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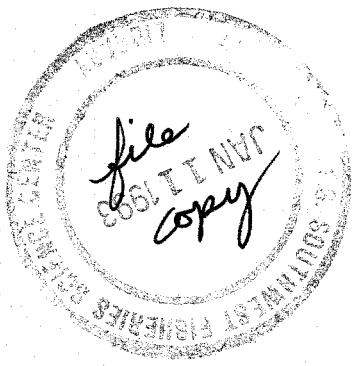

MAY 1990

EFFECTS OF INCLUDING IN MORTALITY ESTIMATES, DOLPHINS CATEGORIZED AS EITHER INJURED OR OF UNDETERMINED STATUS

Charles W. Oliver
Elizabeth F. Edwards

NOAA-TM-NMFS-SWFC-138

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Center

NOAA Technical Memorandum NMFS

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EFFECTS OF INCLUDING IN MORTALITY ESTIMATES, DOLPHINS CATEGORIZED AS EITHER INJURED OR OF UNDETERMINED STATUS

Charles W. Oliver and Elizabeth F. Edwards

INTRODUCTION

The purse-seine fishery for tuna in the eastern tropical Pacific Ocean incurs mortality of dolphins incidental to fishing operations (Perrin 1969). This mortality is monitored by observers placed aboard purse seiners by the National Marine Fisheries Service (NMFS) and the Inter-American Tropical Tuna Commission (IATTC), as required by the Marine Mammal Protection Act (MMPA) of 1972. NMFS uses data collected by these observers to produce bi-weekly estimates of marine mammal mortality attributed to United States-registered vessels which have been certificated[1] to "fish on dolphins". The bi-weekly estimates determine whether the U.S. fleet has met or exceeded an annual quota for allowable mortality (Lo, Powers and Whalen, 1982). Since 1981, this annual quota has been 20,500 animals (total mortality), and there have been with species or stock quotas as small as 250 animals for coastal spotted dolphins (Stenella attenuata). The Eastern spinner dolphin (Stenella longirostris) stock was designated as depleted under the MMPA[2] and currently has an annual quota of 2,750 animals. During late 1986, the total quota was exceeded and "fishing on dolphins" was suspended for the U.S. fleet.

Mortality estimates are based currently on tallies of known to be dead animals (Lo et al., 1982, Hall and Boyer 1986; 1987). In addition to these identified deaths, some dolphins suffer various types of physical "injuries" during fishing operations. Tallies of these "injured" animals have been kept as well. Because some "injuries" may be serious enough to cause subsequent mortality, questions have been raised recently about the effect of including in the mortality estimates, tallies of animals observed or suspected to be "injured". In addition, observers are sometimes unable to determine whether an animal was dead or alive when released. Tallies of these "status undetermined" animals have also been recorded. Because some of these animals may have been dead, the effect of including some or all of them in the mortality estimates is also a concern.

This study describes the results of adding tallies of these "injured" and "status undetermined" animals to the dead tally used to estimate mortality. Results are described for total annual mortality and annual mortality, by species or stock, for the years 1975-1987, both with and without adjustments to the fraction of dolphins tallied as either "status undetermined" or "injured". We limited our analyses to 1975-1987 because 1975 was the first year that both "status undetermined" and "injured"

categories were implemented, and we did not have all the 1988 data when we initiated the study. We arbitrarily divided the data into two periods (1975-1980 and 1981-1987) because the annual mortality quota was reduced to 20,500 animals beginning in 1981. Data were collected by both NMFS and IATTC observers placed aboard U.S.-registered vessels certificated[1] to "fish on dolphins".

METHODS

Data sources and definitions. NMFS has collected data on the numbers of dolphins affected by purse-seine fishing for tuna by U.S.-registered vessels in the eastern tropical Pacific Ocean since 1971. In 1979, IATTC began a similar, concurrent program to collect data from both U.S. and non-U.S. vessels. Since 1981, both agencies have sampled trips from three arbitrarily defined calendar-year intervals, in order to obtain a representative sample and reduce the variance of the dolphin kill estimates. Data are collected by either NMFS or IATTC observers who accompany vessels making trips during each calendar year (Lo et al., 1982). Because trips can overlap years and because mortality estimates are produced for calendar years, we define the number of trips in any year as the number of vessel cruises which made one or more dolphin sets in the eastern tropical Pacific (ETP) during that calendar year. The number of sampled U.S. trips ranged from a minimum of 6 trips in 1971 to a maximum of 119 trips during 1987.

Because our sampling unit is a trip, and because we wanted to produce a multi-year, average annual-percent-increase in kill due to inclusion of undetermined and injured animals, we required an estimate of the total number of trips in each calendar year in order to weight this average by sample coverage. The total number of trips in any given year (sampled or not) cannot be determined until the end of the year, and we were unable to ascertain if trips that were not sampled made a dolphin set. Since 1981, the NMFS and Porpoise Rescue Foundation (PRF)[3] have calculated the observed percent of fleet days for the U.S. fleet fishing on dolphins in the ETP, which ranged from 29% in 1984 to 95% in 1987[3]. We estimated the total number of U.S. trips during each calendar year (1981-1987) by dividing the number of sampled trips in a calendar year (our definition) by the percent coverage for that year[3].

Data were extracted from the NMFS Tuna/Porpoise databases for 1975 through June 1988, primarily from the Marine Mammal Set Log and Tally Sheet. IATTC provided their data from years 1979 through September 1988. We present data and analyses for the period 1975-1987 and part of 1988, during which both "status undetermined" and "injured" data were collected. A total of 27,703 sets (1,030 trips) were available for analysis; 17,942 sets from NMFS and 9,761 sets from IATTC. The analyses presented here include all sets which involved marine mammals, including

sets involving whales and sets which involved marine mammals inadvertently. During some sets, observers were unable to account completely for all animals. These "missing data" sets were identified if either datum **TOTAL KILLED** or **TOTAL INJURED** were missing from the "Marine Mammal Set Log"[4]. We eliminated 90 sets because of "missing data", and used 27,613 sets for subsequent analyses. We limited our analyses to 8 species or stocks of dolphins, a ninth group comprising all remaining marine mammals, and a tenth group of all groups combined. The tallies for each tally category, by group and year, are shown in Appendix 2. We present results for the following cetacean groups:

1)	Offshore Spotted dolphin	Stenella attenuata
2)	Coastal Spotted dolphin	Stenella attenuata
3)	Unidentified Spotted dolphin	Stenella attenuata
4)	Whitebelly Spinner dolphin	Stenella longirostris
5)	Eastern Spinner dolphin	Stenella longirostris
6)	Unidentified Spinner dolphin	Stenella longirostris
7)	Common dolphin	Delphinus delphis
8)	Striped dolphin	Stenella coeruleoalba
9)	All other marine mammals	
10)	1-9 combined	

The data collected by observers include estimates of the number of dolphins observed in various categories of physical condition, and the timing of various events during the purse-seine operation. Between the time a vessel commits to a set ("net let go") and the end of "backdown" (a mortality-reducing procedure conducted after the net is closed and pursed, but before it is brought close to the vessel; Coe and Sousa (1972)), observers estimate the number of animals in the school, the number chased, the number captured, the number released alive before backdown, and the number released alive during backdown. None of these estimates were used in the present analysis.

Throughout a set, observers record the number, species, ageclass, and sex of dolphins released from the net categorized to a number of physical conditions. These "tallies" are recorded on the "Marine Mammal Set Log Tally Sheet" (Appendix 1). Prior to the end of backdown observers tally all animals defined by categories 1, 3, or 5 described below, as they are released from the net. Category 4 animals are counted separately and added to the "Marine Mammal Set Log" variable "Total Injured". Category 2 animals are counted and entered onto the "Marine Mammal Set Log" among a number of variables. After backdown, NMFS observers tally all animals subsequently released from the net as one of 5 categories defined in the NMFS observers' field manual[4]:

1: DEAD (D): those marine mammals that were observed to have been removed from the net in a post-mortem status.

2: ESCAPED OR RELEASED ALIVE: (A) those marine mammals that were observed to have left the net alive and uninjured.

3:	STATUS UNDETERMINED: (SU)	those marine mammals that were observed to have left the net in a condition that could not be categorized as dead or alive.
4:	ESCAPED OR RELEASED ALIVE BUT INJURED: (AI)	those marine mammals that were observed to have left the net alive but injured.
5:	STATUS UNDETERMINED BUT INJURED: (SUI)	those marine mammals that were observed to have left the net in an injured condition that could not be categorized as dead or alive.

The NMFS definition of injured was:

> "animals observed 1) bleeding, 2) having obviously broken bones, or 3) having gone through the power block"[4].

