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ECONOMIC ANALYSIS OF BOTTOMFISH FISHING VESSELS OPERATING IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1984-88

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INTRODUCTION

The limited entry provision of the Western Pacific Fishery Management Council's Bottomfish Fishery Management Plan requires an estimation of the economic profitability of bottomfish fishing vessels operating in the Northwestern Hawaiian Islands (NWHI). In 1988 we collected information on the cost of vessel operations during the 1987 fishing season from a sample of seven bottomfish vessels. This sample represents one-quarter of the active vessels in the NWHI bottomfish fishery in 1987, and 100% of the vessels that we characterized as full-time bottomfishing boats in 1988.

The cost data were consolidated with information on operating characteristics and revenues for 1984-88 that was obtained from our wholesale market monitoring program. This information was then combined into income statement format which provided estimates of net returns and operating rates. These results were analyzed in terms of total revenue and fleet-wide income. The results confirm the perception that the cost of vessel operations in the NWHI bottomfish fishery is excessive, compared with the time required to make a full load on any trip. Estimated net revenue on a fleet-wide basis is negative for the past 3 years (1986-88).[1]

FLEET ACTIVITY

The status of the fishery and the activity of the vessels operating in the NWHI bottomfish fishery is described in recent annual reports on the fishery: Ralston and Kawamoto (1988), Somerton et al. (1989), and Kawamoto and Pooley (1990). Table 1, which is from Kawamoto and Pooley (1990), provides detailed fleet activity information for 1984-89.

Although the NWHI have been fished for bottomfish (snappers, groupers, and jacks) since at least the immediate post-World War II period, the fishery witnessed substantial expansion in the late 1970s, reaching apparently full development in the mid-1980s. Trips peaked in 1986, while landings, as monitored and estimated by the National Marine Fisheries Service (NMFS) Honolulu Laboratory shoreside monitoring program, peaked in 1987. The decline in the past 2 years has been dramatic, with only 13 vessels fishing in 1988, a 50% decline from the previous year. Only six vessels were characterized as full-time NWHI bottom-fishing participants at the end of 1988. The total number of trips declined by 30-45% from 1986-87 to 1988. Total landings by the NWHI bottomfishing fleet decreased by 40% from 1987 to 1988. This decline occurred for two reasons: the markets for longline

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[1] Data for 1989 had not been compiled by the time the analysis in this report was completed.

tuna and other pelagic fishes have expanded rapidly in the past 3 years, and the cost of bottomfishing has grown because more time is now necessary in searching for economically viable concentrations of fish.

The entry and exit pattern of vessels participating in the fishery is depicted in Table 2. Each year (1984-87), a core group of 11 vessels was active in the fishery, with 6-7 vessels entering and 3-4 vessels exiting the fishery annually. Seventeen vessels left the fishery in 1988, and activity remained low in 1989. A major feature of this pattern has been the development of the longline fishery, which drew some bottomfishing vessels.

VESSEL CHARACTERISTICS

The types of vessels that fish for bottomfish in the NWHI can be separated by propulsion and size into three groups: motor sailers, medium-sized powered vessels, and large-sized powered vessels (Fig. 1). The designs are diverse, because these vessels are from many different fisheries. Table 3 provides average vessel characteristics for 53 boats holding Federal permits in 1987. We obtained additional detailed vessel characteristic information on all seven vessels in our sample, which includes the three basic vessel types.

Each vessel uses ice to hold its catch, although some vessels also have blast freezers. Frozen product has not proven successful in the Hawaii market. Each type of vessel operates with hydraulic gurdies, which are used to raise individually weighted handlines from fishing depths of 40-180 fathoms. There are typically three to six gurdies per vessel, depending on vessel size and deck configuration.

The motor sailers are 46-66 ft long and 15-18 ft wide and are more streamlined in hull design than the standard powered vessels. The sail can be used to save on fuel costs, but it also limits the hold capacity compared with powered vessels of similar length. Average hold capacity on motor sailers is 22 net tons, whereas the hold capacity of large-sized powered vessels is as much as 50 net tons. Motor sailers have an average cruising speed of 7.0-8.5 kn.

