Southwest Fisheries Center Administrative Report H-88-6

COMPARISON OF THREE CALCULATIONS OF CATCH RATES OF THE LOBSTER FISHERY IN THE NORTHWESTERN HAWAIIAN ISLANDS

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April 1988

NOT FOR PUBLICATION

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INTRODUCTION

During the last 5 yr, the fishery for spiny lobster, *Panulirus marginatus*, and slipper lobster, *Scyllarides squammosus*, in the Northwestern Hawaiian Islands (NWHI) has expanded into one of Hawaii's most important commercial fisheries. Approximately 440 metric tons (t) of lobsters were landed in 1987, generating approximately $4 million in ex-vessel revenue. The spiny lobster has historically been the predominant target species; however, during the past 3 yr, the slipper lobster has emerged from being an incidentally caught species to nearly equaling the total number of spiny lobsters caught. The fishery is managed by guidelines set forth in the Crustacean Fishery Management Plan for the western Pacific, as developed by the Western Pacific Regional Fishery Management Council.

For the lobster fishery in the NWHI, the Southwest Fisheries Center Honolulu Laboratory of the National Marine Fisheries Service (NMFS) prepares monthly and annual summary reports that are based on information recorded in the catch logs (Daily Lobster Catch Report per Statistical Area, Fig. 1). These logs are completed by vessel operators after each day of fishing; they document the catches (in numbers) of legal-sized (>50-mm tail width), sublegal-sized, and berried spiny lobsters. Vessel operators also reported the total number of slipper lobsters caught and the number of traps set and hauled each day. (Note that prior to 14 January 1988, there was no definition for sublegal-sized slipper lobsters in Federal waters.) These cumulative data on catch numbers and catch per unit effort (CPUE) are used by various managing agencies as well as scientific and commercial interests for determination of relative stock abundance and as general indicators of the status of the fishery. Accurate interpretation of these statistics is of obvious importance, as is the proper understanding of the problems and limitations of the data.

This report describes how CPUE was determined by the NMFS Honolulu Laboratory prior to 1988, then examines and compares two alternative methods of calculating CPUE. The effects of multiple trap-nights (i.e., allowing a trap to soak for two or more consecutive nights) on the CPUE statistics and on the catch of the two target species also are examined. The limitations and possible implications of using each of the different methods of CPUE calculation are discussed, and recommendations for changes in the present reporting system are presented.

BACKGROUND

At present, the unit of effort used to calculate CPUE in the lobster fishery is trap-night. Catch per trap-night is calculated by dividing the reported catch (in numbers) by the number of trap-hauls, adjusted for multiple trap-nights. Traps are normally set 1 d, allowed to soak overnight, and then hauled the next day. Therefore, the reported catch for each species is divided by the total number of trap-hauls for that particular day. To adjust for multiple trap-nights, the reported catch is

divided by the number of trap-hauls multiplied by the number of nights on the bottom:

$$\text{Trap-night CPUE} = \frac{\text{Catch}}{\text{Trap-hauls X No. of nights on bottom}} \qquad (1)$$

Inherent in this method of calculating trap-night CPUE is the assumption that catch is proportional to soak time. However, catch logs and conversations with active fishermen indicate this assumption may be invalid. Several factors reportedly affect catch rates with regard to extended soak time, including bait type and quantity; type, number, and size of lobsters in the trap after the first night; placement of trap; and sea conditions.

The relationship between lobster catch and multiple trap-nights has not been explored by the NMFS for a variety of reasons. One reason is the occurrence of traps soaking more than one night has not been well documented in commercial logs nor has its effects on catch and effort. Another reason is that testing for extended soak time effects on catch rates requires a large sample size to eliminate the substantial variation found in catch rates. This research would require a great deal of time aboard a research vessel or a commercial charter--a requirement that is prohibitively expensive. Finally, the relative importance or contribution of multiple trap-nights was not considered a significant factor in the fishery.

METHODS

Two alternative methods for determining CPUE were used. The first method expresses CPUE as catch per single trap-night, which uses only those lobsters caught from single trap-nights and, therefore, uses only a subset of the total data set:

$$\text{Single trap-night CPUE} = \frac{\text{Single trap-night catch}}{\text{No. of single trap-night trap-hauls}} \qquad (2)$$

The second alternative method calculates catch per trap-haul, regardless of soak time. Thus, it uses the entire data base for lobster catches but disregards information on soak time:

$$\text{Trap-haul CPUE} = \frac{\text{Catch}}{\text{No. of trap-hauls}} \qquad (3)$$

The data used in the single trap-night CPUE calculations were compared to the present CPUE statistics (trap-night CPUE) to determine how much information was excluded and to determine the occurrence of multiple trap-nights. The latter was examined to determine whether the incidence of multiple trap-nights was seasonal or year round and could be corrected. This comparison could not be performed on the trap-haul CPUE method, which uses all the reported lobster catches.

The entire data base was further checked for evidence of relative effects on total catch of spiny and slipper lobsters due to multiple trap-nights, to determine whether the catch rates differed significantly between the two target species.

RESULTS

Catch Per Unit Effort

The trap-night CPUE calculations for 1983-86 are reported in Clarke et al. (1987) and are not repeated here. Catch per trap-night for 1987, by bank and by landing month, is in Tables 1 and 2. For 1983-87, the CPUE using single trap-night CPUE and trap-haul CPUE was calculated by bank and by month, except the 1983 data (April-December) were combined because of confidentiality reasons (Tables 3-6). Months in which less than three vessels landed lobsters, or areas in which less than three vessels fished in a particular year, are not reported for confidentiality reasons.

If a single trap-night is used as the unit of effort to calculate CPUE, the numbers of lobsters reportedly caught are equal to or are less than those calculated by the current system (trap-night CPUE) or by trap-haul CPUE. The differences between trap-night CPUE and single trap-night CPUE are presented in Table 7 for 1983-87. Figure 2 shows that the incidence of multiple trap-nights increases during winter and spring but is relatively low during summer and fall. In some months (e.g., May 1987), up to 86% of the trap-nights reported were multiple trap-nights, but during the summer (July and August), the single trap-nights constituted the overriding majority of the effort.

