Differences in Dolphin Mortality Rates in Night and Day Sets for the U.S. Eastern Tropical Pacific Tuna Purse Seine Fishery

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Introduction

The association of yellowfin tuna, *Thunnus albacares,* with dolphins (mainly *Stenella attenuata* and *S. longirostris*) in the eastern tropical Pacific (ETP) (Fig. 1) has been used by purse seine fishermen to harvest yellowfin tuna since the early 1960's (McNeely, 1961). Purse seiners locate dolphin pods and use speed boats to herd the dolphins into purse seine nets to capture the tuna traveling below them (dolphin sets). As the dolphins are surrounded by the purse seines, some may become entangled and drown before they can be released alive (Perrin, 1969; Green et al., 1971).

While all dolphin sets start in daylight, they sometimes extend into darkness. When this occurs, more animals are killed because the release of entangled dolphins is complicated by the inability to see the animals (IATTC, 1984). Sets can also last longer (sometimes into darkness) if equipment malfunctions, strong currents, high winds, net collapses (cork lines come together, Coe et al., 1984), or canopies (net blossoms out beyond the cork line, Coe et al., 1984) occur. These problems subject dolphins to longer periods of time in the nets and contribute to higher dolphin mortality. Estimated annual dolphin mortality for the ETP international purse seine fleet was as high as 550,000 animals in 1961 (Smith, 1983) and public concern over the numbers of dolphins killed prompted the U.S. Government and U.S. industry to take steps to monitor and reduce this mortality (Fox, 1978).

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ABSTRACT—Because dolphins sometimes travel with yellowfin tuna, Thunnus albacares, *in the eastern tropical Pacific (ETP), purse seiners use the dolphins to locate and capture tuna schools. During the process of setting the purse seine nets, dolphins often become entangled and drown before they can be released. Data for the U.S. purse seine fleet in the ETP during 1979-88 show that dolphin mortality rates in sets made during the night are higher than mortality rates in sets made during the day. Even with efforts to reduce night-set mortality rates through the use of high-intensity floodlights, night set mortality rates remain higher. The data are also used to simulate a regulation on the fishery aimed at eliminating night sets and show that dolphin mortality rates would decrease.*

Monitoring of the incidental dolphin mortality began in 1971 when the National Marine Fisheries Service (NMFS) placed scientific technicians (observers) on U.S. purse seiners fishing in the ETP. In 1979, the Inter-American Tropical Tuna Commission (IATTC) started its own international tuna-dolphin program that placed observers on both U.S. and foreign purse seiners. U.S. regulations were enacted to reduce ETP dolphin mortality through the Marine Mammal Protection Act (MMPA) in 1972, and various reauthorizations of the Act led to the establishment of the current mortality quota of 20,500 dolphins for the U.S. fleet.

Reductions in dolphin mortality were accomplished by modifying purse seines and purse seining operations (Coe et al., 1984). The "Medina panel," a portion of the purse seine net with 1-inch mesh, was developed to reduce dolphin entanglement, and backdown procedures, methods used to submerge a portion of the net, were developed to aid in the release of dolphins (Barham et al., 1977; Coe and Sousa, 1972). In the early 1980's, the U.S. tuna industry also experimented with high-intensity 140,000-lumen floodlights. These high-intensity floodlights were used to reduce dolphin mortality in dolphin sets made at night by making dolphins in the net more visible and aiding the release of captured animals. The high-intensity floodlights became a mandatory requirement for all certificated (licensed to fish on dolphins) U.S. vessels on 1 July 1986.

Our study uses data collected through the NMFS and IATTC monitoring programs, during 1979-88, to look at differences between mortality rates in day and night sets made by U.S. purse seiners fishing in the ETP. The benefits of using high-intensity floodlights to decrease night set mortality rates are assessed, a regulation aimed at eliminating night sets is simulated, and the benefits to mortality rates quantified.

Data and Methods

Data from over 20,000 dolphin sets that produced approximately 302,000 short tons (tons) of yellowfin tuna were collected by IATTC and NMFS observers on U.S. purse seiners fishing in the ETP during the period 1 January 1979 to 31 December 1988. Many types of