The powered vessels generally share one characteristic: a large working area on the back deck. The medium-sized powered vessels are 42-49 ft long and 12-17 ft wide. Because their smaller size limits fishing range and hold capacity, they usually operate in the lower (southeastern) end of the NWHI or in the main Hawaiian islands. Their average cruising speed is 7 kn.

The larger, long-range, powered vessels are 47-64 ft long and 16-18 ft wide. Their size and design make them well suited

to the rigorous conditions found in the NWHI. Their hold capacity is as much as 50 net tons, but the average is only 26 net tons. Increased hold capacity allows the larger load needed for profitability on long-range trips. The cruising speed of these vessels is 7.5-10.0 kn.

Some fleets, such as the NWHI lobster fishing vessels, can be divided into distinct classes by vessel size and operating characteristics (Clarke and Pooley 1988), but we could not make a similar differentiation in the NWHI bottomfishing fleet. Differences in types of propulsion would appear to offer significant differences in catching power and operating costs, but no direct relationship is evident between vessel characteristics and vessel economics.

VESSEL ACTIVITY

Our sample of seven vessels took 54% of the NWHI bottomfishing trips and made 63% of the total NWHI bottomfish landings in 1987. The sample vessels averaged 10 trips each over the year, landing an average of 88,500 lb per vessel in 1987 (Table 4). They averaged 153 days at sea, of which 66 were fishing days and 87 were travel days (almost 60% of their time). Landings per fishing day equaled 1,141 lb and averaged $2.37/lb.

Bottomfishing vessel captains typically search for banks with relatively high catch rates. The distances traveled to fishable banks in the NWHI are substantial (Fig. 2), and the average distance traveled, according to Ralston and Kawamoto (1988), has increased over the history of the fishery. Thus, travel and search costs have increased. With greater distances comes an increase in the time between landing the catch in the NWHI and off-loading it in Honolulu. Prices, in turn, have suffered. For a discussion of price premiums, see Pooley (1987).

Twenty-one other vessels participating in the NWHI bottomfish fishery in 1987 were not included in our sample, because they fished only part time, averaging only three trips per vessel. Their operating patterns differed somewhat, but their total weight in the fishery was limited. Therefore, the remainder of the analysis is conducted on the basis of full-time operating rates derived from our sample.

VESSEL ECONOMICS

We combined the operational data derived from our shoreside monitoring program with our cost data derived from interviews to develop a picture of the average NWHI bottomfishing vessel's costs and earnings in 1987. The data were entered into a microcomputer spreadsheet income statement, which applies a

number of economic restrictions on the data (most important is the estimation of capital costs). The general methodology is spelled out in Clarke and Pooley (1988).

The results from the annualized income statement for full-time operations (11 months of fishing) are reported in Table 5. Annualized average costs on a percentage of total cost per fishing day, per pound, and per trip are reported in Table 6. The annualized results are based on bottomfishing only and do not include periods in which sample vessels fished in associated fisheries, such as trolling for ono (wahoo) in the NWHI.

The operating cost data from our sample included information on the price and use rates of basic productive inputs (e.g., fuel, ice). The "average" vessel is a composite of motor sailers and power-only bottomfishing vessels as well as various vessel sizes. Variation of costs and operating patterns among vessels is substantial: examination of these average input costs and associated use rates must be viewed accordingly.

The average bottomfishing vessel used 1,850 gal of fuel per trip (about 125 gal per day). The smaller sized, power-only vessels and the motor sailers used as little as 1,000 gal per trip, whereas the larger, power-only vessels used more than 2,500 gal.

Some vessels relied primarily on refrigeration, but 8,000 lb of ice per trip was used, based on the average ice cost of all vessel types combined. Bait, which consists of various combinations of squid, anchovy, opelu, sanma, saba, and barley, ranged from 350 to 500 lb per trip (50-75 lb per fishing day).

Most handling costs are attributed to auction fees, which averaged 10% on revenue. Provisions for the crew averaged $800 per trip ($15 per crew member per day). Fishing supplies and gear averaged $330 per trip and hooks, line and leader, gloves, and so on.

Vessels have two kinds of maintenance and repair costs: maintenance costs were attributed to per trip expenditures to ensure equipment was operational; repair costs were attributed to annual expenditures (e.g, annual dry-docking) and breakdown costs (e.g., rebuilding an engine).

