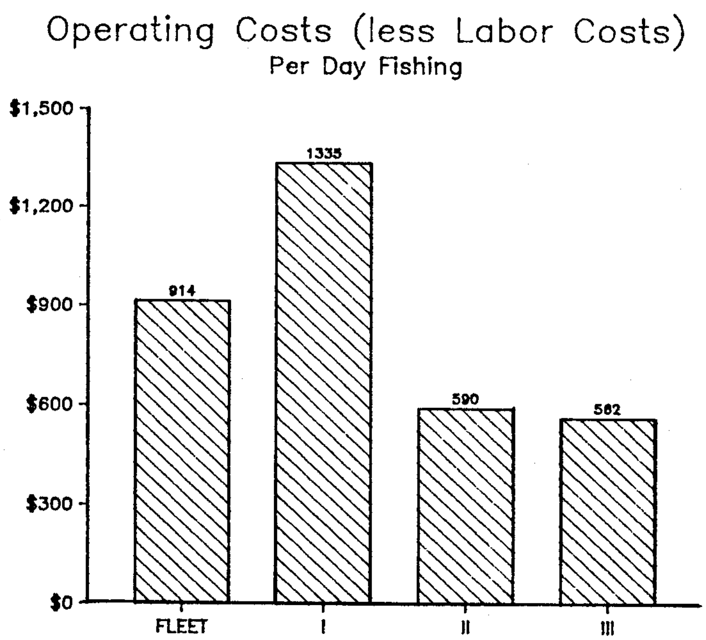


Figure 12.--Fixed costs by class, 1986.

Operating comparisons between vessels are more clearly revealed in Tables 15-17. Operating costs per day fishing (excluding crew and captain's share's) are more than double for Class I vessels ($1,358) compared to Class II ($586) and Class III ($576) vessels (Fig. 13). A major cost differential is handling costs, which are almost $400 for Class I vessels but negligible for Class II and Class II vessels. Handling costs are all those costs incurred by the vessel after landing the product in Honolulu. They include delivery and rental of refrigerated containers; cold storage fees; shipping costs including insurance, sorting, weighing, and repackaging of frozen tails; brokerage fees; and other commissions, along with marketing costs. However, the similarity between basic operating costs for Class II and Class III vessels is clearly shown in Table 14.

On a cost per pound basis, which adjusts costs to the performance of the vessel, Class II vessels have substantially lower operating costs, despite equivalent labor costs (Fig. 14). They are more efficient to run relative to their catch (fuel costs are $0.44/lb of product for Class II compared to $0.71 for Class I and $0.83 for Class III), and they are basically more efficient from every standpoint considered. Crew members make essentially the same per pound on Class I and Class II vessels, but 12% less on Class III vessels. Class II vessels also receive the highest average price per pound because of their concentration on spiny lobsters.

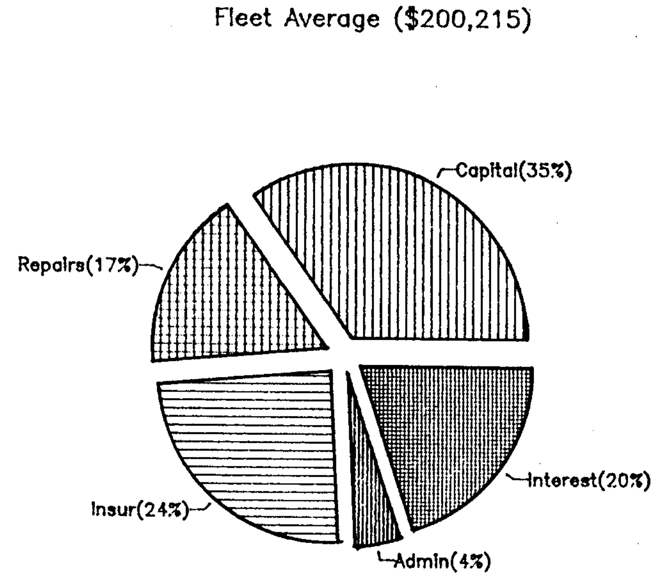
The extrapolation of these cost and return values across the fleet, as it operated in 1986, is shown in Table 18. The number of vessels, covered in this analysis, differs from other annual tables because of our requirement that vessels be categorized Class I, II, or III. Not all vessels fished a full season, and this is taken into account in estimating fleetwide income by extrapolating based on the number of trips actually taken in 1986.

