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TRAP-WEIGHT INFLUENCE ON CATCHES OF HAWAIIAN SPINY LOBSTER (*PANULIRUS MARGINATUS*) AND SCALY SLIPPER LOBSTER (*SCYLLARIDES SQUAMMOSUS*) FROM THE NORTHWESTERN HAWAIIAN ISLANDS

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ABSTRACT

Spiny lobster (*Panulirus marginatus*) and slipper lobster (*Scyllarides squammosus*) were exploited by a commercial trap fishery in the Northwestern Hawaiian Islands (NWHI) from the mid-1970s to 1999. Since 1976, the National Marine Fisheries Service (NMFS) has been conducting lobster research surveys in the NWHI with the mean catch of lobsters per trap and the size composition of lobsters used to compute annual indices of recruitment. A critical assumption made in computing the recruitment indices is that lobster catchability remains constant. This assumption was potentially violated by the use of different weights of lobster traps in the surveys. The varying trap weights may have affected catchability due to trap movement, for lighter traps tend to move more readily, especially in rough weather, than heavier traps. Given a certain density of lobsters at a survey station a stationary trap will catch more lobsters than a trap moving on the seafloor. Because of these concerns and their effect on recruitment indices, the NMFS initiated a study to determine the effects of trap weight on *P. marginatus* and *S. squammosus* catch rates.

Lobster trapping was conducted at Maro Reef and Necker Island aboard the NOAA ship *Townsend Cromwell* during the NMFS lobster stock assessment surveys of 2001 and 2002. Two different trap weights were used to test the influences of weight on catch rates: 10.4 kg (light) and 16.8 kg (heavy). Catch rates were analyzed with a log-linear model that included trap weight and float attachment as the main factors and weather (wind speed) as a covariate. Pair-wise comparisons of the four gear types (heavy trap, no float; heavy trap, float attached; light trap, no float; light trap, float attached) were made to further explore any significant gear effects from the log-linear model. Test results indicated a gear effect on *P. marginatus* at Necker Island in 2001 and suggested a gear effect on *S. squammosus* at Necker Island in 2001 and 2002. However, the float effect on *S. squammosus* at Necker Island in 2001 and 2002 was due to larger catch rates in traps predicted to have lower catch rates. Graphical analysis of wind speed data plotted against *P. marginatus* and *S. squammosus* catch-per-unit-effort (CPUE) did not show any clear relationships. Although there are brief periods where catch rates seem to mirror the weather conditions catch rates also varied in times of constant weather, and some of the highest catches came during periods of the worst weather.

Based on these analyses the effect of trap weight on *P. marginatus* and *S. squammosus* catch rates in 2000 and 2001 is inconclusive. Instances that may be confounding the results include fishing in areas of high abundance in bad weather and vice versa. To further investigate trap weight influence on *P. marginatus* and *S. squammosus* catches, it is recommended that fishing be conducted only in areas of consistent lobster concentrations.

INTRODUCTION

Spiny lobster (*Panulirus marginatus*) and slipper lobster (*Scyllarides squammosus*) were exploited by a commercial trap fishery in the Northwestern Hawaiian Islands (NWHI) from the mid-1970s to 1999. After an initial period of high catches the fishery experienced a drastic decline in catch per unit of effort (CPUE) in the early 90's (DiNardo and Marshall, 2001). Several hypotheses sought to explain this drop in CPUE including lack of recruitment due to poor oceanographic conditions (Polovina and Mitchum, 1992), habitat (Parrish and Polovina, 1994) and commercial fishing (Polovina et. al., 1995). The fishery was closed in 2000 because of increasing uncertainty in population and stock assessment models, and it remains closed to this date.

Since 1976, the National Marine Fisheries Service (NMFS) Pacific Islands Science Center has been conducting lobster resource trapping surveys in the NWHI. Mean catch of lobsters per trap and the size composition of lobsters are used to compute annual indices of recruitment. A critical assumption made in the computing of the recruitment indices is that lobster catchability remains constant. This assumption was potentially violated by the use of different weights in the lobster traps used in the surveys. This in turn may have affected CPUE which directly affects the recruitment indices. Trap weights ranged on an annual basis from 10.4 to 15.8 kg, however, no information was collected as to the specific weights used on the individual surveys (R. Moffitt, NMFS, pers. comm.). The varying trap weights may have affected catchability due to trap movement, for lighter traps tend to move more readily, especially in rough weather, than heavier traps. Given a certain density of lobsters at a survey station a stationary trap will catch more lobsters than a trap moving on the seafloor.