The IATTC definition of injured was:

> "Those live animals that were observed being removed from, or leaving, the net with an injury. An "injured" animal is one that appears to have broken bones, flippers, snout, or severely torn flippers, fin, or flukes and may be swimming erratically. Animals that are bleeding profusely are to be considered as injured, but do not confuse bleeding profusely with superficial net cuts." [5]

There have been changes in data definitions and the methods used to collect data since the NMFS program began in 1971. Differences also exist between NMFS and IATTC methods used to collect and record data. Methods specific to NMFS include: 1) the addition of categories 4(AI) and 5(SUI) beginning in calendar year 1975, 2) tallies by species, sex, and age class within each of five categories beginning with the end of backdown, 3) counting the number of "alive but injured" (AI) prior to the end of backdown, and adding this count to the sum of all tallied injured (AI and SUI) after backdown, to arrive at **"Total Injured"**.

Conversely, IATTC subsumes category 5(SUI) within category 3(SU), records category 2(A) as a total for all species, sexes, and age classes in a variable **"Released Alive After Backdown"** which is not on the "Tally Sheet", and tallies animals which pass over the power block as category 1(D). Also, during 1975-1976 NMFS coded all spotted dolphins as "unidentified spotted dolphin", rather than assigning animals to offshore or coastal spotted dolphin stocks (Figure 1, Appendix 2). We presume all unidentified spotted dolphins to be offshore spotted dolphins for 1975 and 1976, because coastal spotted dolphins are rarely encountered in the fishery (Appendix 2).

We used all tallies recorded on the "Marine Mammal Set Log Tally Sheet", the number of "alive but injured" tallies recorded by NMFS observers before backdown (**"Total Injured"** minus the sum of all injured tallies), and the number of live tallies recorded by IATTC observers after backdown (**"Released Alive After Backdown"**).

Analyses

We added all separate tallies of ageclass and sex, within any group, into totals for the group. We discuss tallies for each group, and totals for "all marine mammals combined" as the sum of all individual groups. We limit our tests and discussion to a grouping of "all marine mammals combined". We used the Mann-Whitney test for the null hypothesis that the distributions of annual-percent-increases are not different between the periods 1975-1980 and 1981-1987. We tested distributions for each category without any adjustments (SU, SUI, and AI), with adjustments (SU-Adjusted and AI-Adjusted), and for options 1, 2, and 3 described below. We will refer to the "status undetermined" (SU) category as simply "undetermined". We will refer to the "status undetermined but injured" (SUI) and "alive but injured" (AI) categories as simply "injured", but perform all calculations and tests on each category separately.

We conducted five sets of analyses referred to as: 1) Simple additions and percentages, 2) Allocation additions, 3) Monthly additions and percentages, 4) Distributions of sets, dead tallies, and undetermined and injured tallies, and 5) Quotas and Closures. We discuss each of these below.

Simple additions and percentages. First, to determine the general effect of including undetermined (SU) and injured (AI and SUI) tallies with the tally of dead, we added the total number of tallies in each of five categories (D, A, SU, AI, and SUI), by year and group. We then calculated the annual-percent-increase in known kill(D) due to including each of three categories (SU, SUI, and AI) separately. We added all injured and undetermined tallies to the dead tally of "all marine mammals combined" for each year using three options. The first option (Option 1) adds all three tally categories (SU, SUI, and AI) to the dead tally, without any adjustments. The second option (Option 2) adds SU-Adjusted tallies (discussed below) in place of SU tallies, and the third option (Option 3) includes both SU-Adjusted and AI-Adjusted tallies (discussed below). Each of these three options represent the mean annual-percent-increase in kill, by year for all marine mammals combined, due to adding injured and undetermined tallies to the dead tally.

Allocation additions. Tallying an animal to the undetermined (SU) category generally means the observer was unable to observe, at close range, the tallied animal. This can occur when large numbers of animals are released from the net at one time, or when animals are released from areas the observer cannot see well (i.e., the vessels' stern). Since these animals were either dead

or alive at the time of release, we decided to present an allocation of these tallies to either dead(D) or alive(A) categories, based upon the ratio of known to be dead and known to be alive tallies, as an alternative to designating all undetermined tallies as dead, or all as alive. We allocated the SU tallies using the formulas:

$$SU(A) = SU * (A/A+D)$$

and

$$SU(D) = SU * (D/A+D)$$

where SU(A) and SU(D) are the number of undetermined tallies(SU) allocated to the categories alive(A) and dead(D), respectively. This allocation, or adjustment, was applied to yearly totals for each group and for all marine mammals combined. We refer to the SU(D) tallies as SU-Adjusted hereafter, and we used these tallies, in addition to all of the undetermined tallies (SU), in some of the analyses.

Although no allocations were necessary for SUI tallies, because all of these tallies represent injured animals, we did make a second allocation which affected the AI category. We applied the ratio of "alive and injured" (AI) tallies and alive (A) tallies to the portion of SU tallies allocated to the alive category above (SU(A)), and added these tallies to the AI category to produce AI-Adjusted. The formula used was:

$$AI(adjusted) = AI + ((AI/(AI + A)) * SU(A))$$

where AI(adjusted) is the number of undetermined tallies assumed to have been released alive but injured. This allocation was applied to yearly totals for each group and for all marine mammals combined.

Monthly additions and percentages. Third, to explore whether the occurrence of injured and undetermined tallies were concentrated during certain times of the year, we calculated monthly totals of the tallies for each of the five categories (D, A, SU, AI, and SUI), for all marine mammals combined during 1987. We then calculated the average percent-increase in known dead, by month, due to including the undetermined and injured tallies with the dead tallies. We used 1987 data because it contains the greatest number of sampled trips, the highest sample coverage (95% of all fleet-days attributed to U.S.-registered, certificated[1] seiners during 1987 were accompanied by either NMFS or IATTC observers), and it was the most recent year for which we had all the data.

Distributions of sets, dead tallies, and undetermined and injured tallies. Fourth, to explore whether a relationship exists between the occurrence of dead tallies and undetermined or injured tallies, we plotted and analyzed the distribution of the number of marine mammal sets, dead tallies, and undetermined and injured

tallies added together, for the period 1981-1987 using the data for "all marine mammals combined".

Quotas and Closures. Finally, to demonstrate graphically the effect of early closure, or inadvertent extension, on the fishery due to under-estimating the kill (by not including undetermined and injured tallies with the dead tallies), we calculated the number of days the fishery would lose (early closure) or gain (extension), and the number of animals that would result from under-estimating the kill by 2%, 5%, and 8%. We chose these percentages because they are similar to the annual-percent-increases in kill we obtained from our analyses for the period 1981-1987, and discuss them in light of annual quotas of 20,500 and 2,750 dolphins.

RESULTS

Additions and Allocations. The number of trips in our sample ranged from 29, in 1984, to 119 during 1987 (Table 1). Our estimates of the total number of US trips in a calendar year (our definition of trip) ranged from 98, in 1986, to 238 during 1981. Five species, or stocks, of dolphins (offshore spotted, whitebelly spinner, eastern spinner, common, and striped dolphins) make up 77.3% of the alive, dead, injured, and undetermined tallies included in the group "all marine mammals combined" for the period 1975-1987.

Adding tallies of undetermined (SU) or injured (SUI or AI) animals to the total dead tally simply increased the total kill for any year (Table 2, Figures 1-2). Using the data for "all marine mammals combined", these increases ranged from 0.6% to 7.5% if only SU tallies were added, from 0% to 2.2% if only SUI tallies were added, and from 0.9% to 6.4% if only AI tallies were added to the dead tallies for 1975-1988. The mean annual-percent-increase for each category and all categories combined, by group, are shown in Figures 6-14.

Allocating a portion of the undetermined tallies (SU) to the alive category, based on the ratio of dead and alive tallies (Figure 3), simply reduced the number of undetermined tallies (SU-Adjusted) added to the total kill (Table 2, Figures 4-5). Using the data for "all marine mammals combined", we did not detect a significant difference in the mean annual-percent-increase between the periods 1981-1987 and 1975-1980, when only undetermined tallies (SU or SU-Adjusted) were added to the dead tally (Mann-Whitney, $P>0.2$, $U_{6,7}=26.5$ and $U_{6,7}=26$).

Although no allocations were necessary for SUI tallies, because all of these tallies represent injured animals, we did make a second allocation which affected the AI category of tallies (Figures 2 and 5). This second allocation results in a slight increase in the number of "alive and injured" tallies (AI-Adjusted) as shown in Table 2, and Figure 5. Again using the data

for "all marine mammals combined", we detected a significant decrease in the mean annual-percent-increase in kill, between the periods 1975-1980 and 1981-1987, due to including only SUI, or only AI, or only AI-Adjusted tallies in the dead tally (Mann-Whitney, $P<0.005$, $U_{6,7}=41$).

We added all injured and undetermined tallies to the dead tally of "all marine mammals combined" for each year using three options (Table 3). While the number of undetermined tallies appears to have remained stable over the years, the number of injured tallies, relative to the dead tallies, has decreased. Adding all tallies of injured and undetermined animals to the tally of "known dead", for all marine mammals combined, would have increased the annual estimate of total mortality as much as $15.2\pm6.0\%$ in 1978, but only by $2.0\pm0.27\%$ in 1985 (Table 3). We detected a significant decrease in the mean annual-percent-increase in kill, between the periods 1975-1980 and 1981-1987, for each of the three options(Mann-Whitney, ($P=0.01$, $U_{6,7}=39$), ($P=0.005$, $U_{6,7}=40$, $U_{6,7}=40$)).