Effects of Soak Time

Between April 1983 and December 1987, 213 trips had been logged by fishermen permitted to trap in the NWHI lobster fishery. In three different instances, vessels kept a close count of the number of traps set, the length of the set, and the number of spiny and slipper lobsters that were captured in the different traps. Three vessels logged the results of their fishing activities during the spring, summer, fall, and winter of 1985. Four banks were fished (Maro Reef, Necker Island, Gardner Pinnacles, and St. Rogatien Bank), with three trips reporting catches from more than one bank. All vessels recorded the number of legal, sublegal, and berried spiny lobsters caught and the total number of slipper lobsters caught. The data are believed to be of good quality and accurately recorded.

During these three trips, two trap-nights occurred on 48 d out of 141 total fishing days. On 10 of those 48 d, the vessels hauled gear that had soaked for one, two, and three consecutive nights. During those 48 d, a total of 41,898 traps were hauled and 122,985 lobsters were caught. Of the lobsters caught, 37.2% were slipper lobsters and 62.8% were spiny lobsters. Catch rates varied substantially (catch rates calculated as catch per number of traps hauled), between 0.26 and 26.83 total spiny lobsters per trap and 0.23 and 16.74 total slipper lobsters per trap. The single trap-night hauls (N = 28,200) caught 48,260 total spiny lobsters and 33,801 total slipper lobsters. The two trap-night hauls (N = 12,882) caught 26,138 total spiny lobsters and 11,161 total slipper lobsters. The three trap-night hauls (N = 816) caught 2,874 total spiny and 715 total slipper lobsters.

To compare the effects of soak time on catch, catch per trap-haul for total spiny lobsters and total slipper lobsters for each trip was calculated for one, two, and three night catches. The single trap-night CPUE was then divided by the two and three trap-night CPUE for each species to determine whether differences occurred. The relative catch for both species, by soak time (in nights), is in Figure 3.

Although catch rates appeared to vary with increasing soak time, the initial results confirmed that catch was not proportional to soak time. This same subset of data was then used to test for any significant difference in CPUE of total spiny lobsters, total slipper lobsters, or the two species combined. Unfortunately, the three trap-night data were inadequate for this analysis, so only single trap-nights and two trap-nights were tested. In addition to testing soak time, we tested for differences by bank and an interaction factor by a two-way analysis of variance (ANOVA) with unequal replication. The results also indicate that there is no significant difference ($P > 0.05$) in CPUE between single and two trap-nights for either species; however, differences in CPUE's between banks are highly significant ($P = 0.001$) (Table 8). The results indicate that, although the effect of soak time on catch rates for spiny lobsters is not significant at the 0.05 level, it is significant at the 0.10 level.

DISCUSSION

Determination of the effect of multiple trap-nights on catch by using commercial lobster data is complicated by four factors. First, the occurrence of multiple trap-nights is apparently year round but has peaks in certain seasons (Fig. 2). The high occurrence of multiple trap-nights coincides with periods of poor weather conditions during winter and spring. However, if the weather is good, then the incidence of multiple trap-nights drops substantially (Fig. 2, e.g., May 1985 vs. May 1987). Multiple trap-nights generally appear to be a direct result of poor weather conditions and, therefore, prove difficult to anticipate or correct. Second, because of the way trap hauls are reported in the daily logs, effort is inferred. For example, if a vessel reports setting 500 traps on day 1, hauling 300 traps and resetting 300 traps on day 2, then hauling all 500 traps on day 3, then it is assumed that, for day 3, the reported catch would be divided by

700 trap-nights (300 + (200 X 2)). This method is standard procedure unless the vessel skipper indicates that traps were not hauled in the sequence set (i.e., if the traps were not hauled in sequence, the vessel's fishing logs are examined, if permission is given by the vessel operator, so that soak time can be determined). Third, catch is reported in total number caught; therefore, it is impossible to know the proportion of the total catch from single trap-nights, from two trap-nights, and so on. Lastly, there is no indication of the targeting practices of the fishermen. Logbook data do not include any trap line information (traps are set in lines or "strings" of 25 to 250 traps per line) or depth of fishing.

In lieu of information on the number of strings set, depth of fishing, and targeting practices, the results of the analysis on catch per night of soak indicate that the present system employed to calculate CPUE probably overestimates effective effort in the NWHI lobster fishery. While this analysis only concentrates on one and two trap-night CPUE's, it does show that, by multiplying the number of trap-hauls by soak time (in nights), effort is overestimated and CPUE is underestimated. Of the average number of trap-nights reported annually from March 1983 to December 1987, 13.4% were two trap-nights and 3.4% were three trap-nights.

Using only single trap-nights to calculate CPUE has two major drawbacks. First, a large percentage of the trapping effort includes multiple trap-nights during certain times of the year and would be eliminated from the CPUE calculation. Second, using data from only single trap-nights represents the best possible scenario (i.e., the vessel hauls all the gear it sets and is not affected by weather, breakdown, or any other anomalies in fishing operations) and, therefore, does not accurately portray what actually occurs.

Based upon the comparison of the three methods reviewed in this study, catch per trap-haul appears to be the most accurate measure of CPUE. This result is further supported by the trip data on catch per night of soak: Catch does not significantly increase if the traps are allowed to soak for more than one night. Although the data used from the three commercial trips have shortcomings, they also have significant strengths, such as the large numbers of lobsters caught and of trap-hauls, which are not possible to obtain in certain situations (research cruises). These data, however, are limited to discerning trends in CPUE after only two trap-nights. If one assumes that bait attractiveness is reduced with time, then the catch rate of the trap should not increase after the second night, all other factors being equal. The catch per trap-haul system lacks some of the bias found in the single trap-night method (exclusion of multiple trap-nights) but still includes the data from trap-hauls in which catch rates may be reduced because of poor operational or weather conditions.