Because of the potential changes in catchability on lobster catch rates, the effect of gear (trap weight and float attachment) and weather (wind speed) on lobster catch rates was tested in an experiment conducted at Maro Reef and Necker Island during the 2001 and 2002 research surveys aboard the NOAA ship *Townsend Cromwell*. The purpose of the experiment was to determine if trap weight does affect lobster catch rates. In addition to determining the effect of trap weight on lobster catch, this study may also clarify some of the interplay between fishing gear, weather, and lobster catch.

METHODS AND MATERIALS

Lobster trapping was conducted at Maro Reef (lat. 25° 25'N, long. 170° 35'W) from June 15 to June 20, 2001, and June 8 to June 15, 2002, and Necker Island (lat. 23° 34'N, long. 164° 42'W) from June 25 to July 8, 2001, and June 17 to July 2, 2002 aboard the NOAA ship *Townsend Cromwell* during annual NMFS lobster resource assessment surveys (Fig. 1). Trapping was conducted at historical sites originally determined by a fixed-site design, stratified by depth. Ten strings of eight traps (standard commercialstyle Fathoms Plus polyethylene plastic traps) were set in shallow water (<37 m), and four strings with 20 traps were set in deeper water (>37 m) each day. Each trap on the string was separated by 37 m of groundline. The first and last traps in each string of 20 traps were connected to a 55-m floatline with an inflatable buoy (47-cm diameter, 55-kg buoyancy) and a hard buoy (17-cm diameter) attached; the strings with eight traps had floats attached to only the first trap. All traps were soaked overnight and baited with 1 kg of mackerel. Two different trap weights were used to test the influence of weight on catch rates: 10.4 kg (light) and 16.8 kg (heavy). The different trap weights were alternated within each string for all strings set.

A Type 3 analysis from a log-linear model that permitted extra-Poisson variation (proc GENMOD, SAS Institute, 1999) was used to test for differences in catch rates of *P. marginatus* and *S. squammosus* between the trap weights at each bank in 2001 and 2002. The Pearson Chi-squared statistic, divided by its degrees of freedom, was used to estimate the dispersion parameter. If this estimate was greater than 1.0, an overdispersed Poisson distribution was assumed. Lobster catch rates from traps that were directly connected to a float (trap 1 in the strings of 8 traps; traps 1 and 20 in the strings of 20 traps) were compared to catch rates from those not connected to floats. Traps attached to floats were expected to be more susceptible to wind and wave action and therefore have lower catch rates than traps not connected to floats. QuickSCAT satellite wind speed data (meters/second at 10 m height) were acquired for survey days at Maro Reef and Necker Island and included as covariates in the model. The full model tested for each species by bank (Necker, Maro) and year (2001, 2002) was

*lobster catch = trap weight + float attachment + weather + trap weight * float attachment*

with trap weight either 10.4 kg or 16.8 kg, float attachment either 'yes' or 'no,' and weather referring to QuickSCAT satellite wind speed data. An $\alpha < 0.1$ significance criterion was employed for all gear effects.

Pair-wise comparisons of the four gear types (heavy trap, no float; heavy trap, float attached; light trap, no float; light trap, float attached) were made to further explore any significant gear effects from the Type 3 analysis. A $\alpha<0.1$ significance criterion was employed in this analysis.

RESULTS

The mean catch rate (# lobsters/trap), standard deviation of catch rates (std), and number of traps fished for each bank, gear type (heavy and light, floats and no floats attached), species and year are shown in Table 1. The estimated dispersion parameter was greater than 1.0 in each fitted model, which indicates overdispersion and warranted the assumption of an overdispersed Poisson distribution in the analysis. The interaction term was not significant in any of the full models and was therefore eliminated from further models. The fitted models (Table 2) for *S. squammosus* in 2001 indicated a weight effect (*P*=0.01) and float effect (*P*=0.01) on catch rates at Necker Island and a float effect (*P*=0.03) and weather effect (*P*=0.07) at Maro Reef. In 2002 there was a weight effect (*P*=0.07) at Necker Island and a float effect (*P*=0.004) and weather effect (P=0.002) at Maro Reef. However, it is important to note that the significant float effects on *S. squammosus* catch rates at Maro Reef in 2001 and 2002 were due to catch rates being higher in the lighter traps than in the heavier traps. *P. marginatus* fitted model results indicated a weight (*P*=0.04), float (*P*<0.0001) and weather effect (*P*=0.003) at Necker Island but only a weather effect (*P*=0.09) at Maro Reef in 2001, while in 2002 there was only a weather effect (*P*=<0.0001) at Necker Island.