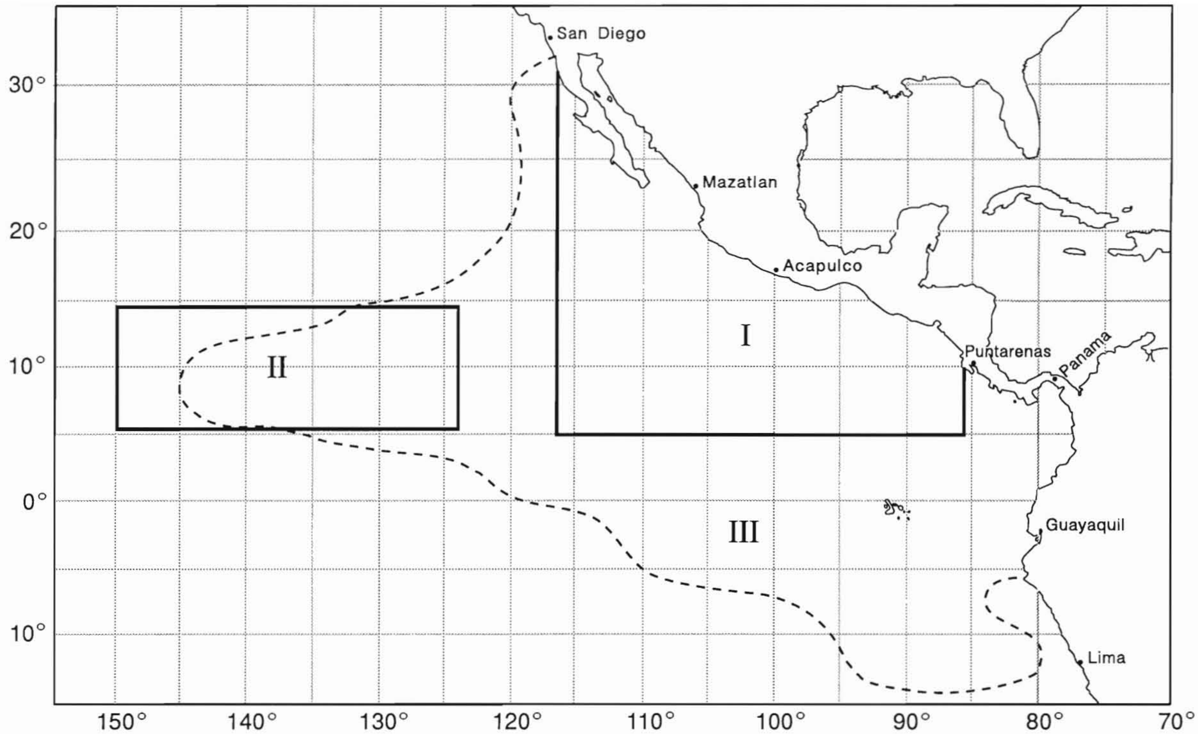

Figure 1.—Area of the eastern tropical Pacific (ETP) historically fished for yellowfin tuna associated with dolphins (dotted line) and three subareas of the ETP used to stratify data in this study and define regions of differing dolphin mortality rates. Area I is the northern coastal inshore area, area II, the offshore area, and area III is all other ETP areas.

data were collected by these observers; however, only information concerning times of various events in the set (e.g., sundown, backdown, etc.), numbers of dolphins killed, geographical location, tons of yellowfin tuna caught, and night light use for each set, was used in this analysis.

Data were divided into night sets (sets started during daylight or twilight hours but with any portion of the backdown occurring in darkness) and day sets (sets started during daylight hours and backdown procedures completed in daylight or twilight hours). For sets where no backdown information was recorded, the time of the end of the set was compared to the time of sunset, and those sets that ended before sunset were considered day sets. Those that ended after sunset were eliminated. If the time of sundown was not recorded, sundown times were calculated from the geographical position and date (Bowditch, 1966). Calculated sundown times are accurate to ±3 minutes for positions between lat. 30°N and 30°S.

In the process of separating day and night sets and computing dolphin mortality rates, certain sets were eliminated: 1) All sets where marine mammals were accidentally caught (e.g., sets on floating objects or free swimming schools of tuna where dolphins were not intentionally herded into nets); 2) sets where the tons of yellowfin caught or the numbers of marine mammals killed were not recorded; or 3) dolphin sets where there was no backdown information and the set terminated after sunset. Approximately 2% of the dolphin sets, 1% of the total dolphin mortality, and 1% of the total yellowfin tuna catch were eliminated by deleting sets that met any of these criteria.

Ninety percent (18,873) of the observed ETP dolphin sets during 1979-88 were day sets that accounted for 90% of the yellowfin tuna catch (270,916 tons) and 70% of the dolphin mortality (58,341). Night sets were much less frequent, with 10% of the dolphin sets (1,849), 10% of the yellowfin tuna catch (29,406 tons) and 30% of the dolphin mortality (25,261). The number of night sets for the entire ETP ranged from 74 to 402 and day sets from 762 to 3,891 annually (Table 1). The number of dolphins killed for the entire ETP ranged from 399 to 4,468 in night sets and 2,573 to 10,533 in day sets.