No one system of calculating CPUE is a definitive indicator of the biological and operational state of the NWHI lobster fishery, but catch per trap-haul appears to be the best alternative of those reviewed here. From an operational standpoint, catch per trap-haul more accurately reflects the activities of fishing vessels and fishermen than either of the other methods reviewed. Biologically, catch per trap-haul also appears acceptable.

Catch per trap-haul was established as the basic measure of effort in analysis of the NWHI lobster fishery beginning in January 1988, coincident with the enactment of other significant changes (e.g., slipper lobster minimum size, escape vents, and reporting changes) in the Crustacean Fishery Management Plan.

REFERENCE

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 Fisheries Center Admin. Rep. H-87-6, 47 p.

Table 1.--Catch (in numbers) and catch per trap-night (catch per unit effort (CPUE)), by area fished, for the lobster fishery in the Northwestern Hawaiian Islands, 1987. For explanation of CPUE calculation, see Equation (1) in text.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Necker Island	49	32,403	3,820	0.12	112	0.00	1,452	0.05	5,384	0.17	6,936	0.22
Nihoa	318	223,406	99,516	0.45	91,030	0.41	27,046	0.12	217,592	0.97	85,272	0.38
French Frigate Shoals	62	45,618	14,733	0.32	24,805	0.54	11,104	0.24	50,642	1.11	16,309	0.36
St. Rogatien Bank	117	68,547	24,269	0.35	7,101	0.10	3,615	0.05	34,985	0.51	15,115	0.22
Gardner Pinnacles	156	122,029	34,689	0.28	17,787	0.15	10,291	0.08	62,767	0.51	56,903	0.47
Raita Bank	48	36,590	5,943	0.16	605	0.02	684	0.02	7,232	0.20	13,753	0.38
Maro Reef	348	271,869	183,415	0.67	87,817	0.32	44,920	0.17	316,152	1.16	178,556	0.66
Total[a]	1,217	902,460	394,556	0.44	234,173	0.26	101,560	0.11	730,286	0.81	476,568	0.53

[a]Total includes banks fished by less than three vessels.

Table 2.--Catch (in numbers) and catch per trap-night (catch per unit effort (CPUE)), by month of landing, for the lobster fishery in the Northwestern Hawaiian Islands, 1987. For explanation of CPUE calculation, see Equation (1) in text.

Date 1987	Areas fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
Jan.[a]												
Feb.[a]												
Mar.	4	110,418	50,010	0.45	20,286	0.18	4,565	0.04	74,862	0.68	54,115	0.49
Apr.[a]												
May	5	38,823	2,172	0.06	5,570	0.14	1,537	0.04	9,279	0.24	14,386	0.37
June	5	111,040	28,449	0.26	20,618	0.19	11,731	0.11	60,798	0.55	56,504	0.51
July	3	46,087	23,592	0.51	12,357	0.27	5,829	0.13	41,778	0.91	13,055	0.28
Aug.	8	158,913	123,805	0.78	56,556	0.36	37,071	0.23	217,432	1.37	127,289	0.80
Sept.[a]												
Oct.	7	78,625	37,831	0.48	12,045	0.15	8,309	0.11	58,182	0.74	26,726	0.34
Nov.[a]												
Dec.	8	196,590	58,817	0.30	58,641	0.30	15,224	0.08	132,682	0.67	117,733	0.60
Total	12	902,460	394,556	0.44	234,173	0.26	101,560	0.11	730,286	0.81	476,568	0.53

[a]Confidential information.

Table 3.--Catch (in numbers) and catch per single trap night (catch per unit effort ((CPUE), by bank, for the lobster fishery in the Northwestern Hawaiian Islands, 1983-87. For explanation of CPUE calculation, see Equation (2) in text.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
1983												
Necker Island	176	36,526	97,260	2.66	45,903	1.26	7,771	0.21	150,934	4.13	11,969	0.33
Total[a]	203	45,666	116,504	2.55	46,576	1.02	8,433	0.18	171,513	3.76	17,455	0.38
1984												
Nihoa	70	20,871	23,335	1.12	1,423	0.07	10,904	0.52	35,662	1.71	12,737	0.61
Necker Island	277	87,387	196,865	2.25	200,610	2.30	38,211	0.44	435,686	4.99	71,810	0.82
Gardner Pinnacles	165	83,997	151,682	1.81	8,199	0.10	4,551	0.05	164,432	1.96	91,945	1.09
Maro Reef	227	128,223	231,847	1.81	18,831	0.15	14,561	0.11	265,239	2.07	78,676	0.61
Total[a]	751	327,346	610,383	1.86	229,230	0.70	68,321	0.21	907,934	2.77	256,341	0.78

Table 3.--Continued.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1985							
Nihoa	23	9,780	6,594	0.67	436	0.04	618	0.06	7,648	0.78	5,765	0.59
Necker Island	383	160,947	163,734	1.02	195,098	1.21	29,953	0.19	388,785	2.42	137,216	0.85
French Frigate Shoals	26	12,316	9,411	0.76	2,326	0.19	1,121	0.09	12,858	1.04	5,182	0.42
Brooks Banks	40	30,428	21,486	0.71	5,669	0.19	4,865	0.16	32,020	1.05	55,843	1.84
St. Rogatien Bank	194	160,545	182,553	1.14	38,827	0.24	30,909	0.19	252,289	1.57	133,717	0.83
Gardner Pinnacles	206	123,451	79,371	0.64	12,460	0.10	8,744	0.07	100,575	0.81	184,024	1.49