A pair-wise comparison of the four gear types was made for the species, years, and banks that had significant weight or float effects in the Type 3 analysis: 2001 *P. marginatus* at Necker Island, and 2001 and 2002 *S. squammosus* at Necker Island (Table 3). This analysis confirmed the weight and float effect for the 2001 *P. marginatus* at Necker Island. The comparison also confirmed the weight effect for 2002 *S. squammosus* at Necker Island but also suggested a float effect that was not significant in the Type 3 analysis. The weight and float effect on 2001 *S. squammosus* was not decisively confirmed but could not be rejected.

Average wind speed from QuickSCAT satellite data and estimated significant wave height during the research survey are shown in Table 5. Generally the wind speed data plotted against *P. marginatus* and *S. squammosus* daily CPUE did not show any clear relationships (Figs. 2, 3, 4, and 5). Although there are brief periods where catch rates seem to mirror the weather conditions (*P. marginatus* at Necker Island in 2002) catch rates also varied in times of constant weather (*S. squammosus* at Maro Reef in 2001) and some of the greatest catches came during periods of the worst weather (*P. marginatus* at Necker Island in 2001).

DISCUSSION

Based on these analyses, the effect of trap weight on *P. marginatus* and *S. squammosus* catch rates in 2000 and 2001 is inconclusive. There appears to be a weight and float effect on *P. marginatus* catch rates at Necker Island in 2001, and this is reflected in the pair-wise comparison. The model results suggested a weight and float effect on *S. squammosus* at Necker Island in 2001, however the pair-wise comparisons neither confirm nor reject this, while the pair-wise comparison does confirm the weight effect on *S. squammosus* at Necker Island in 2002 as well as hinting at a float effect. The fact that the float effect on *S. squammosus* catch rates at Maro Reef in 2001 and 2002 was due to higher catch rates in the lighter traps further confounds interpretation of the results because the lighter traps were predicted to have lower catch rates than the heavier traps. If trap weight had an influence on catch rates, it presumably would have been most apparent in the pair-wise comparison of heavy traps without floats and light traps with floats because these represent the extremes of test conditions. The test statistic was only significant for *P. marginatus* at Necker Island in 2001.

The satellite wind-speed data support these conclusions. If rougher weather had proved to have an effect on the traps in this study, it would have been apparent in the *P. marginatus* results. Necker Island has a higher concentration of *P. marginatus* than Maro Reef. Because the weather was clearly worse at Necker Island in 2002 than in 2001, one would expect a significant difference in the gear comparisons in 2002 especially when compared to the same gear comparison results from 2001. This, however, was not the case.

Only two previous studies have touched on the influence of trap-movement on lobster catch rates. In a 1980 study Polovina found that a trap's position on a string did not significantly affect NWHI *P. marginatus* catch rates. This suggests that float attachment, and therefore trap movement, did not have a significant influence on catch rates for if it did the first and last traps would have had different catch rates from the others. This study, however, fished only 10 strings consisting of 8 California-style traps (traps used by commercial fishers prior to the Fathoms Plus trap) each, and this amount of effort may not have been enough to detect any influence that trap movement had on catch. In a Maine study examining trap material and lobster catch rates, Acheson (1982) found that aluminized traps caught more American lobsters (*Homarus americanus*) than vinyl-coated aluminum traps and many more than traditional wooden traps. He theorized that, although the traps weighed the same, the wooden traps had more of a tendency to float and move on the bottom than aluminized traps. He concluded (along with commercial fishers involved in the study) that lobsters were less willing to enter the moving wooden traps.

The inconclusive results are based on the lack of clear evidence of a gear effect on *P. marginatus* and *S. squammosus* catch rates from the statistical analysis as well as the sometimes contradictory trends in the CPUE vs. weather plots. It is known that lobster habitat is patchy across a bank. Because of the randomly selected fishing stations the survey fishes in areas of high and extremely low lobster abundance. Instances that may be confounding the results include fishing in areas of high abundance in bad weather and vice versa. It is also possible that the trap weights used in this study were not heavy enough to affect lobster catch. To further investigate trap-weight influence on *P. marginatus* and *S. squammosus* catch rates it is recommend that fishing be conducted only in areas of consistent lobster concentrations.