Weighting the 1981-1987 data by the number of total US trips we sampled, then adding all tallies of injured and adjusted tallies of undetermined animals to the tally of "known dead" would have increased the estimate of annual mortality by a weighted average of $5.9\%\pm0.82$ during 1981-1987 (Table 3-Option 1). If only a portion of the animals tallied as undetermined are presumed to have died, then adding all tallies of injured and a portion of the undetermined tallies, to the tally of "known dead", would have increased the estimate of annual mortality by a weighted average of $4.7\pm0.56\%$ (Table 3-Option 3).

Monthly Additions and Percentages. The cumulative tally of injured and undetermined animals increased steadily throughout the year in 1987, for all marine mammals combined and within each of the species/stock groups (Table 4, Figures 15-22). The monthly increase during 1987 ranged from $2.3\pm0.24\%$ to $8.0\pm0.97\%$ (Table 4) with the average for the year equal to $5.1\pm0.17\%$ (Table 3). The additional tallies attributed to injured and undetermined categories remained a small fraction of the total dead tally, and did not show concurrent, precipitous increases as occurred in observed dolphin deaths for some of the groups during 1987 (Figures 17, 18, 19, and 20).

Distributions. The distributions of the number of marine mammal sets, number of dead tallies, and total number of injured and undetermined tallies are shown in Tables 5-7, respectively. These tables show that 59.1% of all 13,673 sets during 1981-1987 did not have any tallies of dead, undetermined, or injured animals. A larger percentage of sets had zero tallies of undetermined or injured animals (92.9%) than sets that had zero tallies of dead animals (60.8%). Conversely, a smaller percentage of sets had tallies totaling 15 or more undetermined and injured animals (0.1%) than sets that killed 15 or more animals (5.5%).

The largest number of undetermined and injured tallies that

occurred in any one set during 1981-1987 was 248 tallies, the next largest 102, and the third largest was 75 tallies. The average number of undetermined and injured tallies in the 15 sets that had tallies of 15 or more animals (undetermined and injured) was 47 animals-per-set. In contrast, the three largest tallies of dead animals were 736, 732, and 446 animals, respectively, and the average number of dead tallies, in 757 sets that killed 15 or more animals, was 52 animals-per set. There were 20 sets that had dead tallies of at least 248 animals, and 220 sets had kills greater than 47 animals-per-set.

There were sets where the dead tally was small (e.g. 3 tallies) and the combined injured and undetermined tally was large (e.g. 248 tallies), as shown in Tables 5-7. Upon examination of the 5 sets that killed fewer than 15 animals, but tallied 15 or more injured and undetermined tallies, we found that most of the tallies were undetermined tallies (76.6%), rather than injured tallies. There were 10 sets that had at least 15 dead tallies, and 15 injured or undetermined tallies, and in these sets, 88.6% of the latter were undetermined tallies. These 15 sets, each of which incurred at least 15 undetermined and injured tallies, account for 36% of all the undetermined and injured tallies during 1981-1987. Most of these tallies were undetermined tallies rather than injured tallies.

Quotas and Closures. Assuming any quota would not be reached until the last day of a calendar year, we calculated the number of days that would be lost to the fishery if the quota was underestimated by 2%, 5%, and 8% as 7 days, 17 days, and 27 days, respectively (Figures 23-26). We calculated the number of additional tallies, that would inadvertently result from reaching any quota without having included undetermined and injured tallies, as 2%, 5%, and 8% of the kill. For a quota of 20,500 animals, the additional tallies would be 410, 1,025, and 1,640 animals, respectively (Figure 24). For a quota of 2,750 animals, the additional tallies would be 55, 138, and 220 animals, respectively (Figure 26).

DISCUSSION

The category "status undetermined" tells us nothing about the physical condition of the animal tallied as such. Whether these animals are dead or alive, or subsequently live or die, is open to argument. The number of these tallies, relative to the dead tallies, appear to be fairly consistent over the years, and may be unavoidable. Operational aspects of the pursing operation, an observers' capabilities and physical location during a set while tallying released animals, the number of live animals remaining in the net after backdown, the methods employed to release animals, and the locations of release, could all increase the number of undetermined tallies, because the observer is unable to ascertain the condition of animals released from the net.

"Injury", as defined by NMFS and IATTC, occurs when animals are entangled in the net, brought aboard in either the net or brailer, or pass over the powerblock. The chance of injury increases as the amount of net left in the water decreases because the animals are more likely to come in contact the net, and thus become entangled. The category "injured" provides some information about the physical condition of an animal tallied as such, although not necessarily the probability that the animals will live or die. Certainly some of these animals die, because "passing over the powerblock" or "bleeding profusely" are injuries severe enough to ultimately, if not immediately, cause death.

The reduced number of injured tallies we found, between the periods 1975-1980 and 1981-1987, may be due, in part, to increased efforts by the fishermen to release animals because of regulations and guidelines established by NMFS, and the reduced mortality quota in effect beginning in 1981. Because most injuries can be ascertained only by relatively close observation of an animal, earlier releases of animals away from the vessel could reduce the number of animals an observer viewed closely, and thus reduce the number of animals tallied as injured. Alternatively, less emphasis by an observer in ascertaining injuries could also account for the reduction in the number of injured tallies between the two periods.

Whether the criteria used by NMFS and IATTC adequately define injury, and whether such injury results in death is unclear. Minor skin abrasions may bleed causing the animal to be tallied as injured by NMFS observers and, only if the bleeding is "profuse", by IATTC observers. Similarly, an animal could suffer internal injuries unknown to the observer that ultimately lead to death, yet be tallied as uninjured. During the period 1981-1987, IATTC observers tallied fewer, and NMFS observers tallied more, than the average annual number of undetermined and injured tallies. In each year, IATTC data produced annual increases less than the combined IATTC and NMFS data, while NMFS data produced greater than the average annual increase of the combined data. This is not entirely unexpected because IATTC observers do not include animals that pass over the powerblock, or animals with "minor skin abrasions", in their tallies of injured and undetermined. However, the effect of future changes in the number of trips sampled, and the observer type assigned to these trips (NMFS or IATTC), may warrant further analysis in any calculation of a multi-year average-annual-percent-increase in kill due to including undetermined and injured tallies.

Because our primary objectives for this study were to determine how much an estimate of total mortality would increase if we included injured and undetermined categories with tallies of known kill within years and, how this increase might affect dates of closure upon reaching a quota, we did not stratify by geographic areas or by intra-annual periods, nor were any adjustments made to account for differences in the percent of vessels observed per year (i.e., fleet coverage), as has been

done by others in analyzing dolphin kill (Hall and Boyer, 1987, 1986, Lo et al., 1982). This lack of accounting for differences in fleet coverage leads in some cases to striking, but for these analyses, irrelevant patterns in the figures. For example, total kill appears to be unusually high during 1987 but this is because, at least in part, more trips were sampled in 1987 (95% of the fleets' trips) than during other years when only 30-40% of trips were sampled[3].

The effect of adding undetermined and injured tallies to tallies of known dead can be dramatic, but potentially misleading, when the kill is small. For example, the tally of coastal spotted dolphins killed during 1981 increased by 100% when a single "status undetermined but injured" (SUI) animal was added to the single "known dead" tally for that year. Similar examples are the percent increases for unidentified spotted dolphins in 1978, unidentified spinner in 1978, common dolphins in 1980, and "all other marine mammals" in 1981 (Figures 7, 8, 11, 12, 14 and Appendix 2). The number of additional tallies (undetermined and injured) added to the dead tally will determine the effect on the mortality estimate, and thus, the effect on any quota or closure date. The annual-percent-increases we present merely provide a convenient means of presenting the number of additional tallies relative to any given kill.

Although we did not test for any effect related to the species or stock of animals, it appears from inspection of the data (Figures 6-14), that the reduction in the annual-percent-increase in kill between 1975-1980 and 1981-1987, due to adding tallies of undetermined and injured animals to dead tallies, was true for at least 3 of the 5 major species or stocks of dolphins (offshore spotted, whitebelly spinner, and common), and in our opinion for eastern spinner too (Figures 6, 9, 12, 10, respectively). The tallies of these four species are 76.6% of all live, dead, injured, and undetermined tallies during 1975-1987.

Monthly additions and percentages. Current estimates of mortality are based upon dolphin kill-per-day rates for the U.S. fleet. Whether our use of "injured-per-month" relative to "kill-per-month" adequately addresses any daily effect may require further analyses. During 1987 the tallies of undetermined and injured, relative to the dead tallies, were not concentrated within any particular month and ranged from 2.3% to 8.0%. While some of these monthly increases deviate by more than one standard error from the yearly average ($5.1 \pm 0.17\%$), we suggest this variability results from the very small number of tallies involved in calculating the monthly increases. In any event, we doubt that an early closure, or inadvertent extension, of the fishery would have occurred during 1987 as a result of the monthly distribution of these tallies, because the even largest monthly increase amounted to only 8.0% of the kill.