The top half of Table 18 reproduces information from the financial operating statements. The bottom half of Table 18 and Figure 15 provide fleetwide and classwide estimates of total revenue, total catch, net revenue, labor income, and total income. Total calculated revenue is 10% less than that actually recorded by the fleet in 1986: Accounting for three trips not attributed by class, the difference is only 4%. Similarly, total "calculated" catch is only 5% less than that actually recorded by the fleet.

All of the actual net revenue generated by the NWHI lobster fleet in 1986 came from Class II vessels. Fleetwide net revenue was $127,000 on revenues of $5,500,000. However, fleetwide labor income was $1,600,000, representing employment of approximately 103 crew members and captains. Total income (profit and labor combined) was $1.7 million. Class I vessels produced 41% of value added (fleetwide total income), Class II vessels contributed 53%, and Class III vessels contributed 6%.

Cost-Earnings Sensitivity Analysis

The net economic performance of these vessels is dependent on the weight economic inputs play in vessel operations. This section tests a number of the key operational variables as well as some of the basic



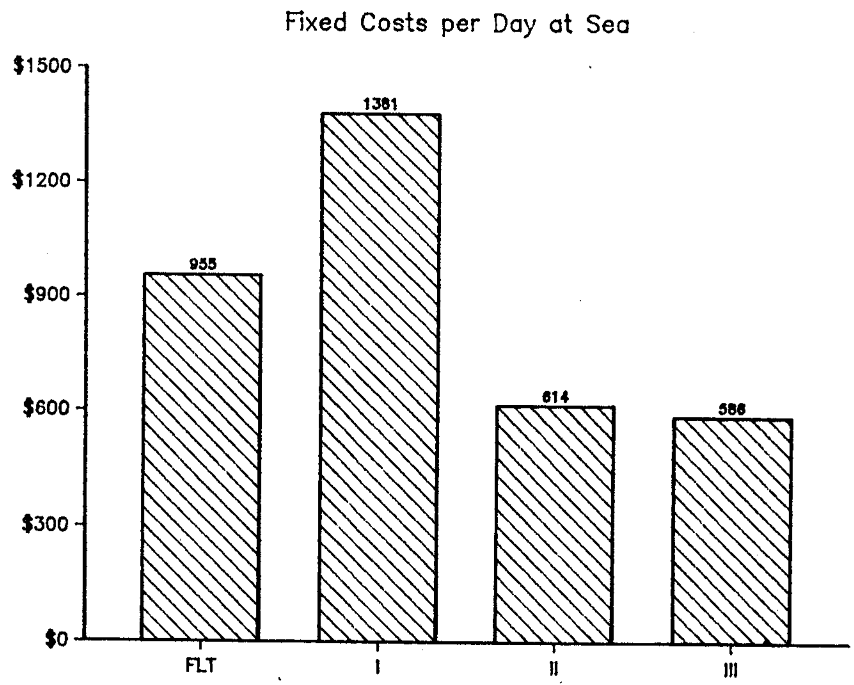


Figure 13.--Operating costs by class, 1986.