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Table 1. 2001 and 2002 mean catch/trap, standard deviation of catch/trap (std), and number of traps fished for each bank, gear type by species.

Bank	Species	Gear type		2001			2002		
		Trap weight	Float attached	*N* traps	Mean	std	*N* traps	Mean	std
All	*S. squammosus*	heavy	n	684	1.14	2.50	555	1.55	3.25
			y	89	1.10	2.39	130	2.39	5.08
		light	n	966	0.95	2.03	961	1.21	2.78
			y	121	1.32	2.80	257	1.49	3.53
	P. marginatus	heavy	n	684	0.64	1.31	555	0.36	0.89
			y	89	0.40	1.08	130	2.39	5.08
		light	n	966	0.54	1.06	961	0.40	0.86
			y	121	0.25	0.69	257	0.37	0.91
Maro	*S. squammosus*	heavy	n	184	3.25	3.95	196	3.67	4.67
			y	21	3.86	3.70	50	5.72	6.99
		light	n	255	2.85	3.12	323	3.03	4.12
			y	35	4.29	3.80	81	4.01	5.42
	P. marginatus	heavy	n	184	0.26	0.68	196	0.14	0.42
			y	21	0.33	1.11	50	0.12	0.33
		light	n	255	0.19	0.49	323	0.15	0.43
			y	35	0.34	0.73	81	0.06	0.37
Necker	*S. squammosus*	heavy	n	500	0.36	0.77	359	0.40	0.82
			y	68	0.25	0.56	80	0.31	0.69
		light	n	711	0.28	0.63	638	0.29	0.68
			y	86	0.12	0.47	176	0.34	0.72
	P. marginatus	heavy	n	500	0.79	1.45	359	0.47	1.04
			y	68	0.43	1.08	80	0.39	0.75
		light	n	711	0.66	1.17	638	0.53	0.99
			y	86	0.21	0.67	176	0.51	1.04

Table 2. *P*-values for weight, float and weather effect on catch of *P. marginatus* and *S. squammosus* from fitted model by bank and year.

Species	Bank	Year	Weight *p*-value	Float *p*-value	Weather *p*-value
P. marginatus	Necker	2001	0.04	<.0001	0.003
	Necker	2002	0.24	0.60	<.0001
	Maro	2001	0.322	0.16	0.09
	Maro	2002	0.83	0.11	0.41
S. squammosus	Necker	2001	0.01	0.01	0.3
	Necker	2002	0.07	0.96	0.17
	Maro	2001	0.34	0.03	0.07
	Maro	2002	0.23	0.004	0.002

Table 3. Pair-wise comparisons of gear types for Necker Island catch rates of *P. marginatus* in 2001 and *S. squammosus* in 2001 and 2002.

Gear comparison		*P. marginatus*	*S. squammosus*	*S. squammosus*
Gear Type 1	Gear type 2	2001 at Necker	2001 at Necker	2002 at Necker
heavy, no	heavy, yes	0.03	0.90	0.02
heavy, no	light, no	0.09	0.10	0.03
heavy, no	light, yes	<0.0001	0.46	0.82
heavy, yes	light, no	0.09	0.53	0.0002
heavy, yes	light, yes	0.12	0.55	0.05
light, no	light, yes	<0.0001	0.08	0.18

Table 4. 2001 and 2002 average wind speed (m/s), average wind speed standard deviation (std), average wave height (m) and average wave height standard deviation (std) for Maro Reef and Necker Island during the annual National Marine Fisheries Service research survey.

	2001		2002	
Bank	Avg. wind speed (std)	Avg. wave height (std)	Avg. wind speed (std)	Avg. wave height (std)
Maro	6.6 (1.7)	1.2 (0.5)	6.8 (1.1)	1.2 (0.4)
Necker	5.4 (2.4)	0.9 (0.6)	7.8 (1.0)	1.5 (0.4