Data for night and day sets were stratified into three subareas of the ETP to assess the effects of geographical location on differences between mortality rates in day and night sets (Fig. 1). The three subareas chosen encompass regions of the ETP having significant differences in mortality rates and are standard subareas used in development of ETP dolphin fishing regulations (Federal Register, 1988, 1989). Area I contains a major portion of the northern coastal region of the ETP that is historically fished for yellowfin tuna

Table 1.—Number of sets and dolphin mortality (animals killed) for day and night sets of U.S. purse seiners fishing in the entire eastern tropical Pacific (ETP) and three subareas.

	Entire ETP		Area I		Area II		Area III	
Year	Day	Night	Day	Night	Day	Night	Day	Night
Number of sets								
1979	2,658	248	1,890	172	351	23	387	51
1980	2,023	159	1,308	103	377	30	336	26
1981	2,065	172	1,306	108	466	35	291	29
1982	1,686	206	1,011	114	217	37	451	55
1983	905	74	361	22	287	23	252	28
1984	762	104	408	51	195	32	158	21
1985	1,787	197	1,476	161	179	23	132	13
1986	1,295	162	671	90	411	47	209	25
1987	3,891	402	3,004	279	387	64	495	59
1988	1,801	168	1,197	123	137	4	467	41
Dolphin mortality								
1979	5,289	2,432	2,770	1,480	1,024	120	1,455	809
1980	4,720	1,911	1,872	427	1,198	210	1,635	1,274
1981	5,724	2,004	2,532	654	1,326	536	1,866	814
1982	6,692	2,695	2,733	1,210	493	697	3,429	788
1983	2,573	399	525	83	1,125	47	923	265
1984	2,673	2,444	1,100	1,432	662	693	911	319
1985	6,225	3,047	4,580	2,115	870	668	775	264
1986	5,781	4,468	2,263	2,106	1,512	2,042	2,001	320
1987	10,533	3,519	6,344	1,996	1,142	679	3,047	844
1988	8,131	2,342	3,978	615	1,136	10	3,017	1,717

associated with dolphins. Area II contains the offshore region, and area III contains all other regions of the ETP not contained in areas I or II.

Sixty-seven percent of the observed ETP dolphin sets during 1979-88 occurred in area I, 16% in area II, and 17% in area III (Table 1). Forty-nine percent of the dolphin mortality occurred in area I, 19% in area II, and 32% in area III. The average number of observed night and day sets (32 and 301) and dolphin mortality (570 and 1,049) was lowest in area II.

Dolphin night sets were divided into sets using high-intensity floodlights and sets using other types of lights (e.g., low-intensity lights). Data for 722 night sets that used high-intensity floodlights were available for 1982-88 only and ranged from a low of 9 in 1983 to a high of 327 in 1987. Data for 451 night sets that used other types of light were available for 1982-88 and ranged from a low of 21 in 1988 to a high of 146 in 1982. In 1982-86, high-intensity floodlights were loaned to only a select group of vessels to test their usefulness. After 1986 the lights were available to all vessels. Due to the limited number of sets that used high-intensity floodlights or other types of light, comparisons of mortality rates for these sets were not stratified by subareas of the ETP.

Two mortality rates were calculated: The total number of dolphins killed divided by the total number of dolphin sets (kill/set); and total number of dolphins killed divided by the total tonnage of yellowfin tuna caught (kill/ton) in dolphin sets. Percentages of dolphin sets with zero dolphins killed (zero-kill sets) and percentages of dolphin sets with more than 15 dolphins killed (high-kill sets) were also calculated.

The Wilcoxon paired-sample test (Zar, 1974; Siegel, 1956) was used to determine significant differences (at the 5% level) between the following pairs of data: 1) Mortality rates in day sets vs. night sets, 2) percentages of high-kill sets in day sets vs. night sets, 3) percentages of zero-kill sets in day sets vs. night sets, and 4) mortality rates in sets that used high-intensity floodlights vs. sets that used other types of light. The pairs of data considered were yearly estimates. The test considers the magnitude and occurrences of positive and negative differences between the estimates in determining whether the differences are randomly distributed. The null hypothesis was that the estimated mortality rates, percentages of zero-kill sets, and percentages of high-kill sets were the same in day and night sets, or that the mortality rates in night sets that used high-intensity floodlights and those that used other types of lights were the same. A nonparametric statistical test was chosen because estimated mortality rates were not normally distributed. The distributions were basically Poisson with the major mode occurring at zero dolphins killed (Fig. 2).

Linear regressions were used to define trends in yearly estimates of mortalities and mortality rates. These trends were considered significant (5% level) if the regression coefficients were statistically different from zero. The Student's T statistic was used to determine significance. To guarantee that the regression coefficients were of minimum variance, autocorrelation was assessed with a Runs test and Durbin-Watson statistic on the residuals (Smillie, 1966).