Distributions. Sets incurring tallies of injured and undetermined animals occurred less frequently than sets incurring tallies of kill, and the number of undetermined and injured tallies in most

sets is much smaller than the number of dead tallies. NMFS defines a "disaster set" as one which incurs a kill of 15 or more animals. The data in Tables 5-7 show that 5.5% of all sets were "disaster sets", and 71.2% of the kill occurred in these sets. Substituting undetermined and injured tallies for dead tallies in defining a "disaster set", the data show that only 0.1% of the sets meet the criteria, and these sets account for only 25% of all undetermined and injured tallies during the period 1981-1987. Thus, while adding these tallies to the dead tallies will increase the estimate of mortality, the effect will be a relative small increase with little additional variability in the estimate of mortality.

Quotas and Closures. The addition of injured and undetermined tallies to dead tallies will increase the cumulative tally for kill at any given time, above that based simply on the tally of "known dead" animals. If these animals did not die subsequent to their release from the net, then adding their tallies to the dead tallies over-estimates the total mortality for the fleet. This will shorten the time required to reach a mortality quota of 20,500 total animals or a quota of 2,750 animals for the Eastern spinner dolphin stock, thus "closing the fishery" earlier during years when mortality has been high enough to approach a quota in less than 365 days. The actual decrease in time to realize a quota will depend upon the specific quota, the kill rate of the observed fleet, and the number of animals tallied as injured and undetermined, that are presumed to have died and therefore should have been tallied as dead. Alternatively, if the animals tallied as injured and undetermined do in fact die, but their tallies are not added to the dead tallies, then the true mortality will be underestimated. For example, if all injured and undetermined animals die, but are excluded from an estimate of total kill relative to an annual quota of 20,500 dolphins, under-estimating the kill by 2% to 8% results in the death of an additional 410 to 1640 dolphins (2% and 8% of 20,500, respectively). Under-estimating the kill relative to a smaller quota (e.g. 2,750 Eastern spinner dolphins) by 2% to 8% results in the death of an additional 55 to 220 dolphins (2% and 8% of 2,750, respectively).

Under-estimating the kill could also result in an inadvertent extension of the fishery, assuming a specific quota would have been reached within some number of days based upon the "known dead". The length of any extension depends upon the percentage by which the true kill-per-day is underestimated, the annual quota, and the fleets' observed kill-per-day (Figures 24 and 26). To fish all 365 days during any year, the fleet must stay at, or below, an average kill-per-day of 56.16 dolphins under a quota of 20,500 animals (20,500 / 365 = 56.16). A kill-per-day of 7.53 Eastern spinner dolphins would allow the fleet to fish through day 365 under a stock quota of 2,750 animals (2,750 / 365 = 7.53).

The length of any extension of the fishing season due to underestimating the kill can be determined using the formula:

$$\text{Extension (days)} = 365 - \frac{Q}{\left(1 + \frac{P}{100}\right) * K}$$

where

Q = annual quota (e.g. 20,500 or 2,750 animals)
P = percentage the true kill-per-day is underestimated
K = observed kill-per-day

Assuming a fleet kill-per-day rate of 56.16 dolphins and an annual total quota of 20,500 dolphins, or a rate of 7.53 Eastern spinner dolphins and an annual stock quota of 2,750 animals, the fishing season would be extended approximately 7 days if the true kill-per-day is underestimated by 2%, 17 days if underestimated by 5%, and 27 days if underestimated by 8% (Figures 24 and 26).

During 1981-1987, the US fishery exceeded the allowable quota of 20,500 animals, and closed early in both 1982 and 1986 (Marine Mammal Commission, 1989). Thus, in these years the effect of including tallies of undetermined and injured in estimates of mortality, would have been to close the fishery earlier. The date of the actual closure would, of course, depend upon the percentage by which mortality was underestimated (e.g. 6.6% using Option 1, 5.9% using 1981-1987 average, or 5.1% using Option 3, for 1982)(Table 3). The estimated kill by the US fleet in 1981 was 18,780 porpoise. If the mortality for 1981 was underestimated by the percentage calculated using either Option 1 (5.9%) or Option 3 (4.7%), then the effect of including the tallied injured and undetermined would have been additional dolphin deaths, although the quota still would not have been reach during the year. If however, the underestimate of the kill was based upon the actual number of injured and undetermined tallies which occurred during 1981 (10.6% of kill estimate), then the effect would have been an early closure because the quota would have been exceeded if these tallies were added to the dead tallies (20,771 porpoise).

ACKNOWLEDGMENTS

We thank the many observers who have collected data aboard tuna purse-seiners over the years. Jim Joseph and Martin Hall (IATTC) provided access to the data collected by IATTC observers. Ken Wallace (NMFS) and Susan Boyer (IATTC) developed the computer programs used to extract these data to our specifications. Ken Raymond contributed to the quality of the figures. We received many useful comments on various drafts from Steve Reilly and Doug DeMaster. Cleridy Lennert was immensely helpful in the application of the various statistical tests. Thanks to all.

LITERATURE CITED

Coe, J.M. and G. Sousa 1972. Removing porpoise from a tuna purse seine. Marine Fisheries Review. 34(11-12):15-19.

Hall, M.A. and Boyer, S.D. 1986. Incidental mortality of dolphins in the eastern tropical Pacific tuna fishery: description of a new method and estimation of 1984 mortality. Rep. int. Whal. Commn 36:375-381.

Hall, M.A. and Boyer, S.D. 1987. Incidental mortality of dolphins in the eastern tropical Pacific tuna fishery in 1985. Rep. int. Whal. Commn 37:361-362.

Lo, N.C.H., Powers, J.E. and Whalen, B.E. 1982. Estimating and monitoring incidental dolphin mortality in the eastern tropical Pacific tuna purse seine fishery. Fish Bull., U.S. 80(2):396-401.

Marine Mammal Commission. 1989. Annual report of the Marine Mammal Commission, Calendar Year 1988. A report to congress. page 149. Marine Mammal Commission, 1625 I Street, N.W., Washington, D.C., 20006. 232pp.

Perrin, W.F. 1969. Using porpoise to catch tuna. World Fishing 18(6):42-45.

FOOTNOTES

1 United States vessels which plan to initiate sets involving dolphins must first obtain a certificate from the National Marine Fisheries Service, Southwest Region, 300 South Ferry Street, Terminal Island, CA. 90731.

2 Established as Pub. L. 98-364, July 17, 1984

3 Porpoise Rescue Foundation, Mr. Robert Solomons, pers. comm., P.O. Box 210271, San Diego, CA 92121.

4 1987 Tuna/Porpoise Observer Field Manual. National Marine Fisheries Service. 1520 State Street, Suite 200, San Diego, CA 92101.

5 1987 Inter-American Tropical Tuna Commission Tuna-Dolphin Investigation Field Manual. Edited by David Bratten, Inter-American Tropical Tuna Commission. c/o Scripps Institution of Oceanography, La Jolla, CA 92093.

Table 1. Number of sampled trips, percent of US fleet-days sampled, and estimated total number of US trips, by calendar year, for 1975-1988.

YEAR	Number of TRIPS sampled	Percent Coverage	Estimated total U.S. TRIPS
	n	%	N
1975	34		
1976	67		
1977	102		
1978	108		
1979	103		
1980	105		
1981	95	40	238
1982	82	40	205
1983	44	30	147
1984	29	29	100
1985	49	47	104
1986	43	44	98
1987	119	95	125
1988	50	53	

Table 2. Percent increase, and standard errors (S.E.), in marine mammal kill caused by including other categories of "Marine Mammal Set Log Tally Sheet" data. Data are from NMFS and IATTC for calendar years 1975-1988. A finite population correction factor is included in the standard errors for 1981-1987. (1988 does not include NMFS data after June, nor IATTC data after September).

Year	Status Undetermined						Alive			
	Uninjured (SU)		Uninjured (SU) Ajusted		Injured (SUI)		Injured (AI)		Injured (AI) Ajusted	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.	%	S.E.
1975	1.8	1.25	1.5	1.11	.8	.22	4.2	.91	4.3	1.03
1976	2.0	1.52	1.4	1.14	2.0	1.49	6.1	2.63	6.2	2.73
1977	2.5	.54	1.1	.24	2.0	.39	6.3	.98	6.3	1.14
1978	7.5	5.59	3.6	2.63	2.2	.78	5.6	1.51	5.7	2.41
1979	3.8	.82	2.0	.47	.8	.26	6.4	1.60	6.5	1.84
1980	2.5	.97	1.4	.51	.6	.23	5.3	1.37	5.4	1.39
1981	5.4	2.14	2.7	1.05	.7	.22	4.4	.97	4.6	1.24
1982	3.8	1.19	2.2	.70	.1	.04	2.7	.43	2.7	.54
1983	2.2	.81	1.4	.51	.4	.25	2.5	.75	2.5	.76
1984	.8	.40	.6	.29	.0	.02	1.9	.58	1.9	.58
1985	.6	.12	.4	.08	.2	.05	1.2	.24	1.2	.24
1986	1.7	.40	1.0	.25	.0	.01	1.0	.14	1.0	.19
1987	2.7	.12	1.6	.08	.5	.04	2.0	.07	2.0	.07
1988	1.2	.46	.9	.34	.1	.07	.9	.26	.9	.26
1981-1987 Weighted Average	3.0	0.57	1.7	0.29	0.3	0.06	2.6	0.27	2.6	0.34

Table 3. Percent increase in marine mammal kill caused by including other categories of "Marine Mammal Set Log Tally Sheet" data. Data are from NMFS and IATTC for calendar years 1975-1988. Numbers in parenthesis are the numbers of additional animals tallied. (1988 does not include NMFS data after June, nor IATTC data after September). Variances are based on the "Delta method". Standard errors include a finite population correction factor for 1981-1987.