Table 3.--Continued.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1985 (continued)							
Raita Bank	25	9,452	9,304	0.98	570	0.06	270	0.03	10,144	1.07	4,526	0.48
Maro Reef	329	241,687	266,596	1.10	38,364	0.16	32,934	0.14	337,894	1.40	406,823	1.68
Lisianski Island	3	1,265	36	0.03	10	0.01	14	0.01	60	0.05	840	0.66
Pearl and Hermes Reef	63	28,975	25,245	0.87	6,022	0.21	2,045	0.07	33,312	1.15	31,910	1.10
Kure Atoll	23	13,328	12,447	0.93	993	0.07	1,861	0.14	15,301	1.15	6,828	0.51
Total[a]	1,352	801,162	777,494	0.97	300,901	0.38	113,536	0.14	1,191,931	1.49	974,357	1.22

Table 3.--Continued.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1986							
Nihoa	62	25,252	4,405	0.17	235	0.01	3,412	0.14	8,052	0.32	25,316	1.00
Necker Island	285	152,634	122,939	0.81	89,303	0.59	27,649	0.18	239,891	1.57	65,018	0.43
French Frigate Shoals	81	51,040	58,234	1.14	23,440	0.46	12,086	0.24	93,760	1.84	19,811	0.39
Brooks Banks	122	70,401	26,472	0.38	4,350	0.06	1,949	0.03	32,771	0.47	106,590	1.51
St. Rogatien Bank	173	133,396	115,139	0.86	21,017	0.16	9,372	0.07	145,528	1.09	87,615	0.66
Gardner Pinnacles	200	148,858	78,305	0.53	14,308	0.10	12,983	0.09	105,556	0.71	80,898	0.54
Raita Bank	206	100,569	47,020	0.47	4,835	0.05	5,032	0.05	56,887	0.57	75,185	0.75
Maro Reef	577	414,908	327,839	0.79	95,786	0.23	60,078	0.14	483,703	1.17	419,968	1.01
Lisianski Island	20	14,828	1,827	0.12	93	0.01	170	0.01	2,090	0.14	26,212	1.77
Total[a]	1,847	1,199,965	797,133	0.66	256,186	0.21	134,550	0.11	1,187,829	0.99	1,127,076	0.94

Table 3.--Continued.

Area	Days fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1987						
Nihoa	34	14,569	1,999	0.14	15	0.00	745	0.05	2,759	0.19	4,494	0.31
Necker Island	256	158,466	86,436	0.55	77,718	0.49	24,271	0.15	188,425	1.19	74,593	0.47
French Frigate Shoals	51	34,480	12,973	0.38	18,972	0.55	10,589	0.31	42,534	1.23	14,069	0.41
St. Rogatien Bank	110	63,222	22,465	0.36	6,752	0.11	3,441	0.05	32,658	0.52	14,377	0.23
Gardner Pinnacles	119	84,280	27,369	0.32	15,333	0.18	8,833	0.10	51,535	0.61	47,953	0.57
Raita Banka	29	20,050	4,789	0.24	496	0.02	531	0.03	5,816	0.29	10,307	0.51
Maro Reef	273	203,577	156,416	0.77	75,818	0.37	37,943	0.19	270,177	1.33	154,559	0.76
Total[a]	975	665,422	339,533	0.51	199,730	0.30	88,603	0.13	627,863	0.94	416,366	0.63

[a]Total includes banks fished by less than three vessels.

Table 4.--Catch (in numbers) and catch per single trap-night (catch per unit effort (CPUE)), by month of landing, for the lobster fishery in the Northwestern Hawaiian Islands, 1983-87. For explanation of CPUE calculation, see Equation (2) in text.

Date	Areas fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1983							
Total	3	45,666	116,504	2.55	46,576	1.02	8,433	0.18	171,513	3.76	17,455	0.38
					1984							
Jan.[a] Feb.[b]												
Mar.	3	12,288	36,702	2.99	17,075	1.39	2,474	0.20	56,251	4.58	41,935	1.22
Apr.	4	46,653	84,794	1.82	7,584	0.16	6,972	0.15	99,350	2.13	34,631	0.74
May[a] June[b]												
July	2	10,090	9,669	0.96	442	0.04	6,317	0.63	16,428	1.63	3,546	0.35
Aug.	5	59,266	136,152	2.30	45,455	0.77	10,185	0.17	191,792	3.24	29,230	0.49
Sept. Oct.[b]	2	14,181	28,525	2.01	41,150	2.90	2,754	0.19	72,429	5.11	14,699	1.04
Nov.	4	42,981	75,568	1.76	25,597	0.60	5,487	0.13	106,652	2.48	41,926	0.98
Dec.	6	102,004	165,178	1.62	57,234	0.56	24,667	0.24	247,079	2.42	93,558	0.92
Total	7	327,346	610,383	1.86	229,230	0.70	68,321	0.21	907,934	2.77	256,341	0.78

Table 4.--Continued.

Date	Areas fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1985						
Jan.	3	12,196	11,656	0.96	2,687	0.22	1,262	0.10	15,605	1.28	4,186	0.34
Feb.	3	18,395	17,483	0.95	25,485	1.39	4,371	0.24	47,339	2.57	15,636	0.85
Mar.	6	22,462	22,210	0.99	24,877	1.11	3,329	0.15	50,416	2.24	25,180	1.12
Apr.	9	99,235	47,020	0.47	14,325	0.14	3,886	0.04	65,231	0.66	177,146	1.79
May	9	37,832	22,168	0.59	26,277	0.69	3,661	0.10	52,106	1.38	68,626	1.81
June	5	103,554	85,581	0.83	35,451	0.34	13,002	0.13	134,034	1.29	286,143	2.76
July	4	90,863	108,280	1.19	16,696	0.18	15,664	0.17	140,640	1.55	92,295	1.02
Aug.	10	88,468	97,271	1.10	37,804	0.43	16,526	0.19	151,601	1.71	59,402	0.67
Sept.	9	34,645	51,219	1.48	30,300	0.87	8,685	0.25	90,204	2.60	13,939	0.40
Oct.-Nov.[b]	9	158,319	188,373	1.19	44,457	0.28	31,194	0.20	264,024	1.67	130,156	0.82
Dec.	8	107,440	95,232	0.89	38,181	0.36	9,488	0.09	142,901	1.33	78,988	0.74
Total	18	801,162	777,494	0.97	300,901	0.38	113,536	0.14	1,191,931	1.49	974,357	1.22

Table 4.--Continued.