Results

The number of observed sets and dolphin mortality in most areas of the ETP was highest in 1987, when observer coverage was 92% and lowest in 1983 (31% observer coverage) or 1984 (28% observer coverage), when a court injunction limited the placement of observers. While this relationship of higher estimates in high coverage years and lower estimates in low coverage years may imply an autocorrelation between coverage rates and mortality and mortality rate estimates, no positive or negative autocorrelation was detected at the 5% level of significance. Therefore, esti-

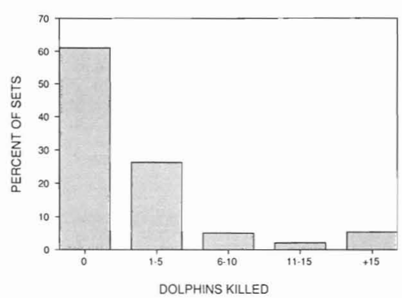

Figure 2.—A typical distribution of mortality rates in dolphin sets of U.S. purse seiners fishing in the eastern tropical Pacific.

Table 2.—Statistical comparisons of mortality rates and percentages of zero-kill and high-kill (more than 15 dolphins killed) sets in the entire eastern tropical Pacific and three subareas. Values of the Wilcoxon's T statistic greater than eight are considered significant at the 5% level, except for high-intensity light comparisons that are significant if values are greater than three.

Comparison	Wilcoxon's T statistic	Conclusion
Kill/set day vs. night		
Entire ETP	0	Night sets higher
Area I	0	Night sets higher
Area II	5	Night sets higher
Area III	0	Night sets higher
Kill/ton day vs. night		
Entire ETP	0	Night sets higher
Area I	0	Night sets higher
Area II	5	Night sets higher
Area III	0	Night sets higher
% Zero-kill sets day vs. night		
Entire ETP	0	Night sets lower
Area I	0	Night sets lower
Area II	0	Night sets lower
Area III	3	Night sets lower
% High-kill sets day vs. night		
Entire ETP	0	Night sets higher
Area I	0	Night sets higher
Area II	4	Night sets higher
Area III	1	Night sets higher
High-intensity lights vs. other lights		
Kill/set entire ETP	0	Other light higher
Kill/ton entire ETP	1	Other light higher
High-intensity lights vs. day sets		
Kill/set entire ETP	0	High-intensity light higher
Kill/ton entire ETP	1	High-intensity light higher
Kill/set Area I vs. Area II		
Day sets	2	Area II higher
Night sets	13	No significant difference
Kill/set Area I vs. Area III		
Day sets	0	Area III higher
Nights sets	13	No significant difference
Kill/set Area II vs. Area III		
Day sets	6	Area III higher
Night sets	18	No significant difference
Kill/ton Area I vs. Area II		
Day sets	13	No significant difference
Night sets	26	No significant difference
Kill/ton Area I vs. Area III		
Day sets	0	Area III higher
Night sets	15.5	No significant difference
Kill/ton Area II vs. Area III		
Day sets	4.5	Area III higher
Night sets	15	No significant difference
Zero-kill Area I vs. Area II		
Day sets	0	Area I higher
Night sets	0	Area I higher
Zero-kill Area I vs. Area III		
Day sets	6	Area I higher
Night sets	0	Area I higher
Zero-kill Area II vs. Area III		
Day sets	1	Area II higher
Night sets	19	No significant difference
High-kill Area I vs. Area II		
Day sets	6	Area I lower
Night sets	15	No significant difference
High-kill Area I vs. Area III		
Day sets	0	Area I lower
Night sets	4	Area I lower
High-kill Area II vs. Area III		
Day sets	1	Area II lower
Night sets	12	No significant difference

mates of mortality rates and mortalities are randomly ordered and independent of yearly coverage rates, and trends generated from simple regressions will properly estimate the variance.

ETP night set dolphin mortality rates (kill/set and kill/ton) were significantly higher than ETP day set mortality rates during 1979-88 (Table 2). Day set kill/set ranged from 1.99 to 4.51 dolphins per set and for night sets from 5.39 to 27.58 dolphins per set (Fig. 3). Day set kill/ton ranged from 0.19 to 0.38 dolphins/ton and for night sets from 0.5 to 1.31 dolphins/ton. A significant increasing trend during 1979-88, was detected in kill/set for day sets (Table 3).

Night set mortality rates were significantly higher in all three subareas of the ETP than day set mortality rates (Table 2). Dolphin mortality rates in day sets were generally lower in area I than in areas II and III, whereas no significant differences in night set mortality rates between areas were detected. Mortality rates were highest in area III in 1980 when kill/set was 49 dolphins/set and kill/ton was 4.39 dolphins/ton. Night set mortality rates were always higher than day set mortality rates, except in area II in 1983 and 1988 (Fig. 3). Significant increasing trends during 1979-

Table 3.—Kill/set and kill/ton for day and night sets in the entire eastern tropical Pacific (ETP) and three subareas. The Student's T statistic is used to detect significant trends in the data. Values greater than ±2.306 are significant at the 5% level. Positive values indicate increasing trends and negative values reflect decreasing trends.