In terms of other fixed (annual) costs, vessel insurance, which was a combination of hull and indemnity insurance, varied dramatically in terms of size and type of boat. Administrative costs generally involved office and communications; other costs included mooring, marketing, and non-attributable expenses.

Finally, the analysis is designed to view capital costs as the cost of owning the fishing boat as a productive asset,

independent of various financing and accounting schemes. Therefore, capital costs are calculated as a consistent rate of the investment value of the vessel (the actual purchase price plus major improvements). Most of this analysis uses the 1987 average U.S. Treasury bill interest rate, 8.22%. Also included in capital costs is any additional expense to ensure the vessel is not "mined" through inadequate repairs (i.e., a circumstance in which accounting depreciation rates are used for tax advantages while the actual asset value is diminished). This "supplemental depreciation" is calculated as the difference, if any, between actual repairs and an annualized depreciation rate of 15 years. In most cases, supplemental depreciation was zero because the remoteness of the NWHI and the fishing conditions require vessel owners to adequately repair and maintain their vessels.

Based on the annualized performance data, the average NWHI bottomfish vessel, fishing full-time in 1987, could have landed 111,000 lb of fish valued at $265,000 ($2.37/lb). With annual fixed costs of $60,000 per year, operating costs (less labor) of $110,000 ($500 per day at sea) and labor costs of $83,000 per year (for a crew, including captain, of 3.64 people), the average vessel made a net return of $10,000 in 1987. This amounts to a 3.5% rate of return on investment, confirming that prospects in the NWHI bottomfish fishery have not been good. As an average, however, it must be stressed that some vessels were able to make positive profits, while others had considerable losses. Combining net revenue and labor income, total income generated per vessel was $93,000.

SENSITIVITY TESTING

Sensitivity testing indicates how robust the results are to changes in key parameters. For example, if changing costs by 10% leads to a more than 10% change in the operating profile, then the reliability of costs is a particularly important component of the analysis whose measurement must be examined carefully. On the other hand, if the results change less than 10%, then the profile is considered insensitive to costs, allowing more attention to be placed on other variables.

We conducted sensitivity tests on a number of key variables in the analysis. Simulation of cost, operating patterns, and revenue changes (Table 7) indicates that net revenue is most sensitive to in the crew share percentage (which effectively increases operating costs borne by the owner) and to changes in total fixed costs (which are 25% of the total cost) and entirely attributable to the owner. Increasing the number of fishing days per trip has the most positive effect on net revenue, if all other parameters stay the same. However, increasing trip length also bears on the shelf life of the product and thus may, in

reality, be met by an equivalent decline in price. Total cost is not affected greatly by variation in any individual component: only increasing the number of fishing days increases total cost by more than 10%, which is attributable to costs associated with increased revenue (i.e., labor share and handling) as much as for actual fishing expenses (e.g., gear).

The labor share agreements of commercial fishing vessels make net revenue sensitive to changes in any major cost or operational component, although total cost (including labor) is not as sensitive.

In terms of the overall results from sensitivity testing, it would appear that concentration on the operating and revenue characteristics of NWHI bottomfishing is most important for ensuring the validity of economic analysis, rather than refinement of individual cost components. In particular, the relationship between operations (such as lengthening the trip length), catch rates, and final price of the product are important determinants of vessel profitability.

FLEET INCOME

Quantitative information was not available on the behavior of vessels that switched fisheries during the year. Therefore, it was necessary to estimate the number of full-time equivalent (FTE) vessels in the fleet (adding increments of the part-time participants) to assess industry-wide costs and returns. We developed income statements for 1986-88, using annualized performance based on actual total fleet-wide landings for each year. The 1987 average annualized income statement served as the baseline. Costs were adjusted for inflation and different operating patterns, and prices also were adjusted to market averages. Average landings per annualized full-time vessel were divided into the total fleet landings to provide the figure for FTE vessels. Next, revenue and cost components on a per vessel basis were multiplied by the FTE figure for each year, generating estimates of costs and incomes for the NWHI bottomfishing fleet for the 3 years.