Year	Percent Increase Under								
	Option 1			Option 2			Option 3		
	%	S.E.	#	%	S.E.	#	%	S.E.	#
1975	6.8	2.09	(1136)	6.5	1.95	(1093)	6.6	1.99	(1104)
1976	10.1	5.59	(1500)	9.5	5.20	(1416)	9.6	5.29	(1429)
1977	10.8	1.49	(1024)	9.4	1.23	(885)	9.4	1.25	(891)
1978	15.2	6.60	(1068)	11.3	3.88	(792)	11.5	4.04	(806)
1979	11.1	2.03	(795)	9.2	1.78	(660)	9.3	1.82	(669)
1980	8.5	2.03	(564)	7.3	1.68	(488)	7.4	1.71	(493)
1981	10.6	3.19	(825)	7.8	2.08	(612)	8.0	2.15	(621)
1982	6.6	1.32	(624)	5.0	0.86	(473)	5.1	0.89	(479)
1983	5.1	1.36	(153)	4.4	1.13	(131)	4.4	1.14	(132)
1984	2.7	0.73	(121)	2.5	0.66	(113)	2.5	0.67	(114)
1985	2.0	0.27	(170)	1.8	0.26	(153)	1.8	0.26	(153)
1986	2.7	0.44	(242)	2.0	0.29	(180)	2.0	0.30	(181)
1987	5.1	0.17	(674)	4.0	0.12	(532)	4.1	0.13	(536)
1988	2.3	0.68	(152)	2.0	0.55	(132)	2.0	0.56	(133)
1981-1987 Weighted Average	5.9	0.82	(476)	4.6	0.55	(367)	4.7	0.56	(371)

OPTION 1: SU + SUI + AI

OPTION 2: SU ajusted + SUI + AI

OPTION 3: SU ajusted + SUI + AI ajusted

Table 4. Percent increase in marine mammal kill caused by including other categories of "Marine Mammal Set Log Tally Sheet" data. Data are from NMFS and IATTC for calendar year 1987, by month. Numbers in parenthesis are the numbers of additional animals tallied. Sampled trips indicate that a U.S. vessel made a dolphin set during the month. Total trips include the sampled trips and U.S. vessels which operated during the month but were not observed. Variance estimates are based on the "Delta method". Standard errors include a finite population correction factor.

Month	Number of TRIPS	Number of TRIPS sampled	Percent Increase Under Option 1			Option 2			Option 3		
	N	n	%	S.E.	#	%	S.E.	#	%	S.E.	#
January	24	18	3.2	0.63	(26)	2.6	0.50	(21)	2.6	0.51	(21)
February	30	25	6.5	1.12	(67)	5.3	0.90	(54)	5.3	0.91	(54)
March	27	25	8.0	0.97	(54)	5.9	0.65	(40)	5.9	0.66	(40)
April	23	22	3.2	0.34	(12)	2.7	0.28	(10)	2.7	0.29	(10)
May	27	27	4.3	0.	(47)	3.6	0.	(39)	3.6	0.	(39)
June	28	28	2.4	0.	(39)	2.2	0.	(35)	2.2	0.	(35)
July	27	27	5.9	0.	(79)	5.0	0.	(67)	5.1	0.	(68)
August	26	26	5.2	0.	(58)	4.2	0.	(47)	4.2	0.	(47)
September	25	25	7.5	0.	(71)	5.9	0.	(56)	6.0	0.	(57)
October	25	25	7.5	0.	(85)	4.2	0.	(48)	4.3	0.	(49)
November	29	28	5.5	0.21	(112)	4.9	0.20	(101)	5.0	0.20	(102)
December	29	27	2.3	0.24	(24)	2.2	0.23	(23)	2.2	0.23	(23)

OPTION 1: SU + SUI + AI

OPTION 2: SU ajusted + SUI + AI

OPTION 3: SU ajusted + SUI + AI ajusted

Table 5. The number of marine mammal sets that tallied dolphins as dead ("intervals of kill") and tallied dolphins as undetermined or injured ("intervals of undetermined or injured"), for the period 1981-1987 (13,673 sets).

		Number of animals tallied as either undetermined or injured																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-25	>25
Number of animals tallied as dead and intervals of kill	0	8081	181	32	15	1	6	1	1			1						1
	1	1409	90	19	7	2	3	2				1		1				
	2	812	54	13	6	4				1	1	1					1	
	3	529	39	16	9	4	3				1							1
	4	324	36	3	4	3	1					2						
	5	215	22	11	5	3	1	2		1						1	1	
	6	206	10	7	2		4	2				1				1		
	7	122	12	10	3			1									1	
	8	114	8	3	2	4												
	9	82	8	4	5	2	1	1			1							
	10	79	4	3			2	1	1	1								
	11	66	9	3	1	2		1	1									
	12	35	5	3	2		1		1			1		1				
	13	39	6	3	1	2	1							1				
	14	30	5	2								1		1				
	15-25	242	29	17	5	4	3	7	1	1	1	1	3				2	
	> 25	320	30	23	15	11	13	3	3	3	3	2	2	2	2	1	3	5

Table 6. The number of marine mammals killed, in sets that tallied dolphins as dead ("intervals of kill") and tallied dolphins as undetermined or injured ("intervals of undetermined or injured"), for the period 1981-1987 (55,572 animals).

		Number of animals tallied as either undetermined or injured																
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-25	>25
Number of animals killed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	1409	90	19	7	2	3	2				1		1				
	2	1624	108	26	12	8				2	2	2					2	
	3	1587	117	48	27	12	9				3							3
	4	1296	144	12	16	12	4					8						
	5	1075	110	55	25	15	5	10		5						5	5	
	6	1236	60	42	12		24	12				6				6		
	7	854	84	70	21			7									7	
	8	912	64	24	16	32												
	9	738	72	36	45	18	9	9			9							
	10	790	40	30			20	10	10	10								
	11	726	99	33	11	22		11	11									
	12	420	60	36	24		12		12			12		12				
	13	507	78	39	13	26	13							13				
	14	420	70	28								14		14				
	15-25	4635	558	310	98	72	57	133	24	16	21	16	57				45	
	> 25	23721	2059	1446	1129	1634	1319	147	123	109	327	124	114	220	94	35	191	740

Table 7. The number of marine mammals tallied as either undetermined or injured, in sets that tallied dolphins as dead ("intervals of kill") and tallied dolphins as undetermined or injured ("intervals of undetermined or injured"), for the period 1981-1987 (2,809 animals).

Number of animals tallied as either undetermined or injured																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-25	>25
Number of tallies of dead animals																	
0	0	181	64	45	4	30	6	7			10						30
1	0	90	38	21	8	15	12				10		12				
2	0	54	26	18	16				8	9	10					15	
3	0	39	32	27	16	15				9							248
4	0	36	6	12	12	5					20						
5	0	22	22	15	12	5	12		8						14	25	
6	0	10	14	6		20	12				10				14		
7	0	12	20	9			6									15	
8	0	8	6	6	16												
9	0	8	8	15	8	5	6			9							
10	0	4	6			10	6	7	8								
11	0	9	6	3	8		6	7									
12	0	5	6	6		5		7			10		12				
13	0	6	6	3	8	5							12				
14	0	5	4								10		12				
15-25	0	29	34	15	16	15	42	7	8	9	10	33				39	
> 25	0	30	46	45	44	65	18	21	24	27	20	22	24	26	14	54	275