	Entire ETP		Area I		Area II		Area III	
Year	Day	Night	Day	Night	Day	Night	Day	Night
Kill/set								
1979	1.99	9.81	1.46	8.60	2.92	5.22	3.76	15.86
1980	2.33	12.02	1.43	4.14	3.18	7.00	4.87	49.00
1981	2.77	11.65	1.94	6.06	2.84	15.31	6.41	28.07
1982	3.97	13.08	2.70	10.61	2.27	18.84	7.60	14.32
1983	2.84	5.39	1.45	3.77	3.92	2.04	3.66	9.46
1984	3.51	23.50	2.70	28.08	3.39	21.66	5.76	15.19
1985	3.48	15.47	3.10	13.14	4.86	29.04	5.87	20.31
1986	4.46	27.58	3.37	23.40	3.68	43.45	9.57	12.80
1987	2.71	8.75	2.11	7.15	2.95	10.61	6.16	14.30
1988	4.51	13.94	3.32	5.00	8.29	2.50	6.46	41.88
Student's T	2.74	0.97	3.04	0.68	2.24	0.78	1.56	–0.24
Kill/ton								
1979	0.20	0.79	0.16	0.83	0.25	0.47	0.26	0.87
1980	0.23	1.09	0.18	0.43	0.22	0.45	0.37	4.39
1981	0.26	1.02	0.21	0.63	0.22	0.93	0.48	2.25
1982	0.38	0.98	0.31	1.03	0.19	1.17	0.55	0.80
1983	0.28	0.50	0.22	0.55	0.30	0.18	0.29	0.68
1984	0.18	1.31	0.15	1.82	0.17	1.07	0.28	0.75
1985	0.20	0.81	0.18	0.71	0.20	1.24	0.44	1.12
1986	0.15	1.03	0.17	0.92	0.12	1.39	0.41	0.55
1987	0.26	0.50	0.13	0.45	0.13	0.54	0.31	0.68
1988	0.19	0.76	0.20	0.29	0.44	0.17	0.34	1.95
Student's T	–0.88	–0.85	–0.69	–0.35	0.27	0.15	–0.21	–1.11