As can be seen in Table 8, total fleet net revenue was negative each year, although there was a positive income flow when labor income was considered. Net revenue per vessel became less negative over the period as vessels left the fishery. It is important to understand why a difference occurs between our positive net revenues estimated for an average annualized vessel using our sample's characteristics (Table 5) and the negative net returns projected in Table 8. This difference is due to the sample vessels operating more intensively than the fleet as a whole, even on a FTE and annualized basis.

We also estimated net economic returns based on inflation-adjusted interest rates and longer term depreciation schedules. These returns are more reflective of traditional cost-benefit accounting principles than the financial accounts considered by individual enterprises. The effect of changing capital costs is substantial in terms of net revenue on a per vessel basis: net revenue increases from $-8,000 to a positive $9,000 per year (using the FTE vessel basis), equivalent to the decrease in capital costs from $27,400 to $9,800. This amounts to a 3% rate of return on investment, still sub par for an industry as risky and uncertain as commercial fishing.

CONCLUSIONS

The estimated NWHI bottomfish landings for 1988 were 15% less than the estimated maximum sustainable yield for the NWHI bottomfish fishery, as calculated by Ralston and Kawamoto (1988). Somerton et. al. (1989) found no signs of biological stress in the NWHI bottomfish populations. However, both noted that the locus of the fishery has shifted to more distant banks and that the species composition of the landings now includes more lower priced fish. The "fishing up" (or "down") process in the NWHI appears to have been completed; the question is how the fishery will respond to the changes brought by 10 years of fishing. Catch rates have remained below economically viable levels for most of the vessels participating in the NWHI fishery over the past 3 years, particularly in light of the positive returns in the lobster and longline fisheries. Catch rates in the main Hawaiian Islands are so much lower than the NWHI as to provide no relief for this size of bottomfishing vessel.

It is possible that the low level of activity in 1988 and 1989 will allow the NWHI bottomfish fishery to recover in the sense that fishable concentrations of higher priced species may be found. The limited entry procedures will prevent any potential surplus from being skimmed by vessels from other fisheries, but the operating margins are still slim. Perhaps limited entry is allowing time for better biological and economic assessments of the NWHI bottomfish resources. How this translates into an economically more viable fishery remains to be seen.

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Table 1.--Activity of the bottomfish fleet in the Northwestern Hawaiian Islands, 1984-88. NMFS estimates are based on shoreside monitoring (from Kawamoto and Pooley (1989); BMUS = bottomfish management unit species).

Variable	1984	1985	1986	1987	1988
Vessels (No.)	19	23	24	28	13
Trips (No.)	135.0	160.0	163.0	134.0	93.0
Trips (No.)/vessel	7.11	6.96	6.79	4.79	7.15
Days at sea	--	--	2445	2211	1418
Days fished	--	--	978.0	938.0	651.0
Days/trip	--	--	15	17	15
Days fished/trip	--	--	6	7	7
BMUS (lb) per trip	4,318	4,659	4,803	6,145	5,502
Total catch (lb)/ trip	--	--	5,805	7,303	6,842
BMUS (lb) per fishing day	--	--	800	877	786
Total catch (lb) per fishing day	--	--	967	1,043	977
Revenue (US$)/trip	--	--	13,125	17,462	16,400
Revenue (US$)/vessel	--	--	87,500	83,571	117,324

Table 2.--Entry and exit pattern of bottomfish vessels in the Northwestern Hawaiian Islands, 1984-88 (+ = entry; - = exit; X = continued participation).

Vessel	1984	1985	1986	1987	1988
A	X	X	-	.	.
B	X	-	.	.	.
C	X	-	.	+	-
D	X	-	.	+	-
E	X	X	X	-	.
F	X	X	-	.	.
G	X	X	-	.	.
H	X	X	X	X	-
I	X	X	X	X	-
J	X	X	X	X	X
K	X	X	X	X	-
L	X	X	X	X	X
M	X	X	X	X	X
N	X	X	X	X	X
O	X	X	X	X	-
P	X	X	X	X	X
Q	X	X	X	X	-
R	X	X	X	X	X
S	.	+	X	X	-
T	.	+	X	-	.
U	.	+	X	X	-
V	.	+	X	X	X
W	.	+	X	X	X
X	.	+	X	X	-
Y	.	+	-	+	-
Z	.	.	+	X	X
AA	.	.	+	X	-
BB	.	.	+	-	.
CC	.	.	+	X	-
DD	.	.	+	X	-
EE	.	.	+	-	.
FF	.	.	.	+	X
GG	.	.	.	+	-
HH	.	.	.	+	X
II	.	.	.	+	-
JJ	.	.	.	+	-
KK	.	.	.	.	+
LL	.	.	.	.	+
Participants (No.)	18	22	24	28	13
Entrants	--	+7	+6	+8	+2
No. exiting	--	-3	-4	-4	-17
Net change	--	+4	+2	+4	-15