Number of tallies of undetermined or injured animals

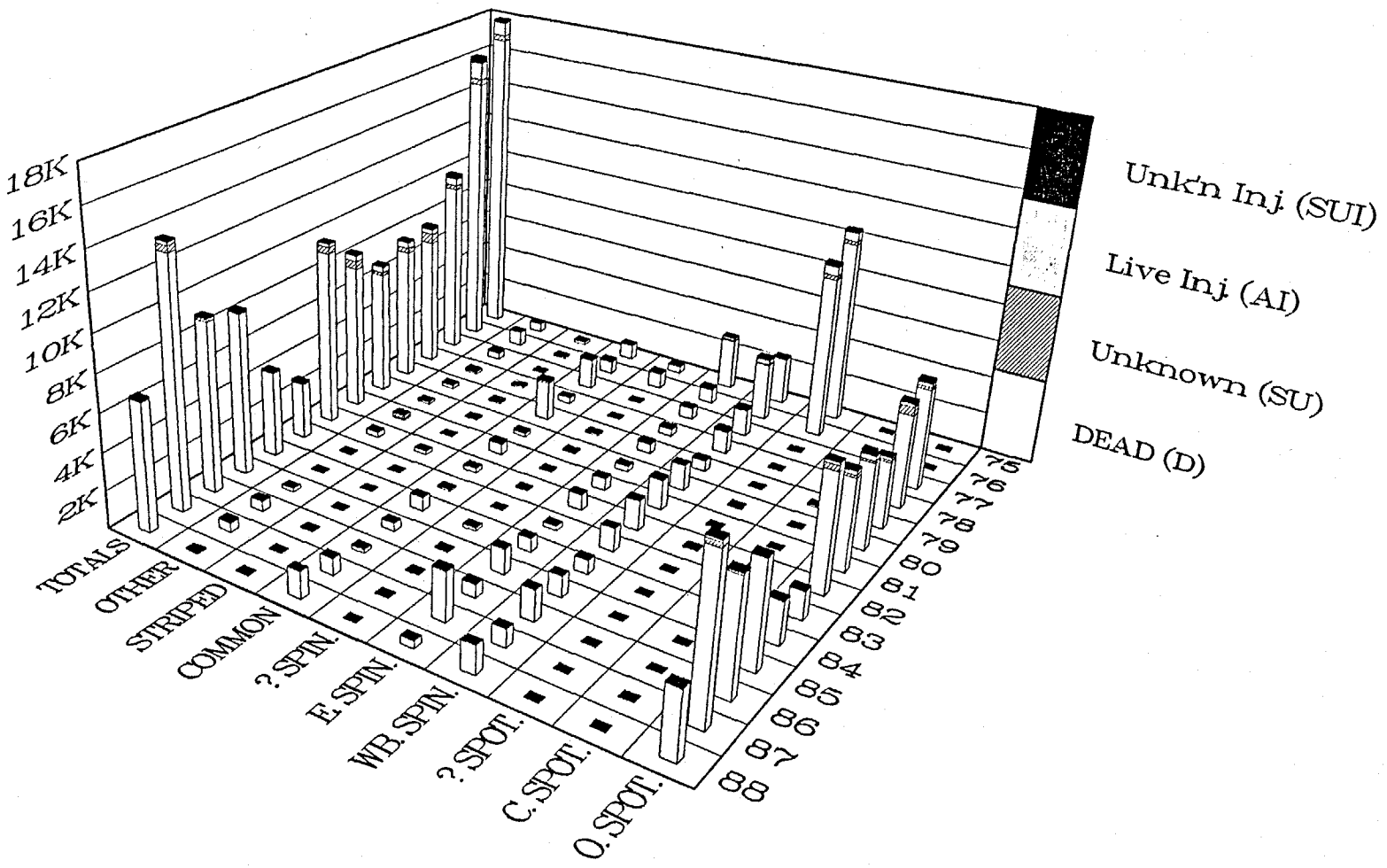

Figure 1. Unadjusted numbers of marine mammals tallied in each of 4 categories (dead, status unknown, alive injured, and status unknown injured) by NMFS and IATTC observers aboard tuna purse-seine vessels fishing in the eastern tropical Pacific Ocean, 1975-1988. Each tower shows the numbers of animals tallied in each category, during each year, for 10 groupings of marine mammals. Groupings include 1-Offshore Spotted dolphin, 2-Coastal Spotted dolphin, 3-Unidentified Spotted dolphin, 4-Whitebelly Spinner dolphin, 5-Eastern Spinner dolphin, 6-Unidentified Spinner dolphin, 7-Common dolphin, 8-Striped dolphin, 9-All other marine mammals, and 10- all 9 groups totaled.

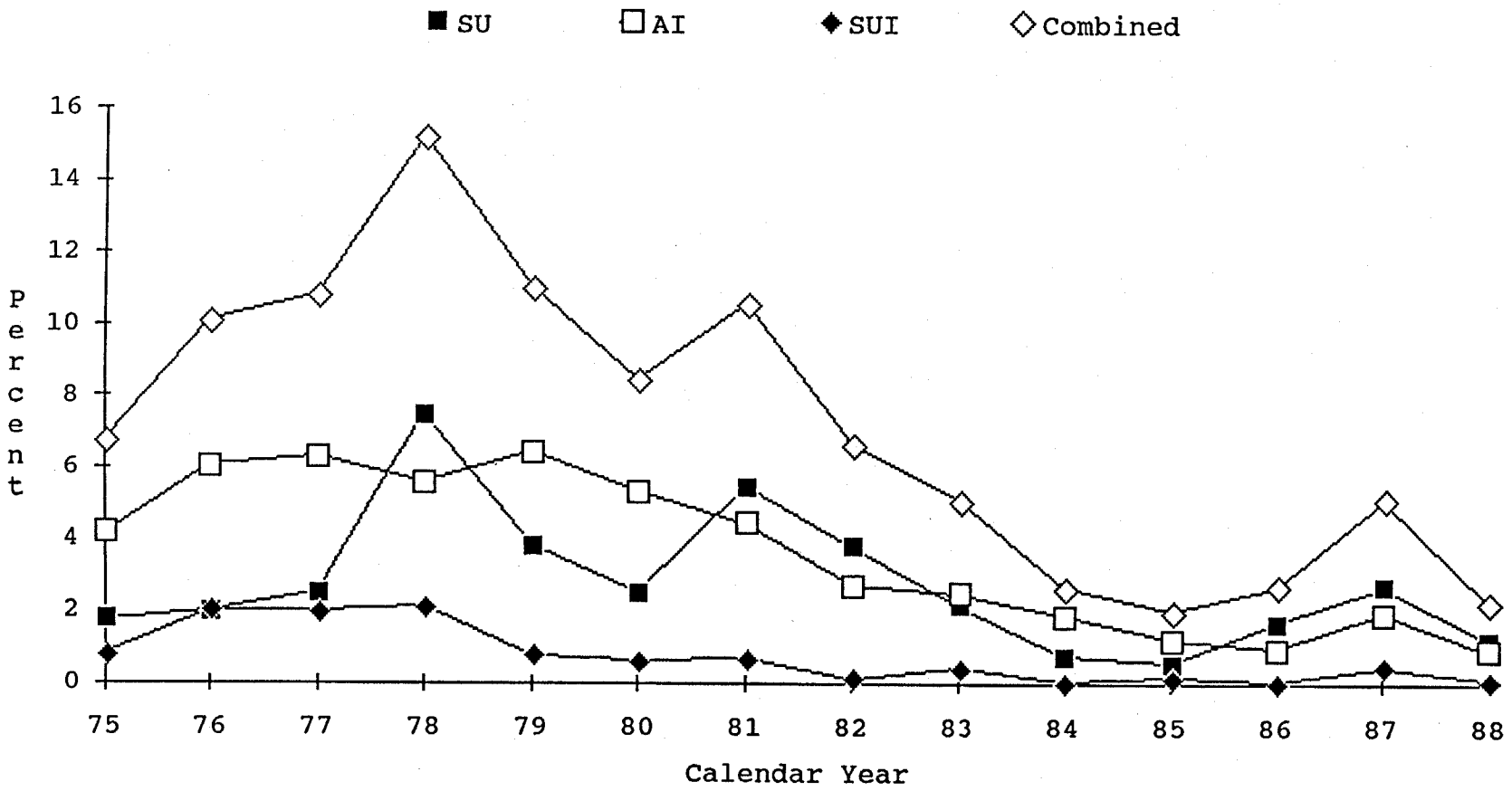

Figure 2. Percent increase in tallied kill of marine mammals due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined (unadjusted) .