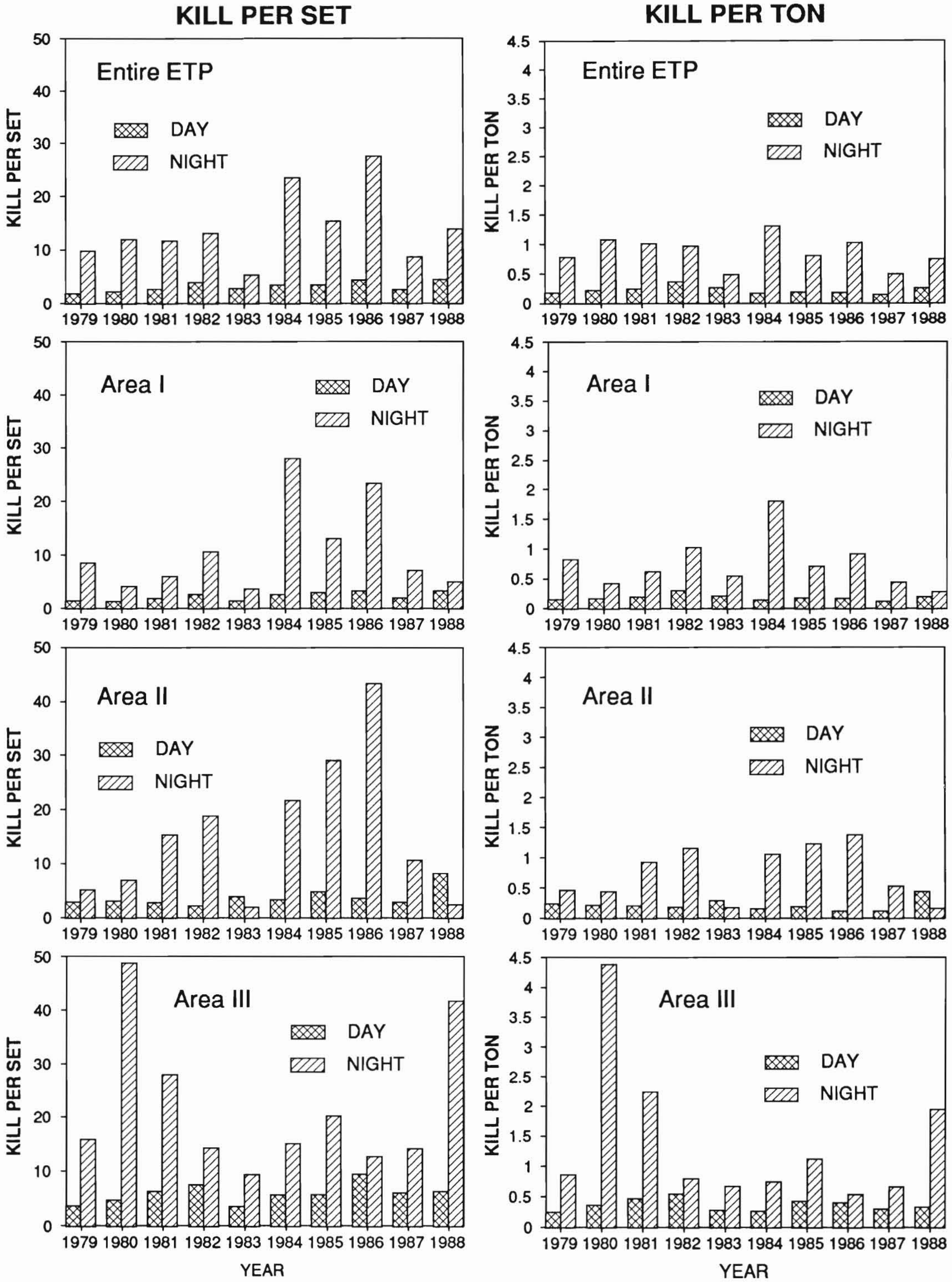

Figure 3.—Kill/set and kill/ton in day and night sets of U.S. purse seiners fishing in the eastern tropical Pacific (ETP) and three subareas of the ETP.

88 were detected in kill/set for day sets in area I only (Table 3).

Day sets in the ETP had significantly higher percentages of zero-kill sets and lower percentages of high-kill sets than night sets (Table 2). Night set zero-kill percentages ranged from 36 to 51%, whereas day set percentages ranged from 52 to 71% (Figure 4). Percent-