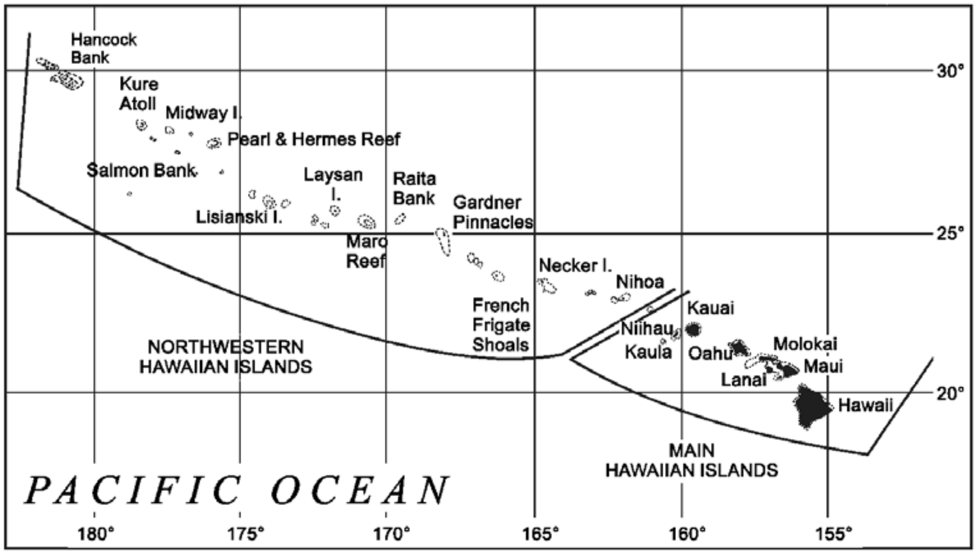

Figure 1. The main and Northwestern Hawaiian Islands including Maro Reef Necker Island.

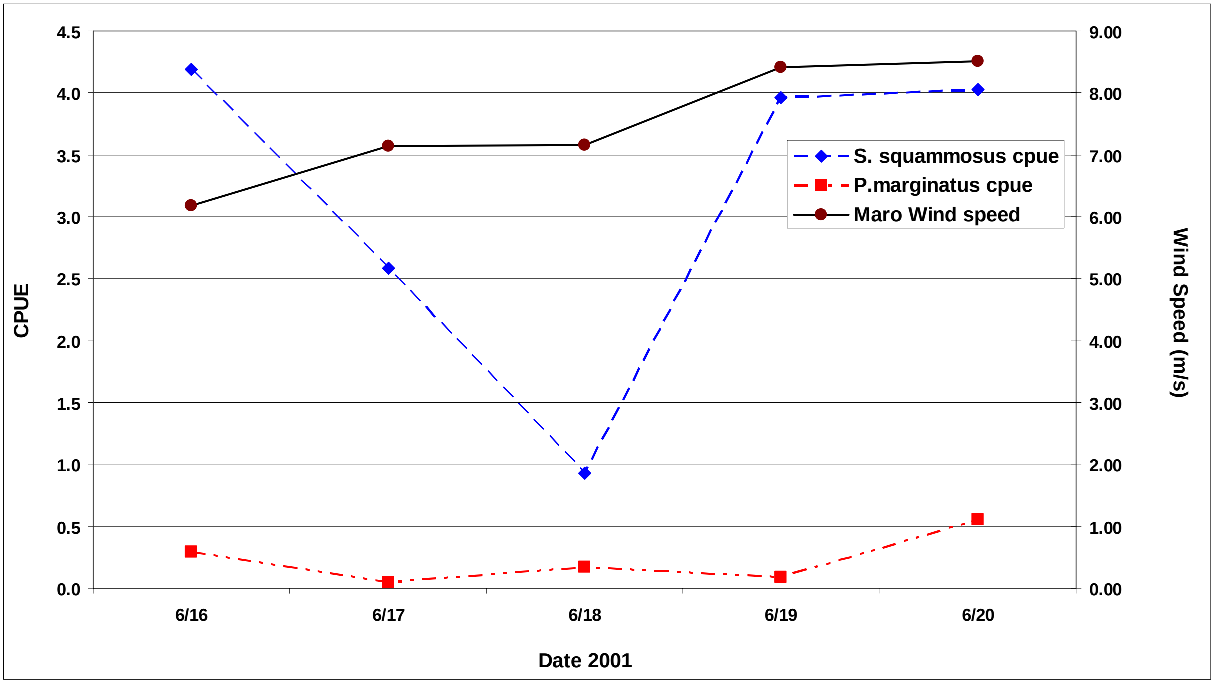

Figure 2. Wind speed (m/s) vs. *P. marginatus* and *S. squammosus* lobster catch-per-unit-of-effort (catch/trap) during 2001 annual resource survey at Maro Reef.