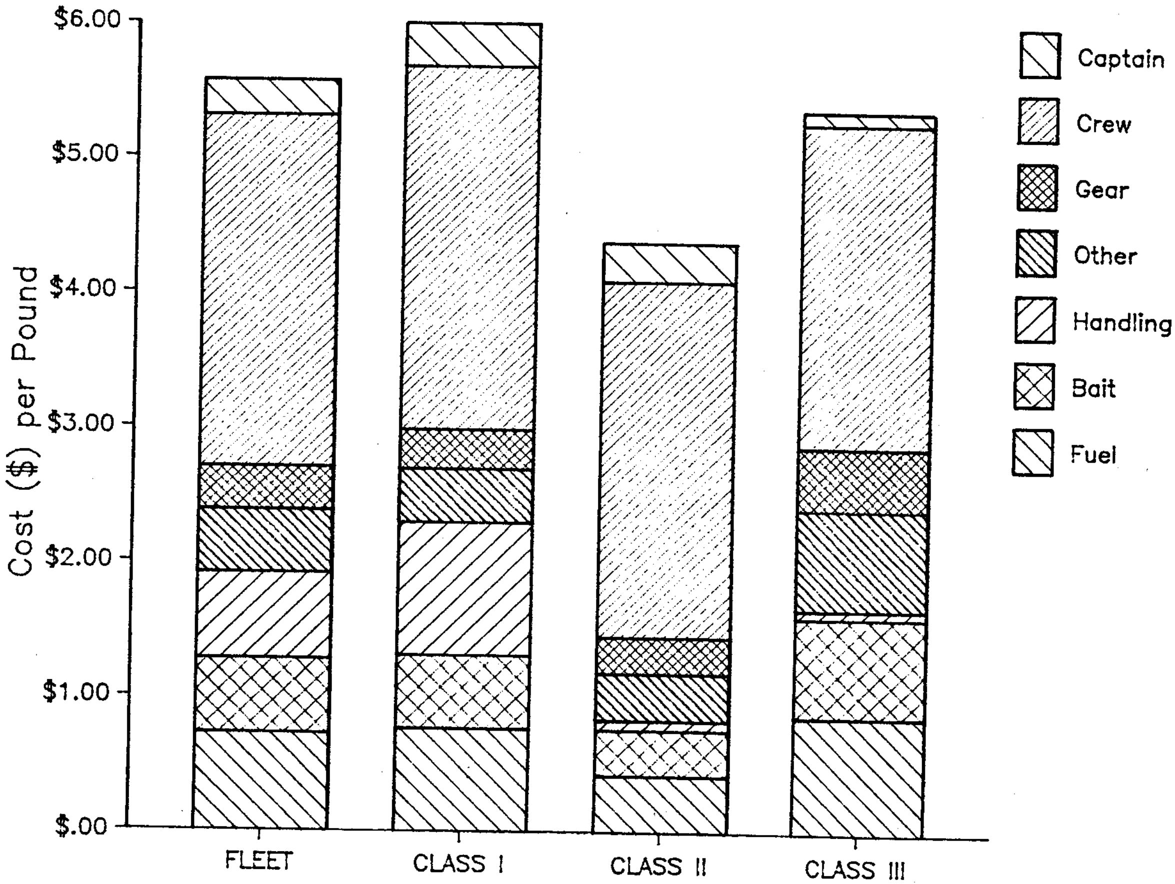


Figure 14.--Operating costs per pound, by class, 1986.

methodological assumptions. The results are presented by class in Tables 19 and 20 as a response of net returns to the change in costs or operations. Table 19 tests include increasing fixed costs by 10%, changing the capital cost factor from 10 to 8%, changing the supplemental depreciation factor from one-fifteenth to one-eighth, increasing overall operating costs by 10%, and decreasing fuel costs by 10%. Table 20 tests include increasing and decreasing trips per year by one trip, increasing the number of days per trip by 10% (implying greater search time), increasing and decreasing the catch per unit effort by 20%, adjusting prices, and adjusting the costs and operations to mid-1987 levels.

The mid-1987 adjustment includes an average price of $11.66 for landed product (combined species), zero handling costs, and catch rates reduced to 0.33 lb per trap hauled (these averages assume a 1986 mix of spiny and slipper lobsters, although the fleet as a whole was targeting less on slipper lobsters in 1987). The average price increase is 51%; the reduction in handling costs reduces operating costs by 16% for Class I vessels, but negligible amounts for Class II and Class III vessels. The catch rate decline is approximately 33%.