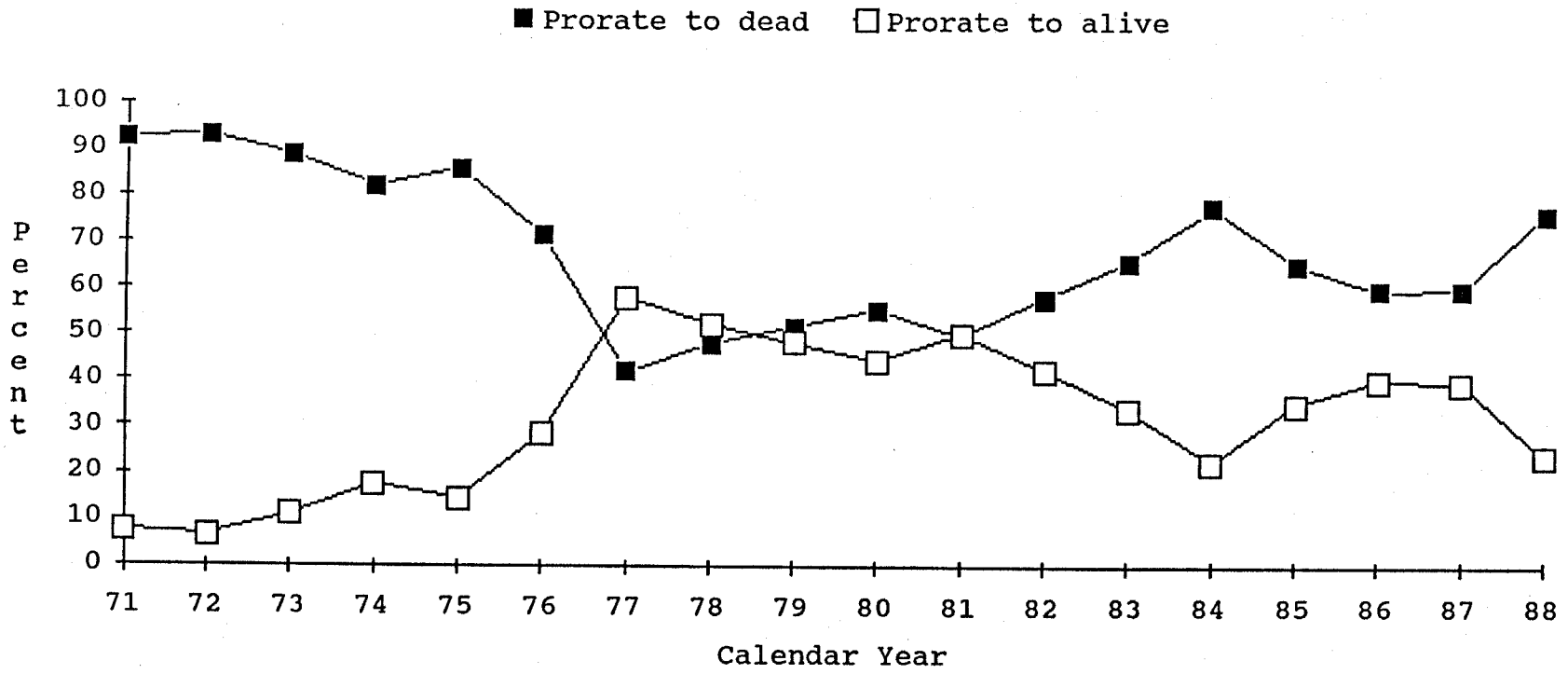

Figure 3. Annual percentages used to prorate individuals in the category status unknown to a fraction that survived SU(A) and a fraction assumed to have died SU(D). Calculated as SU(A)=A/A+D; SU(D)=D/(A+D).

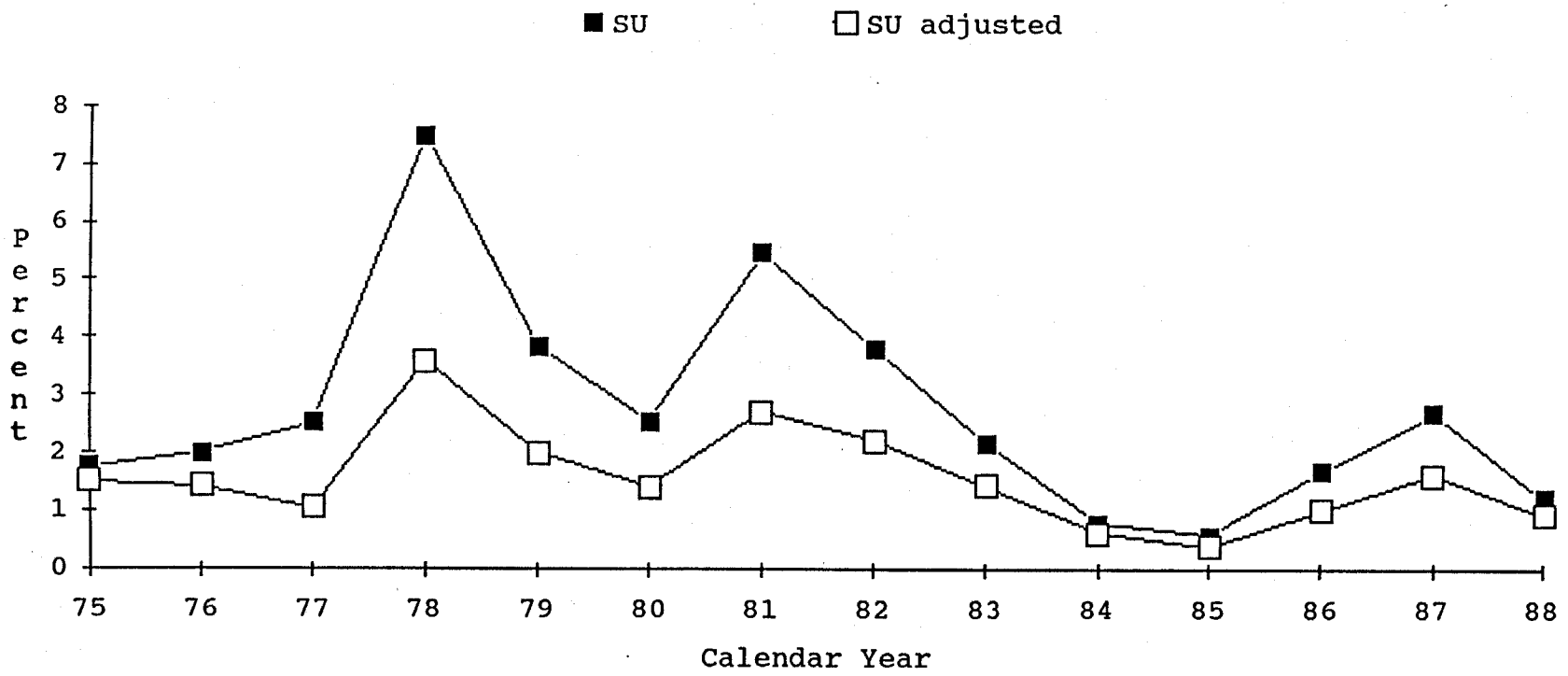

Figure 4. Percent increase in tallied kill of marine mammals due to including in the kill tally animals categorized as status unknown (unadjusted) and status unknown (adjusted). Calculated as SU(adjusted) = SU * SU(D) .

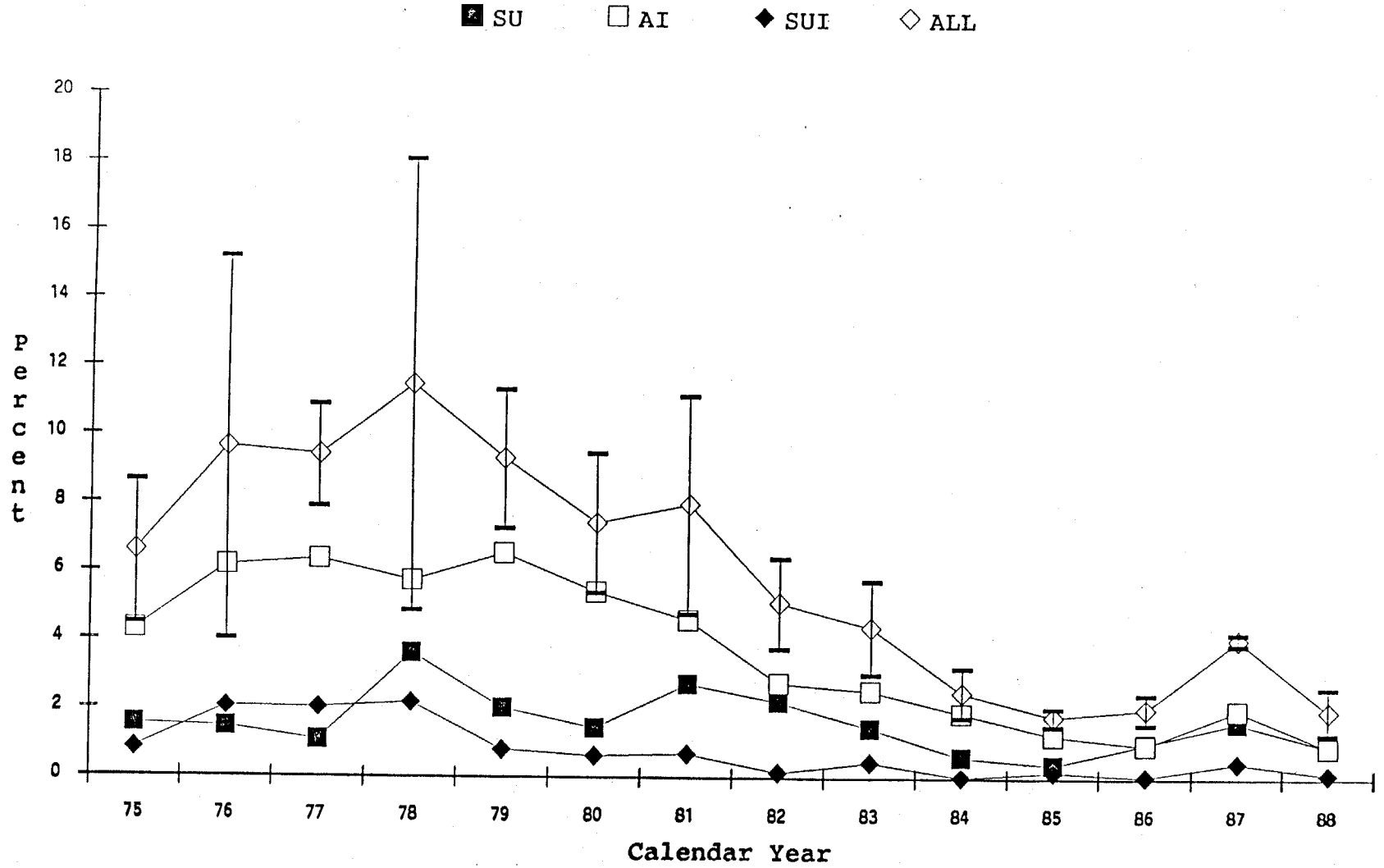

Figure 5. Percent increase in tallied kill of marine mammals due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (adjusted).