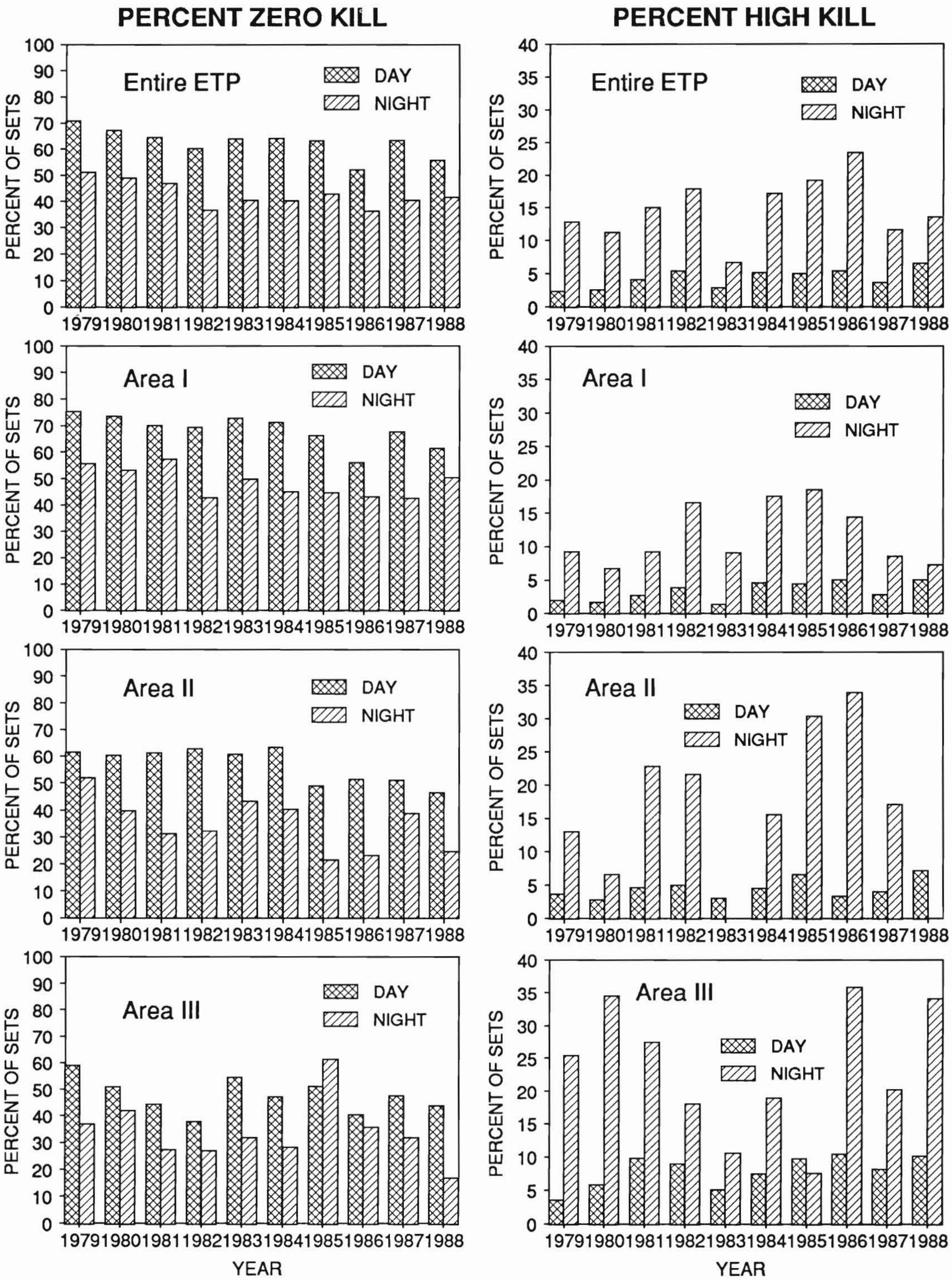

Figure 4.—Percentages of zero-kill sets and high-kill sets in day and night sets of U.S. purse seiners fishing in the eastern tropical Pacific (ETP) and three subareas of the ETP.

ages of high-kill sets ranged from 7 to 23% for night sets and 2 to 7% for day sets. The greatest differences between the percentages occurred in zero-kill sets, where day sets were as much as 20% higher than night sets. Significant decreasing trends in both day and night set percentages of zero-kill sets during 1979-88, were detected (Table 4).

Stratified percentages of zero-kill sets in night sets were significantly lower than in day sets for all subareas

Table 4.—Percentages of zero-kill sets and high-kill sets (more than 15 dolphins killed) for day and night sets in the entire eastern tropical Pacific (ETP) and three subareas. The Student's T statistic detects significant trends in the data. Values greater than ±2.306 are significant at the 5% level. Positive values indicate increasing trends and negative values reflect decreasing trends.

	Entire ETP		Area I		Area II		Area III	
Year	Day	Night	Day	Night	Day	Night	Day	Night
Zero-kill:								
1979	71.07	51.21	75.34	55.81	61.82	52.17	59.43	37.25
1980	67.47	49.06	73.70	53.40	60.74	40.00	51.19	42.31
1981	64.75	47.09	70.29	57.41	61.59	31.43	44.67	27.59
1982	60.26	36.89	69.44	42.98	63.13	32.43	38.14	27.27
1983	64.20	40.54	72.85	50.00	60.98	43.48	54.76	32.14
1984	64.44	40.38	71.32	45.10	63.59	40.62	47.47	28.57
1985	63.51	43.15	66.33	44.72	49.16	21.74	51.52	61.54
1986	52.12	36.42	56.18	43.33	51.58	23.40	40.67	36.00
1987	63.61	40.55	67.74	42.65	51.16	39.06	47.88	32.20
1988	55.91	41.67	61.57	50.41	46.72	25.00	44.11	17.07
Student's T	−3.01	−2.53	−3.44	−2.34	−4.04	−2.17	−1.31	−0.50
High-kill:								
1979	2.41	12.90	1.96	9.30	3.70	13.04	3.62	25.49
1980	2.62	11.32	1.68	6.80	2.92	6.67	5.95	34.62
1981	4.21	15.12	2.76	9.26	4.72	22.86	9.97	27.59
1982	5.46	17.96	3.86	16.67	5.07	21.62	9.09	18.18
1983	2.98	6.76	1.39	9.09	3.14	0.00	5.16	10.71
1984	5.25	17.31	4.66	17.65	4.62	15.62	7.59	19.05
1985	5.09	19.29	4.47	18.63	6.70	30.43	9.85	7.69
1986	5.41	23.46	5.07	14.44	3.41	34.04	10.53	36.00
1987	3.68	11.69	2.86	8.60	4.13	17.19	8.28	20.34
1988	6.61	13.69	5.10	7.32	7.30	0.00	10.28	34.15
Student's T	−0.88	−0.85	−0.69	−0.35	0.27	0.15	−0.21	−1.11

of the ETP, and percentages of high-kill sets in night sets were significantly higher than in day sets (Table 2). Percentages of zero-kill sets were significantly lower for both day and night sets in areas II and III than in area I. However, areas II and III generally had significantly higher percentages of high-kill sets than area I. Percentages of zero-kill sets were always lower in night sets than in day sets except for area III in 1985 (Fig. 4). Percentages of high-kill sets were always higher in night sets than in day sets, except in 1983 and 1988 in area II, and 1985 in area III. Significant decreasing trends were found in the percentages of zero-kill sets for day sets in areas I and II and for night sets in area I (Table 4).