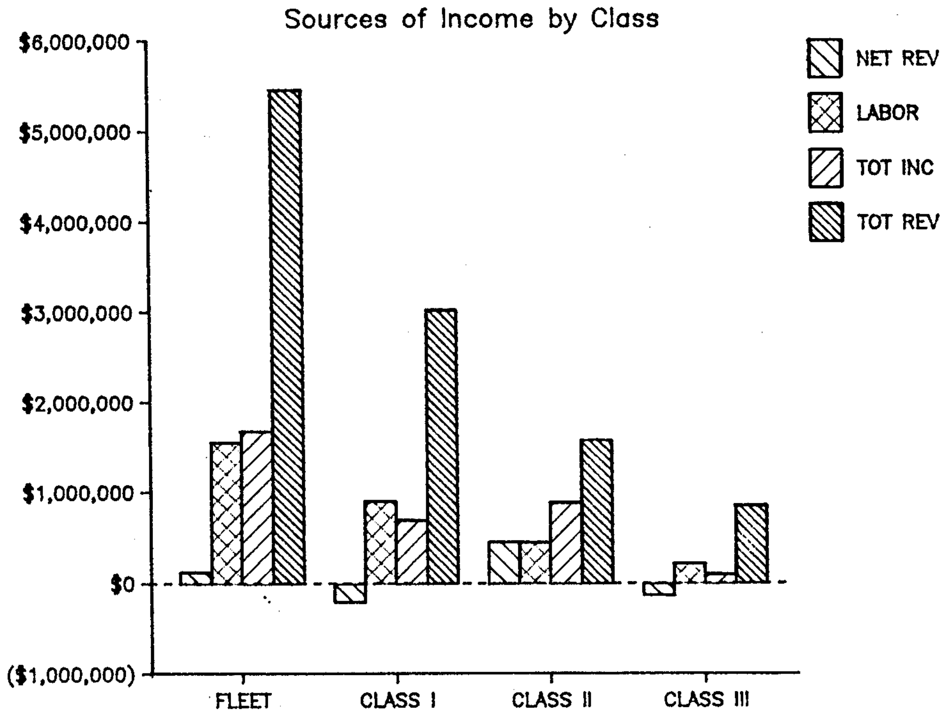
Table 18.--Class, labor, and income of the lobster fleet in the Northwestern Hawaiian Islands, 1985-86 (in US$).

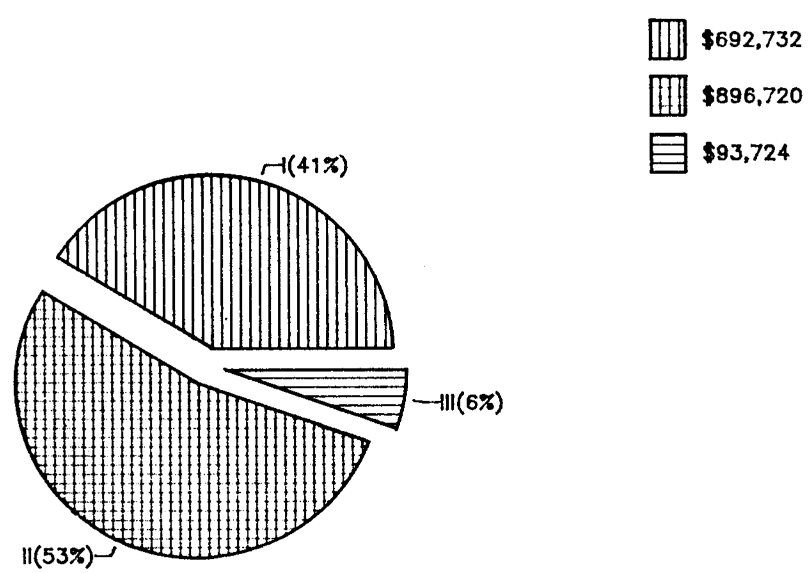
Individual vessel	Class I	Class II	Class III	Fleet average
Total revenue	$793,772	475,139	213,341	451,933
Total catch (lb)	102,027	59,992	29,964	59,226
Average price	$ 7.78	7.92	7.12	7.63
Net revenue	$-52,586	135,663	-31,334	-14,385
Labor income	$234,884	133,353	54,765	128,419
Total income	$182,298	269,016	23,431	114,034
Vessels in fleet (No.)	5.00	3.00	7.00	15.05
Fleet trips (No.)	19	10	28	57

Fleet income	Class I	Class II	Class III	Fleet total
Total revenue	$3,770,417	950,278	1,493,387	6,214,082
Total catch (lb)	484,628	119,984	209,748	814,360
Net revenue	$ -249,784	271,326	-219,338	-197,796
Labor income	$1,115,699	266,706	383,355	1,567,965
Total income	$ 865,916	538,032	164,017	1,567,965

It is apparent that cost and operational items affect classes differently. Class I vessels with high fixed costs receive substantial swings in net revenue from changes in insurance or repair costs or from changes in capital costs. Class III vessels can profit from more liberal depreciation schedules. Interestingly, changes in operating costs have only a marginal impact on net revenue, largely because the gain is shared with the crew and because fixed costs carry such a burden for Class I and Class III vessels.