Table 3.--Average vessel characteristics of 53 bottomfishing vessels holding Federal permits for fishing in the Northwestern Hawaiian Islands in 1987 (data are derived from NMFS permit files).

Variable	Average
Length	60.2 ft
Beam	18.2 ft
Fuel capacity	7,058 gal
Speed	8.5 kn
Range	4,921.0 mi
Engine horsepower	353 hp
Date of construction	1973
Date of purchase	1981
Purchase price	$US278,767.00
Hold capacity	36.4 net tons
Sail power	5 vessels

Table 4.--Average operating characteristics of a sample (N = 7) of bottomfish vessels operating in the Northwestern Hawaiian Islands, 1987, based on NMFS shoreside monitoring. Coefficient of variation is the ratio of the sample's standard deviation to the sample mean. It represents how similar the sample is to the average. (Columns in this table may not total because of unweighted averaging.)

Variable	Average cost (US$)	Coefficient of variation (%)
Operating costs (per day at sea)		
Fuel and oil	123	33.5
Ice	25	54.4
Bait	39	26.3
Handling	123	31.9
Provisions	54	52.2
Maintenance	140	67.8
Supplies	36	80.9
Gear	15	128.2
Other	2	244.9
Labor income	307	43.9
Captain's bonus	43	49.6
Revenue (per day at sea)	1,229	31.9
Operating costs	906	28.4
Net return on operations	322	58.3
Fixed costs (annual)		
Capital	32,544	59.9
Annual repair	15,071	62.3
Vessel insurance	14,500	79.9
Administrative	1,513	74.0
Other	6,219	109.7
Total fixed costs	69,847	42.0

Table 4.--Continued.

Variable	Average cost (US$)	Coefficient of variation (%)
Operating characteristics (annual)		
Investment	285,381	45.8
Trips (No.)	10.29	34.0
Catch (lb) per day	1,140.95	40.1
Trip days	15.02	33.5
Fishing days	6.42	27.4
Crew share (%)	47.3	11.0
Crew (No.)	3.64	12.1
Shared costs	77,766	52.6
Revenue	198,965	63.3
Product price per pound	2.37	16.9
Total catch (lb)	88,460	64.4
Capital factor (%)	8.22	--
Depreciation factor (%)	6.67	--

Table 5.--Annualized average income statement (US$) of bottomfish vessel operating in the Northwestern Hawaiian Islands, 1987.

Revenue		264,672
Fixed costs		64,838
Capital costs	27,404	
Annual repair	15,079	
Vessel insurance	14,508	
Administrative	1,624	
Other	6,223	
Operating costs		193,417
Fuel and oil	28,156	
Ice	2,400	
Bait	3,771	
Handling	26,467	
Provisions	12,323	
Maintenance	32,030	
Supplies	3,518	
Gear	1,485	
Other	371	
Labor income	72,892	
Captain's bonus	10,005	
Total Cost		258,256
Net Revenue		6,416

Operating characteristics

Investment (US$)	285,381	
Trips (No.)	15.23	
Catch (lb) per day	1,140.95	
Trip days	15.02	229
Fishing days	6.42	98
Crew share (%)	47.29%	
Crew (No.)	3.64	
Shared costs (US$)	110,521	
Revenue (US$)	264,672	
Product price (US$) per pound	2.37	
Total catch	111,543	

Table 6.--Revenue and costs (by percentage per fishing day, per pound, and per trip) of the bottomfish fleet operating in the Northwestern Hawaiian Islands, 1987.