Comparisons of Floodlight Use in Night Sets

During 1982-88, night sets using high-intensity floodlights generally produced significantly lower mortality rates (4-77%) than night sets using other types of lights (Table 2). Only in 1985 did kill/ton for night sets that used other lights fall below kill/ton in night sets that used high-intensity floodlights (Fig. 5). The greatest difference occurred in 1984 when kill/set in sets using high-intensity floodlights was approximately 77% lower than kill/set in sets using other types of light. High-intensity floodlights were therefore effective in reducing night set mortality rates. However, mortality rates were

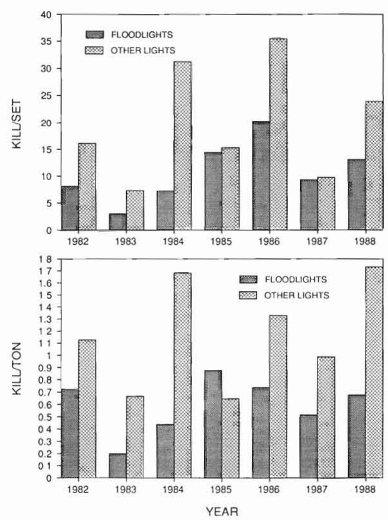

Figure 5.—Kill/set and kill/ton in night sets of U.S. purse seiners fishing in the eastern tropical Pacific that used high-intensity floodlights or other types of lights.

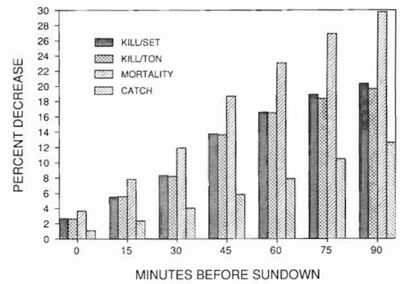

Figure 6.—Percent decreases in kill/set, kill/ton, dolphin mortality, and yellowfin catch if sets beginning after sundown or at various times before sundown (e.g., 15, 30, 45, etc., minutes) were eliminated from dolphin sets made by U.S. purse seiners fishing in the eastern tropical Pacific during the period 1979 to 1988.

still significantly lower in day sets (Table 2).

Effects of Prohibiting Night Sets

Night sets begin before sundown or during the twilight hours, while herds of dolphins can still be seen, extend into darkness, and are usually completed before midnight. Regulations prohibiting these night sets were simulated by selecting time limits (sundown and 15, 30, 45, 60, 75, and 90 minutes before sundown), eliminating both day and night sets starting after each of these time limits and calculating and comparing the new total (day and night sets combined) mortality rates to rates before any sets were eliminated.

Results showed that average total mortality rates for 1979-88, decreased approximately 6-20% (Fig. 6), depending on the time limit chosen. Total mortality decreased as much as 30% and catches dropped 13%.

The simulation did not eliminate all night sets. Even by prohibiting sets starting after 90-minutes before sundown, 144 night sets that killed 3,651 animals still remained. Some of these sets started as much as 5 hours before sundown and, because of problems during the set or other reasons, extended into darkness. The resulting average kill/set of 25 dolphins per set for these sets was almost 79% higher than the average kill/set in the ETP (14 dolphins/set) before any night sets were eliminated.

The simulation also eliminated valid day sets that started after the time limits and, because operations went so quickly, were completed before darkness. Under the 90-minute set prohibition, 705 sets or approximately 4% of the valid day sets were lost along with 4% (9,800 tons) of the yellowfin tuna catch.

Discussion

Our results show that night sets, while contributing only 30% of the observed mortality, killed animals at a significantly higher rate than day sets. Stratification of the data by the three subareas did not change these results.

Factors such as proximity of the start of the set to sundown, size of the yellowfin catch, and problems that occur during dolphin sets extend sets into darkness where higher mortalities occur. Fishermen have tried to reduce the effects of darkness in night sets through the use of high-intensity floodlights. While these lights decreased mortality rates in night sets by making animals in the net more visible, mortality rates in sets using these lights were still significantly higher than day set mortality rates, probably because animals that are usually seen in daylight, i.e., just below the surface and at the fringes of the lighted area, still go undetected.

It appears that all past efforts to eliminate the significant differences between day and night set mortality rates failed, probably due to the unique factor that darkness plays in making dolphins more vulnerable during night sets. However, our study shows that through regulations aimed at reducing the number of night sets while minimizing the effect on day sets, substantial decreases in overall mortality rates (day and night sets combined) can be attained. Since some night sets would still occur under these regulations, additional decreases in mortality rates could be made if they were eliminated.

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