Date	Areas fished (No.)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1986						
Jan.	6	97,406	86,562	0.89	32,247	0.33	6,488	0.07	125,297	1.29	69,338	0.71
Feb.	6	13,478	4,377	0.32	4,133	0.31	863	0.06	9,373	0.70	19,150	1.42
Mar.	3	17,250	15,896	0.92	10,487	0.61	2,965	0.17	29,348	1.70	8,513	0.49
Apr.	11	144,734	85,215	0.59	33,729	0.23	11,640	0.08	130,584	0.90	204,672	1.41
May	4	47,926	12,991	0.27	13,300	0.28	4,389	0.09	30,680	0.64	48,852	1.02
June	6	84,974	27,382	0.32	12,310	0.14	7,538	0.09	47,230	0.56	124,426	1.46
July	12	151,615	63,655	0.42	9,408	0.06	18,633	0.12	91,696	0.60	256,288	1.69
Aug.	8	149,255	100,881	0.68	17,662	0.12	14,329	0.10	132,872	0.89	112,164	0.75
Sept.	3	86,695	109,311	1.26	26,580	0.31	14,561	0.17	150,452	1.74	33,382	0.39
Oct.	3	70,591	46,013	0.65	16,741	0.24	13,906	0.20	76,660	1.09	36,359	0.52
Nov.	3	218,311	184,808	0.85	50,653	0.23	22,437	0.10	257,858	1.18	153,480	0.70
Dec.	8	117,730	60,042	0.51	28,936	0.25	16,801	0.14	105,779	0.90	60,452	0.51
Total	19	1,199,965	797,133	0.66	256,186	0.21	134,550	0.11	118,829	0.99	1,127,076	0.94

Table 4.-Continued.

Date	Areas fished (No)	Trap-night (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1987						
Jan.[b]												
Feb.[b]												
Mar.	4	88,263	45,330	0.51	18,264	0.21	4,101	0.05	67,695	0.77	49,009	0.56
Apr.[b]												
May	2	5,453	1,488	0.27	4,301	0.79	1,118	0.21	6,907	1.27	2,271	0.42
June	5	96,550	25,719	0.27	18,331	0.19	10,755	0.11	54,805	0.57	50,296	0.52
July	3	45,187	23,380	0.52	11,843	0.26	5,496	0.12	40,719	0.90	12,872	0.28
Aug.	8	110,623	104,967	0.95	50,583	0.46	32,498	0.29	188,048	1.70	110,841	1.00
Sept.[b]												
Oct.	7	65,820	34,087	0.52	10,440	0.16	7,142	0.11	51,666	0.78	24,766	0.38
Nov.[b]												
Dec.	8	142,140	45,339	0.32	47,732	0.34	12,545	0.09	105,616	0.74	107,544	0.76
Total	12	665,422	339,533	0.51	199,730	0.30	88,603	0.13	627,863	0.94	416,366	0.63

[a]No landings.
[b]Confidential data.

Table 5.--Catch (in numbers) and catch per trap-haul (catch per unit effort (CPUE)), by bank, for the lobster fishery in the Northwestern Hawaiian Islands, 1983-87. For explanation of CPUE calculation, see Equation (3) in text.

Area	Days fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
1983												
Necker Island	215	42,004	111,710	2.66	48,148	1.15	8,710	0.21	168,568	4.01	13,731	0.33
Total[a]	279	63,653	157,606	2.48	50,780	0.80	9,712	0.15	218,098	3.43	25,609	0.40
1984												
Nihoa	73	21,801	24,174	1.11	1,531	0.07	11,213	0.51	36,918	1.69	12,993	0.60
Necker Island	294	94,423	210,494	2.23	206,919	2.19	40,765	0.43	458,178	4.85	77,401	0.82
Gardner Pinnacles	192	98,770	174,274	1.76	9,059	0.09	5,836	0.06	189,169	1.92	109,264	1.11
Maro Reef	247	139,531	250,489	1.80	20,789	0.15	16,329	0.12	287,607	2.06	83,855	0.60
Total[a]	822	363,003	667,292	1.84	238,479	0.66	74,251	0.20	980,022	2.70	284,815	0.78

Table 5.--Continued.

Area	Days fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1985						
Necker Island	435	185,118	185,654	1.00	212,970	1.15	32,440	0.18	431,064	2.33	154,464	0.83
French Frigate Shoals	28	13,087	10,011	0.76	2,462	1.19	1,172	0.09	13,645	1.04	5,306	0.41
Brooks Banks	40	30,428	21,486	0.71	5,669	0.19	4,865	0.16	32,020	1.05	55,843	1.84
St. Rogatien Bank	213	176,370	200,054	1.13	42,308	0.24	33,954	0.19	276,316	1.57	161,030	0.91
Gardner Pinnacles	245	145,336	96,484	0.66	15,354	0.11	10,289	0.07	122,127	0.84	212,528	1.46
Raita Bank	28	10,448	9,583	0.92	644	0.06	295	0.03	10,522	1.01	5,468	0.52

Table 5.--Continued.