Variable	Percent total cost	Cost (US$)		
		Per fishing day	Per pound	Per trip
Revenue	102.48	2,707	2.37	17,379
Fixed costs	25.11	663	.58	4,257
Capital costs	10.61	280	.25	1,799
Annual repair	5.84	154	.14	990
Vessel insurance	5.62	148	.13	953
Administrative	.63	17	.01	107
Loan costs	2.41	64	.06	409
Operating costs	74.89	1,978	1.73	12,700
Fuel and oil	10.90	288	.25	1,849
Ice	.93	25	.02	158
Bait	1.46	39	.03	248
Handling	10.25	271	.24	1,738
Provisions	4.77	126	.11	809
Maintenance	12.40	328	.29	2,103
Supplies	1.36	36	.03	231
Gear	.57	15	.01	97
Other	.14	4	.00	24
Crew share	28.22	746	.65	4,786
Captain's bonus	3.87	102	.09	657
Total cost	100.00	2,642	2.32	16,958
Net revenue	2.48	66	0.06	421

Table 7.--Sensitivity analysis of net revenue and total cost to income statement parameters for the bottomfish fleet operating in the Northwestern Hawaiian Islands, 1987.

Variable to change (increase 10%)	Effect on	
	Net revenue (%)	Total cost (including labor) (%)
Fixed costs	-99	+2.5
Capital factor	-36	+1
Operating costs (excluding labor)	-61	+1.5
Fuel prices	-20	+0.5
Labor share	-129	+3
Trips	+90	+8
Days at sea	-61	+1.5
Fishing days	+312	+14
Catch per trip	+151	+6.5
Price per pound	+151	+6.5

Table 8.--Estimated income of the bottomfish fleet operating in the Northwestern Hawaiian Islands, 1986-88. Values projected from 1987 baseline. Costs adjusted for inflation. "FTE vessels" equal the number of full-time equivalent vessels required to harvest the total reported landings.

Category	Estimated income (US$) per year		
	1986	1987	1988
FTE vessels (No.)	9.8	10.0	6.1
Net returns per vessel	-19,250	-8,200	-6,800
Fleet-wide values			
Total revenue	1,900,000	2,300,000	1,500,000
Fixed costs	610,000	650,000	410,000
Operating costs (less labor)	985,000	1,075,000	700,000
Labor costs (includes captain's bonus	490,000	660,000	430,000
Total costs	2,100,000	2,385,000	1,540,000
Net revenue (US$)	-185,000	-85,000	-40,000
Total income (includes labor)	305,000	575,000	390,000