In terms of operations, squeezing in another trip would have a substantial impact on Class I and Class III vessels. However, Class I vessels were already at sea 247 d/yr (an additional trip would bring this to 309 d). This addition would cut into maintenance time and might change conditions on which crews could be obtained. Class III vessels





Total Fleet Income (Net Revenue + Labor)

Figure 15.--Source of income by class, 1986.

Table 19.--Sensitivity analysis of cost factors.

Cost item[a]	Percentage change in net revenue Class I	Class II	Class III
Fixed costs (+10%)	-70	-9	-40
Capital factor (8%)	+48	+6	+27
Depreciation (12.5%)	-185	-22	-101
Total operating costs (+10%)	-21	-4	-17
Fuel costs (-10%)	+9	+1	+5

[a]Change of amount specified for each input variable in the first column.

Table 20.--Sensitivity analysis of operating characteristics.

Operating item[a]	Percentage change in net revenue Class I	Class II	Class III
Trips (+1)	+118	+37	+59
Trips (-1)	-128	-37	-70
Days at sea (+10%)	-21	-4	-17
Catch per trap (+20%)	+132	+45	+93
Catch per trap (-20%)	-145	-45	-104
Price (+10%)	+69	+23	+11
Mid-1987 conditions	+97	+4	+6

[a]Change of amount specified for each variable in first column.

have more latitude for increasing operations, with an additional trip bringing their time at sea up to 226 d. Given the weather conditions during the early months of the year, this addition may be precluded as well. Reducing the number of trips per year (such as might be suggested through a trip limit) would reduce net revenue by 83% on average. Marginal decreases or increases in days at sea would have a smaller impact on net revenue.

Catch rate and price effects are parallel because they affect revenue equally. The mid-1987 price and catch rate effects are approximately offsetting. However, in 1987 the demand for lobster was so strong, as indicated by the 51% increase in price, that buyers also absorbed handling costs. Assuming that this would also be true for the Class I vessels which paid high handling fees in the past, their net revenue situation would be 97% better this year, but still they would be approximately breaking even.

CONCLUSIONS

This analysis was conducted to provide a current economic picture of NWHI lobster fishing operations. Differences are strong between classes, because of differences not only in the size of vessels but also in the intensity of their operation. It is interesting to speculate why the Class II vessels do so much better than the Class III vessels, their physical twins. Obviously, the Class II vessels fish much harder, as determined by the number of traps fished and the number of days fished. However, we have no specific information to explain this result.

The sensitivity of net revenues to relatively marginal changes in catch rates underscores the vessel operators' concern over the direction of biological management. Clearly, there is a tradeoff between catch rates and prices, but the prices are determined by people outside the Hawaii fishery and most often reflect worldwide conditions. If prices fall next year, with catch rates also depressed, then conditions in the fishery will be extremely poor.

The NWHI lobster fishing vessel captains and owners were extremely cooperative in providing information for this report. Our goal has been to reproduce their information reliably in a form that can be used by the industry, the fishery management council, and others to assess conditions in the fishery.

The success or failure of the lobster fishery in Hawaii probably has more to do with the intangibles of the human element than it does with either the biological condition of the fishery or its strictly economic factors. For fisheries managers to adequately reflect this intangible element requires frequent interaction with the people engaged in the fishery at the harvesting, processing, distributing, and supplying stages. This report, as well as the others in this series, is our attempt to encourage that interaction.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance and cooperation we received from the owners, captains, and crew members of the NWHI lobster fleet. Their support was very helpful. In addition we thank Ann Todoki who patiently ran a good deal of the computer analysis required to complete this study.

Appendix A.--Annualized mean number of sea days and standard deviations (in parentheses) for the lobster fleet and vessel classes in the Northwestern Hawaiian Islands in 1983-86. Some 1983 and 1984 class data are not reported because of confidentiality reasons.