Area	Days fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1985 (continued)							
Maro Reef	467	331,008	359,949	1.09	53,874	0.16	41,200	0.12	455,023	1.37	538,288	1.63
Lisianski Island	3	1,265	36	0.03	10	0.01	14	0.01	60	0.05	840	0.66
Pearl and Hermes Reef	104	53,712	49,960	0.93	9,659	0.18	2,252	0.04	61,871	1.15	40,466	0.75
Kure Atoll	25	15,378	14,159	0.92	1,057	0.07	2,021	0.13	17,237	1.12	7,396	0.48
Total[a]	1,653	983,018	956,042	0.97	344,611	0.35	129,403	0.13	1,430,056	1.45	1,189,842	1.21

Table 5.--Continued.

Area	Days fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1986							
Nihoa	70	28,138	5,272	0.19	246	0.01	3,902	0.14	9,420	0.33	29,131	1.04
Necker Island	405	210,831	173,785	0.82	119,252	0.57	38,973	0.18	332,010	1.57	84,382	0.40
French Frigate Shoals	99	61,368	66,640	1.09	30,711	0.50	13,519	0.22	110,870	1.81	23,681	0.39
Brooks Banks	131	75,326	27,472	0.36	4,650	0.06	2,004	0.03	34,126	0.45	113,036	1.50
St. Rogatien Bank	179	137,190	117,156	0.85	21,469	0.16	9,441	0.07	148,066	1.08	90,596	0.66
Gardner Pinnacles	233	168,790	86,556	0.51	16,209	0.10	14,183	0.08	116,908	0.69	94,002	0.56
Raita Banka	225	180,267	52,039	0.48	6,430	0.06	5,572	0.05	64,041	0.59	78,948	0.73
Maro Reef	670	458,559	350,234	0.76	104,886	0.23	65,583	0.14	520,703	1.14	476,671	1.04
Lisianski Island	20	14,828	1,827	0.12	93	0.01	170	0.01	2,090	0.14	26,212	1.77
Total[a]	2,166	1,352,559	896,407	0.66	307,864	0.23	155,564	0.12	1,359,795	1.01	1,237,527	0.91

Table 5.--Continued.

Area	Days fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
					1987							
Nihoa	49	23,323	3,820	0.16	112	0.00	1,452	0.06	5,384	0.23	6,936	0.30
Necker Island	318	188,823	99,516	0.53	91,030	0.48	27,046	0.14	217,592	1.15	85,272	0.45
French Frigate Shoals	62	42,045	14,733	0.35	24,805	0.59	11,104	0.26	50,642	1.20	16,309	0.39
St. Rogatien Bank	117	66,602	24,269	0.36	7,101	0.11	3,615	0.05	34,985	0.53	15,115	0.23
Gardner Pinnacles	156	105,130	34,689	0.33	17,787	0.17	10,291	0.10	62,767	0.60	56,903	0.54
Raita Bank	48	29,950	5,943	0.20	605	0.02	684	0.02	7,232	0.24	13,753	0.46
Maro Reef	348	251,970	183,415	0.73	87,817	0.35	44,920	0.18	316,152	1.25	178,556	0.71
Total[a]	1,217	804,711	394,556	0.49	234,173	0.29	101,560	0.13	730,286	0.91	476,568	0.59

[a]Total includes banks fished by less than three vessels.

Table 6.--Catch (in numbers) and catch per trap-haul (catch per unit effort (CPUE)), by month of landing, for the lobster fishery in the Northwestern Hawaiian Islands, 1983-87. For explanation of CPUE calculation, see Equation (3) in text.

Date	Areas fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1983						
Total	3	63,653	157,606	2.48	50,780	0.80	9,712	0.15	218,098	3.43	25,609	0.40
						1984						
Jan.[a]												
Feb.[b]												
Mar.	3	13,598	40,047	2.95	17,824	1.31	2,676	0.20	60,547	4.45	15,999	1.18
Apr.	4	52,706	95,206	1.81	8,694	0.16	7,748	0.15	111,648	2.12	39,756	0.75
May[a]												
June[b]												
July	2	10,090	9,669	0.96	442	0.04	6,317	0.63	16,428	1.63	3,546	0.35
Aug.	5	66,035	152,085	2.30	47,221	0.72	11,488	0.17	210,794	3.19	33,261	0.50
Sept.	2	14,181	28,525	2.01	41,150	2.90	2,754	0.19	72,429	5.11	14,699	1.04
Oct.[b]												
Nov.	4	42,981	75,568	1.76	25,597	0.60	5,487	0.13	106,652	2.48	41,926	0.98
Dec.	6	121,279	189,713	1.56	62,814	0.52	28,249	0.23	280,776	2.32	111,217	0.92
Total	7	363,003	667,292	1.84	238,479	0.66	74,251	0.20	980,022	2.70	284,815	0.78

Table 6.--Continued.

Date	Areas fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1985						
Jan.	3	16,278	14,497	0.89	4,226	0.26	1,561	0.10	20,284	1.25	5,610	0.34
Feb.	3	22,911	21,034	0.92	28,297	1.24	4,757	0.21	54,088	2.36	17,929	0.78
Mar.	6	45,612	44,234	0.97	30,152	0.66	4,066	0.09	78,452	1.72	48,081	1.05
Apr.	10	118,454	57,345	0.48	16,895	0.14	4,333	0.04	78,573	0.66	199,932	1.69
May	9	47,891	30,811	0.64	27,918	0.58	4,872	0.10	63,601	1.33	95,392	1.99
June	5	115,073	88,386	0.77	36,350	0.32	13,544	0.12	138,280	1.20	311,125	2.70
July	4	108,714	136,408	1.25	19,506	0.18	20,444	0.19	176,358	1.62	123,367	1.13
Aug.	10	94,942	106,871	1.13	39,730	0.42	17,943	0.19	164,544	1.73	63,181	0.67
Sept.	9	45,351	76,563	1.69	32,447	0.72	9,912	0.22	118,922	2.62	18,131	0.40
Oct.	9	168,669	194,812	1.15	45,730	0.27	31,843	0.19	272,385	1.61	134,911	0.80
Nov.[b]												
Dec.	8	167,793	150,944	0.90	58,410	0.35	13,440	0.08	222,794	1.33	149,092	0.89
Total	18	983,018	956,042	0.97	344,611	0.35	129,403	0.13	1,430,056	1.45	1,189,842	1.21

Table 6.--Continued.