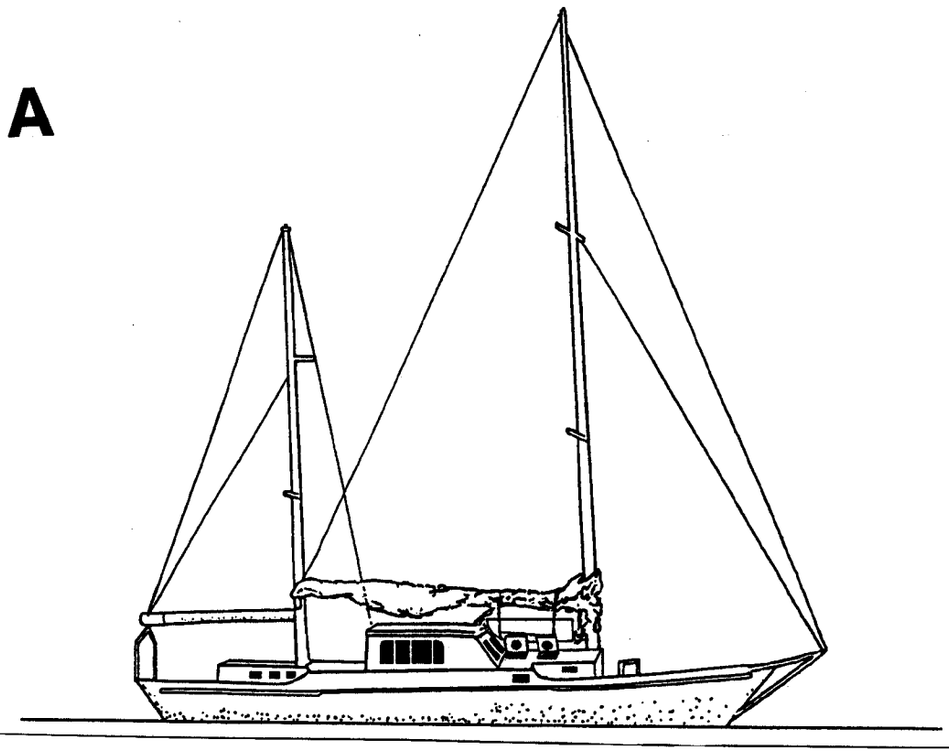

Figure 1.--Typical bottomfishing vessels in the Northwestern Hawaiian Islands: (A) A motor sailer (length, 46-66 ft; width, 15-18 ft).

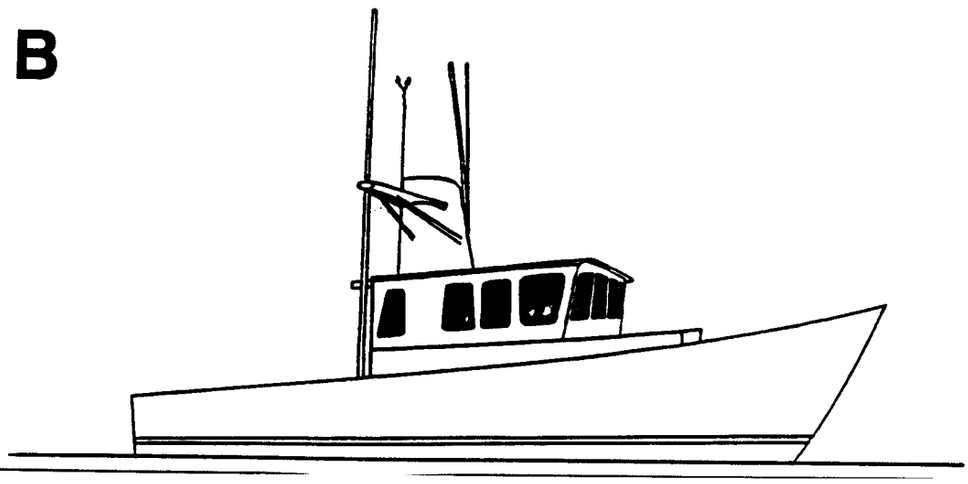

Figure 1.--Continued. (B) A medium-sized powered vessel (length, 42-49 ft; width, 12-17 ft).

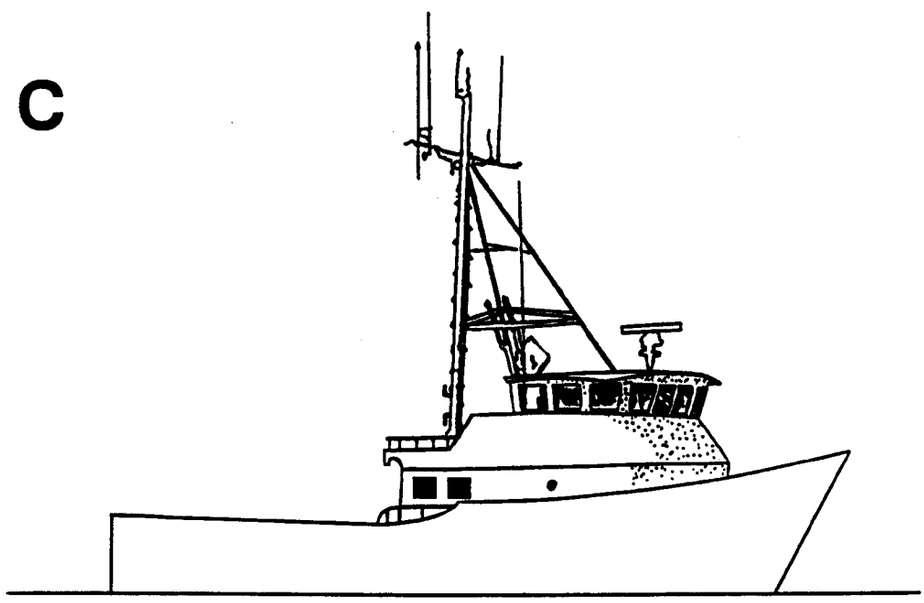

Figure 1.--Continued. (C) A large-sized powered vessel (length, 47-64 ft; width, 16-18 ft).