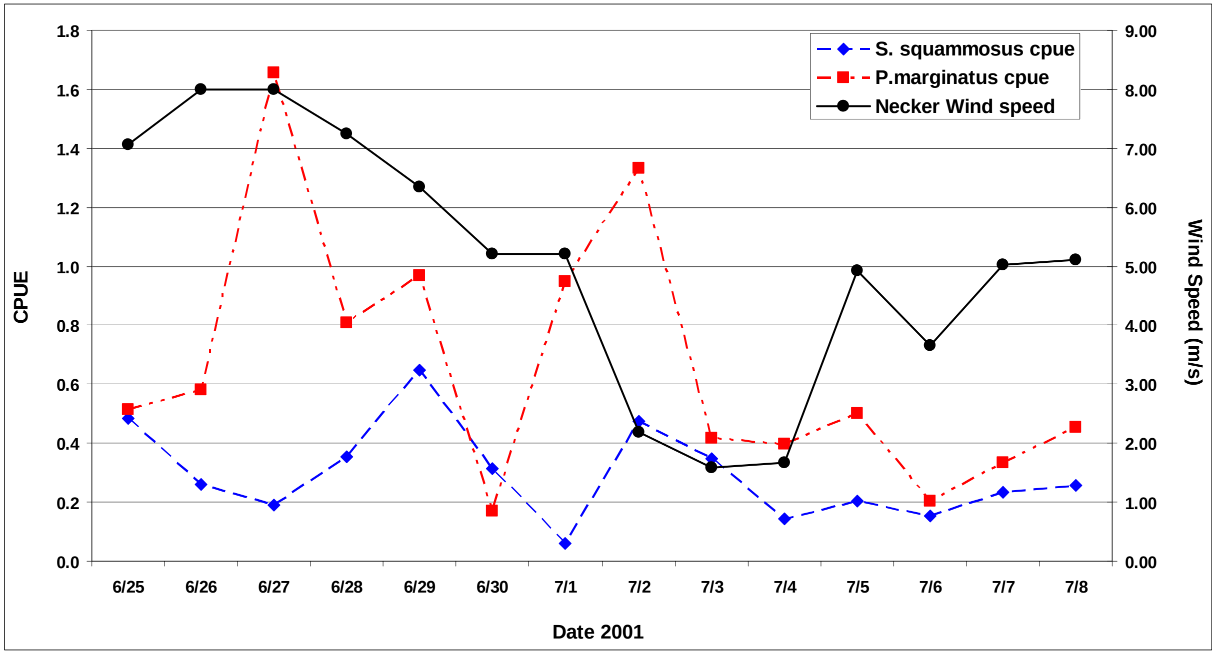

Figure 3. Wind speed (m/s) vs. *P. marginatus* and *S. squammosus* lobster catch-per-unit-of-effort (catch/trap) during 2001 annual resource survey at Necker Island.