Class	No. of vessels	Sea days	Fishing days	Traveling days	Running days	Weather days	Breakdown days	Rest/deck-work days	Missing days
					1983				
I		—	—	—	—	—	—	—	—
II		—	—	—	—	—	—	—	—
III		—	—	—	—	—	—	—	—
Fleet total	3	171.7 (37.6)	123.3 (43.8)	1.0 (1.7)	36.0 (13.9)	0.0 (0.0)	0.0 (0.0)	11.3 (13.3)	0.0 (0.0)
					1984				
I		—	—	—	—	—	—	—	—
II	3	173.0 (15.7)	138.7 (13.6)	6.0 (4.0)	18.7 (4.0)	3.3 (3.1)	0.0 (0.0)	6.3 (0.6)	0.0 (0.0)
III	4	114.0 (18.1)	79.3 (11.5)	3.0 (6.0)	21.0 (9.6)	9.8 (9.7)	0.0 (0.0)	1.0 (2.0)	0.0 (0.0)
Fleet total	9	149.1 (39.9)	113.1 (36.0)	4.1 (4.4)	21.6 (7.6)	6.4 (7.3)	0.0 (0.0)	3.9 (4.3)	0.0 (0.0)
					1985				
I	4	213.8 (72.0)	163.0 (65.9)	7.3 (7.2)	32.3 (11.4)	2.5 (5.0)	0.0 (0.0)	5.0 (5.2)	3.5 (5.7)
II	3	166.0 (26.1)	130.7 (22.4)	6.7 (2.9)	22.7 (3.5)	1.3 (2.3)	1.0 (1.7)	3.7 (4.7)	0.0 (0.0)
III	5	173.2 (61.6)	122.2 (42.4)	7.0 (7.7)	27.8 (9.1)	5.4 (6.5)	0.4 (0.9)	8.6 (7.4)	1.8 (2.9)
Fleet total	12	184.9 (58.2)	137.9 (47.8)	7.0 (6.1)	28.0 (9.0)	3.4 (5.1)	0.4 (1.0)	6.2 (6.0)	1.9 (3.8)
					1986				
I	5	247.0 (56.6)	199.0 (55.5)	7.2 (4.6)	29.8 (7.5)	1.0 (2.2)	2.2 (4.4)	5.0 (4.7)	2.6 (5.3)
II	3	191.5 (72.8)	151.0 (62.2)	4.5 (6.4)	29.0 (9.9)	3.0 (1.4)	0.0 (0.0)	3.5 (4.9)	0.5 (0.7)
III	7	188.0 (54.9)	138.4 (55.7)	2.9 (4.2)	30.1 (6.8)	4.4 (8.7)	2.9 (4.4)	6.4 (3.6)	2.9 (4.4)
Fleet total	15	209.6 (60.2)	161.9 (59.2)	4.6 (4.7)	29.9 (6.8)	3.0 (6.3)	2.2 (4.0)	5.5 (4.0)	2.4 (4.3)

Appendix B.--Annualized mean total trip length and trip subcomponents for the lobster fleet and vessel classes, in the Northwestern Hawaiian Islands in 1983-86. Some 1983 and 1984 class data are not reported because of confidentiality reasons.

Class	No. of vessels	No. of trips	Total trip length	Fishing days	Traveling days	Running days	Weather days	Breakdown days	Rest/deck-work days	Missing days
1983										
I		—	—	—	—	—	—	—	—	—
II		—	—	—	—	—	—	—	—	—
III		—	—	—	—	—	—	—	—	—
Fleet total	3	23	22.4	16.1	0.1	4.7	0.0	0.0	1.5	0.0
1984										
I		—	—	—	—	—	—	—	—	—
II	3	12	43.3	34.7	1.5	4.7	0.8	0.0	1.6	0.0
III	4	22	20.7	14.4	0.5	3.8	1.8	0.0	0.2	0.0
Fleet total	9	41	32.7	24.8	0.9	4.7	1.4	0.0	0.9	0.0
1985										
I	4	17	50.3	38.4	1.7	7.6	0.6	0.0	1.2	0.8
II	3	13	38.3	30.2	1.5	5.2	0.3	0.2	0.9	0.0
III	5	27	32.1	22.6	1.3	5.1	1.0	0.1	1.6	0.3
Fleet total	12	57	38.9	29.0	1.5	5.9	0.7	0.1	1.3	0.4
1986										
I	5	20	61.8	49.8	1.8	7.5	0.3	0.6	1.3	0.7
II	3	10	38.3	30.2	0.9	5.8	0.6	0.0	0.7	0.1
III	7	35	37.6	27.7	0.6	6.0	0.9	0.6	1.3	1.6
Fleet total	15	65	45.1	34.9	1.0	6.4	0.6	0.5	1.2	0.5

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