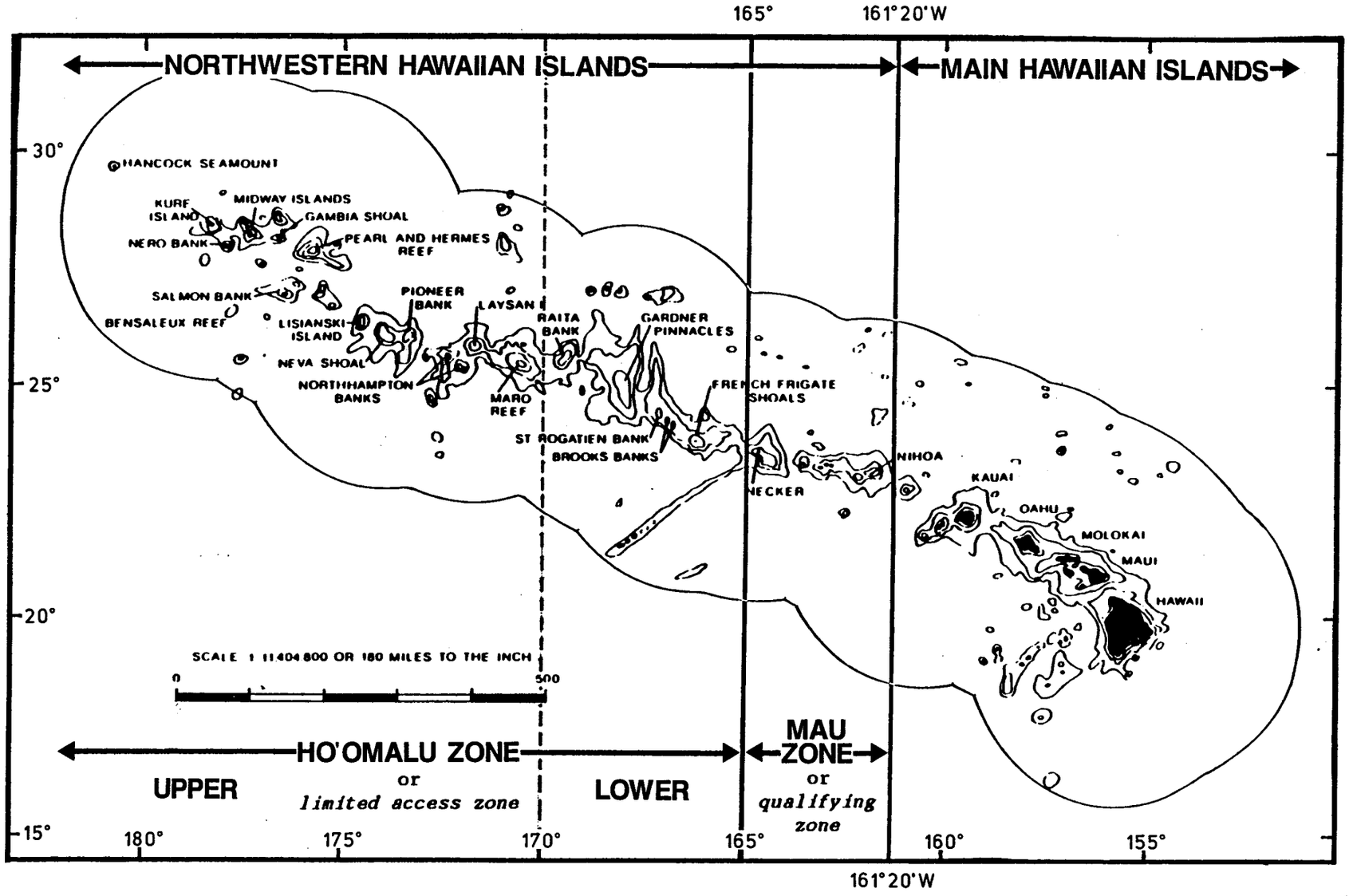

Figure 2.--Map of the Northwestern Hawaiian Islands.