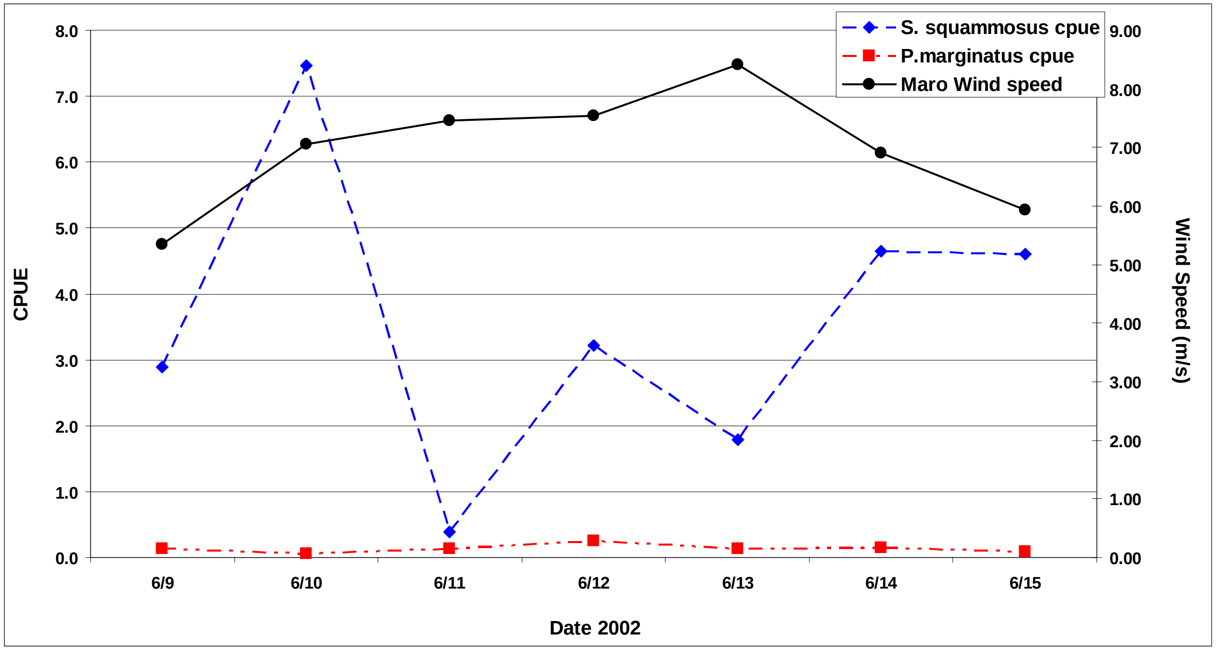

Figure 4. Wind speed (m/s) vs. *P. marginatus* and *S. squammosus* lobster catch-per-unit-of-effort (catch/trap) during 2002 annual resource survey at Maro Reef.

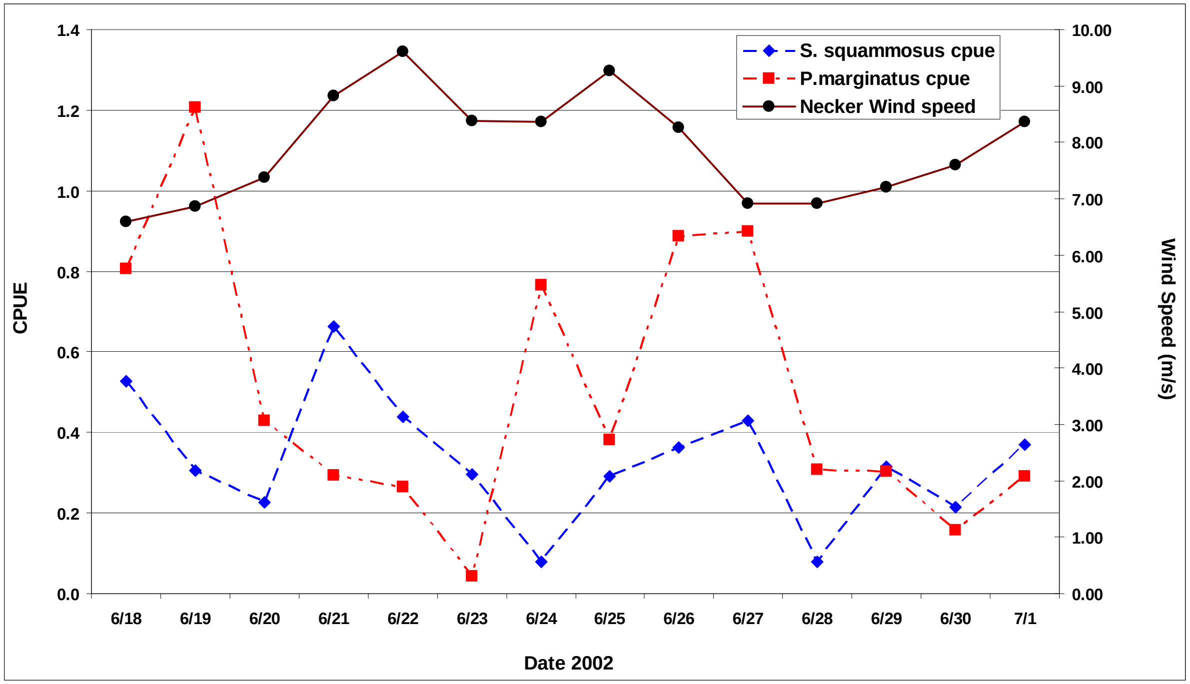

Figure 5. Wind speed (m/s) vs. *P. marginatus* and *S. squammosus* lobster catch-per-unit-of-effort (catch/trap) during 2002 annual resource survey at Necker Island.