Date	Areas fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1986						
Jan.	6	101,876	88,929	0.87	33,622	0.33	6,787	0.07	129,338	1.27	70,392	0.69
Feb.	7	20,937	9,096	0.43	7,170	0.34	1,737	0.08	18,003	0.86	4,401	1.17
Mar.	3	18,650	17,185	0.92	10,835	0.58	3,172	0.17	31,192	1.67	8,668	0.46
Apr.	11	165,150	95,342	0.58	37,230	0.23	12,863	0.08	145,435	0.88	226,482	1.37
May	4	56,913	15,471	0.27	14,065	0.25	5,541	0.10	35,077	0.62	60,934	1.07
June	6	102,103	36,258	0.36	16,031	0.16	10,137	0.10	62,426	0.61	155,223	1.52
July	12	152,035	63,924	0.42	9,411	0.06	18,836	0.12	92,171	0.61	256,660	1.69
Aug.	9	167,534	118,275	0.71	24,024	0.14	17,586	0.10	159,885	0.95	117,873	0.70
Sept.	3	107,314	130,712	1.22	41,272	0.38	19,171	0.18	191,155	1.78	40,351	0.38
Oct.	3	77,410	49,964	0.65	18,589	0.24	15,364	0.20	83,917	1.08	41,946	0.54
Nov.	6	237,316	197,230	0.83	58,771	0.25	24,392	0.10	280,353	1.18	160,845	0.68
Dec.	8	145,321	74,021	0.51	36,844	0.25	19,978	0.14	130,843	0.90	73,752	0.51
Total	19	1,352,559	896,407	0.66	307,864	0.23	155,564	0.12	1,359,795	1.01	1,237,527	0.91

Table 6.--Continued.

Date	Areas fished (No.)	Trap-haul (No.)	Legal spiny		Sublegal spiny		Berried spiny		Total spiny		Total slipper	
			No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE	No.	CPUE
						1987						
Jan.[b]												
Feb.[b]												
Mar.	4	99,563	50,011	0.50	20,286	0.20	4,565	0.05	74,862	0.75	54,115	0.54
Apr.[b]												
May	5	23,400	2,172	0.09	5,570	0.24	1,537	0.07	9,279	0.40	14,386	0.61
June	5	104,820	28,449	0.27	20,618	0.20	11,731	0.11	60,798	0.58	56,504	0.54
July	3	45,787	23,592	0.52	12,357	0.27	5,829	0.13	41,778	0.91	13,055	0.29
Aug.	8	144,623	123,805	0.86	56,556	0.39	37,071	0.26	217,432	1.50	127,289	0.88
Sept.[b]												
Oct.	7	74,680	37,831	0.51	12,045	0.16	8,309	0.11	58,182	0.78	26,726	0.36
Nov.[b]												
Dec.	8	173,510	58,817	0.34	58,641	0.34	15,224	0.09	132,682	0.76	117,733	0.68
Total	12	804,711	394,556	0.49	234,173	0.29	101,560	0.13	730,286	0.91	476,568	0.59

[a]No landings.
[b]Confidential data.

Table 7.--Breakdown of trap-nights in the lobster fishery in the Northwestern Hawaiian Islands, 1983-87.

Year	Trap-nights fished			
	Single (No.)	Multiple and single (No.)	Percent single	Percent multiple
1983[a]	45,666	77,542	58.9	41.1
1984	327,346	393,859	83.1	16.9
1985	801,162	1,091,070	73.4	26.6
1986	1,199,965	1,455,790	82.4	17.6
1987	665,422	920,460	73.7	26.3

[a]Indicates incomplete year.

Table 8.--Two-way analysis of variance of catch per trap-haul (catch per unit effort (CPUE)) by soak time (in trap-nights) and by area fished for total spiny, total slipper, and combined lobsters caught in the lobster fishery in the Northwestern Hawaiian Islands, 1987. These CPUE data were transformed ln (1 + CPUE).

Source of variation	S.S. (Type I)	df	M.S.	*F*	*P* > *F*
		Spiny Lobster			
Bank	6.8547	3	2.2849	26.66	0.0001
Soak	0.2691	1	0.2691	3.14	0.0807
Bank X soak	0.9482	3	0.3160	3.69	0.0158
		Slipper Lobster			
Bank	4.7204	3	1.5734	12.91	0.0001
Soak	0.004	1	0.0041	0.03	0.8548
Bank X soak	0.04122	3	0.0137	0.11	0.9523
		Combined			
Bank	3.6773	3	1.2257	5.72	0.0010
Soak	0.1033	1	0.1033	0.48	0.4884
Bank X soak	0.6540	3	0.2180	1.02	0.3867

DAILY LOBSTER CATCH REPORT PER STATISTICAL AREA

№ 12047

NAME OF VESSEL: _____ LOBSTER PERMIT NO.: _____

SIZE OF CREW: _____ RADIO CALL SIGN: _____

NUMBER OF TRAPS: _____ STATISTICAL AREA OF FISHING: _____

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

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

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

Endangered Species observations (write numbers in pertinent blocks):

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

Comments: _____

LOGGED BY: _____ (Signature) DATE: _____

Figure 1.--Catch per statistical area report form.

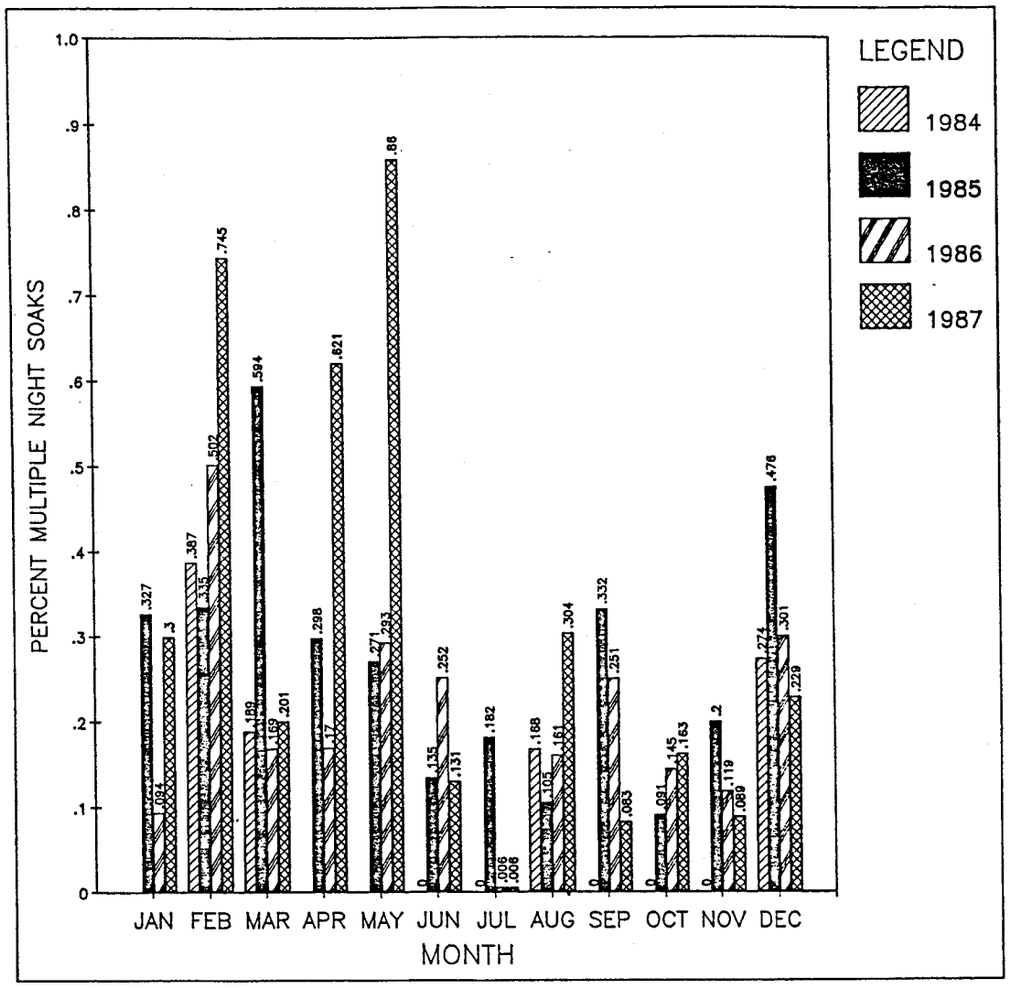
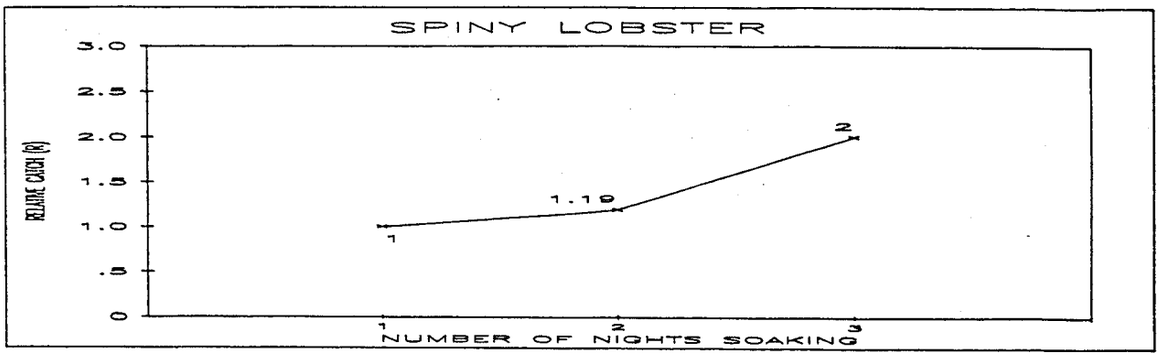


Figure 2.--Monthly occurrence of multiple trap-nights in the lobster fishery in the Northwestern Hawaiian Islands 1984-87.



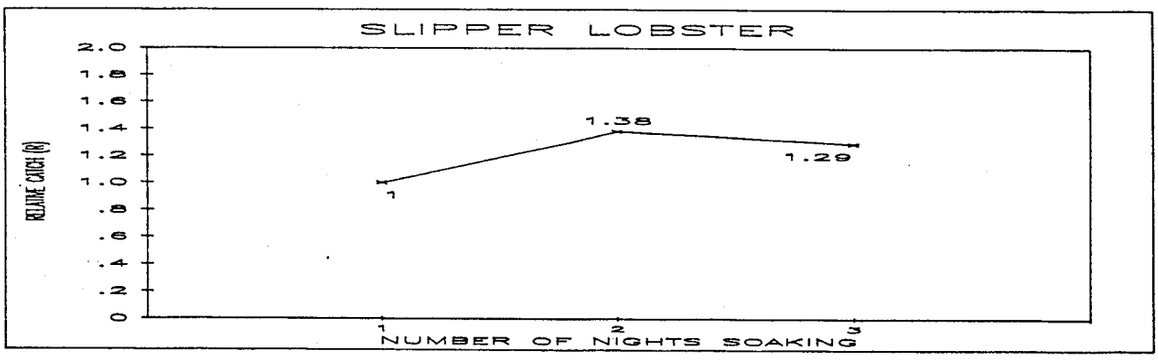


Figure 3.--Relative catch rates for spiny lobster and slipper lobster for three commercial trips in the lobster fishery in the Northwestern Hawaiian Islands, 1985.