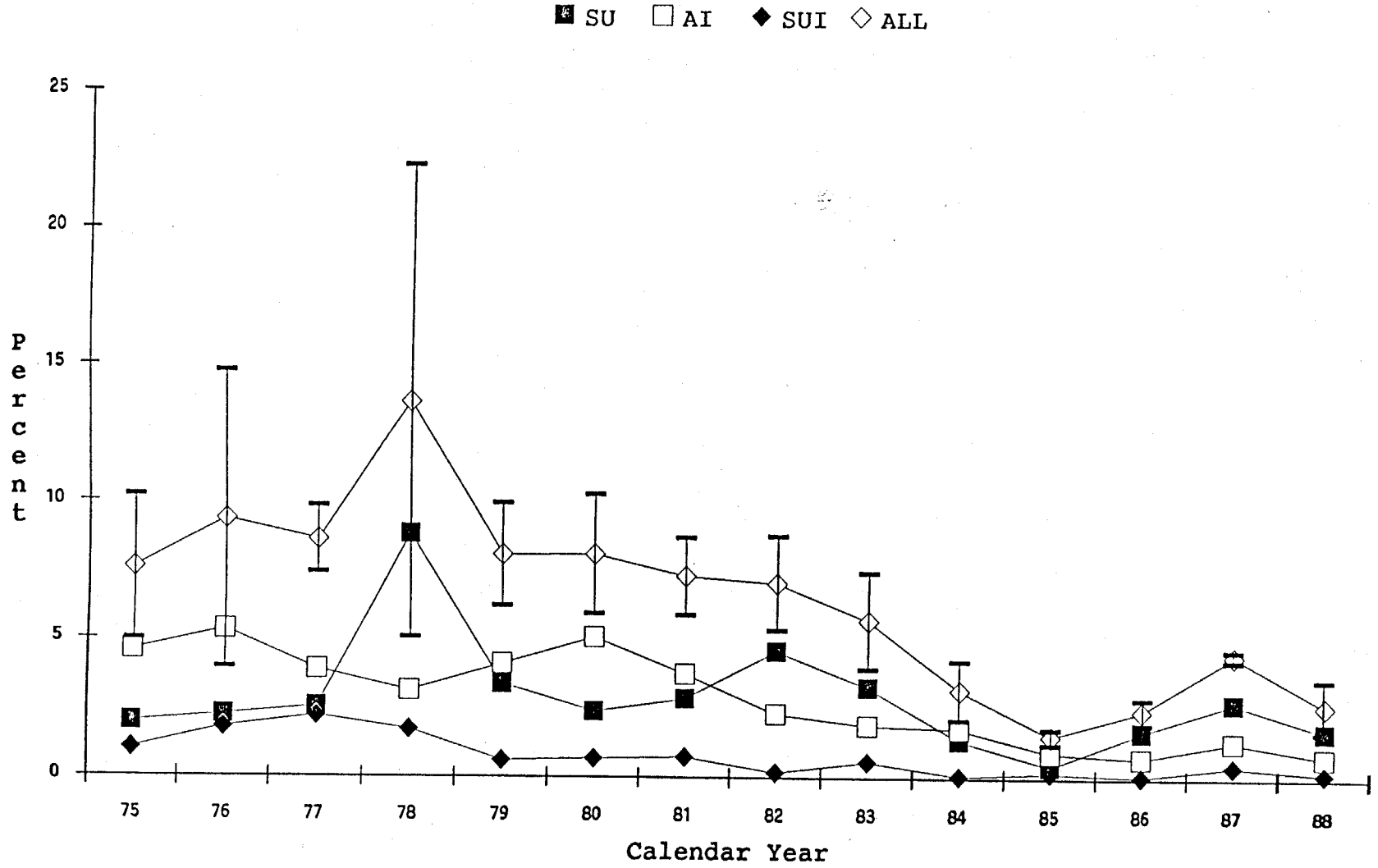

Figure 6. Percent increase in tallied kill of Offshore Spotted dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

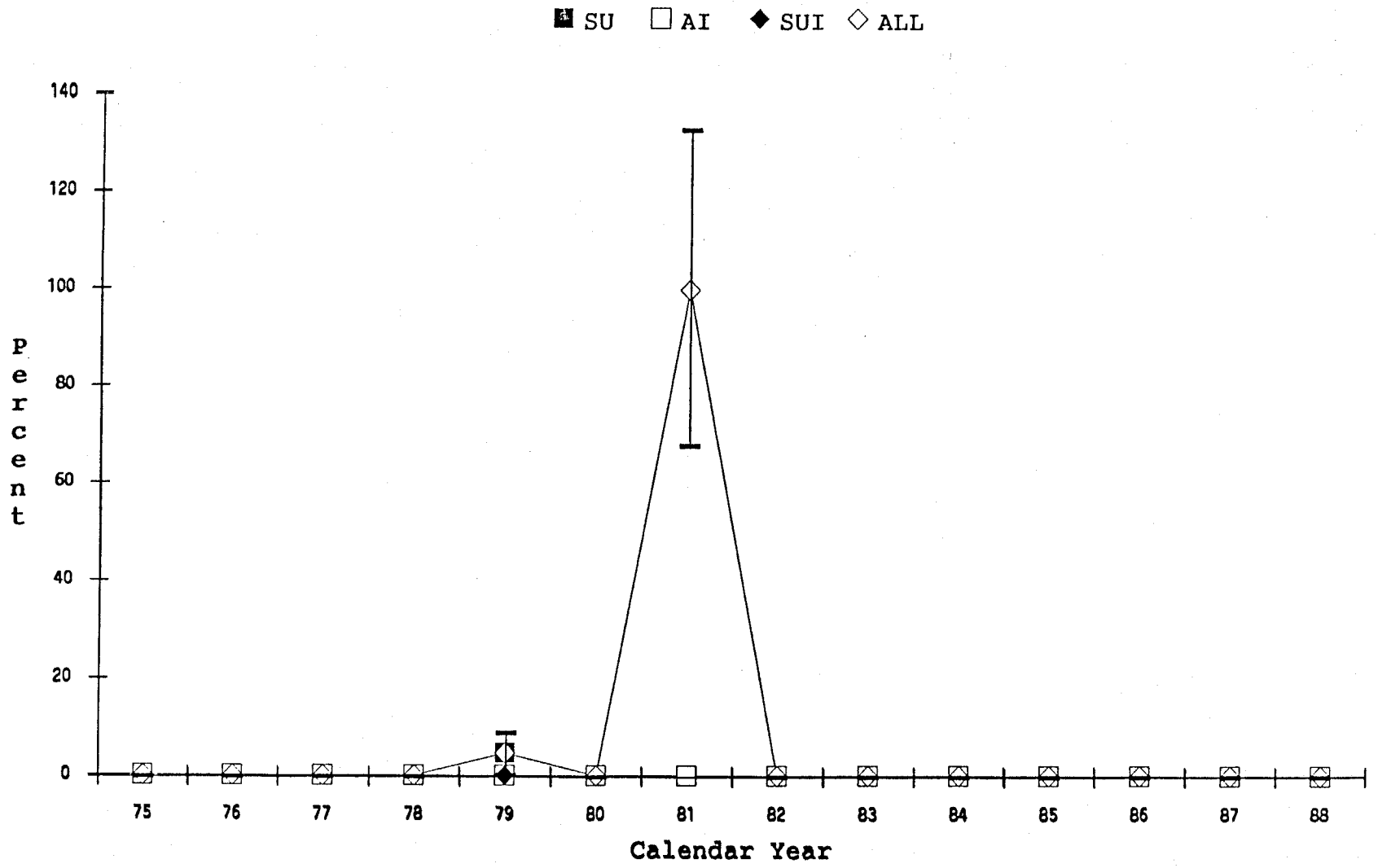

Figure 7. Percent increase in tallied kill of Coastal Spotted dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

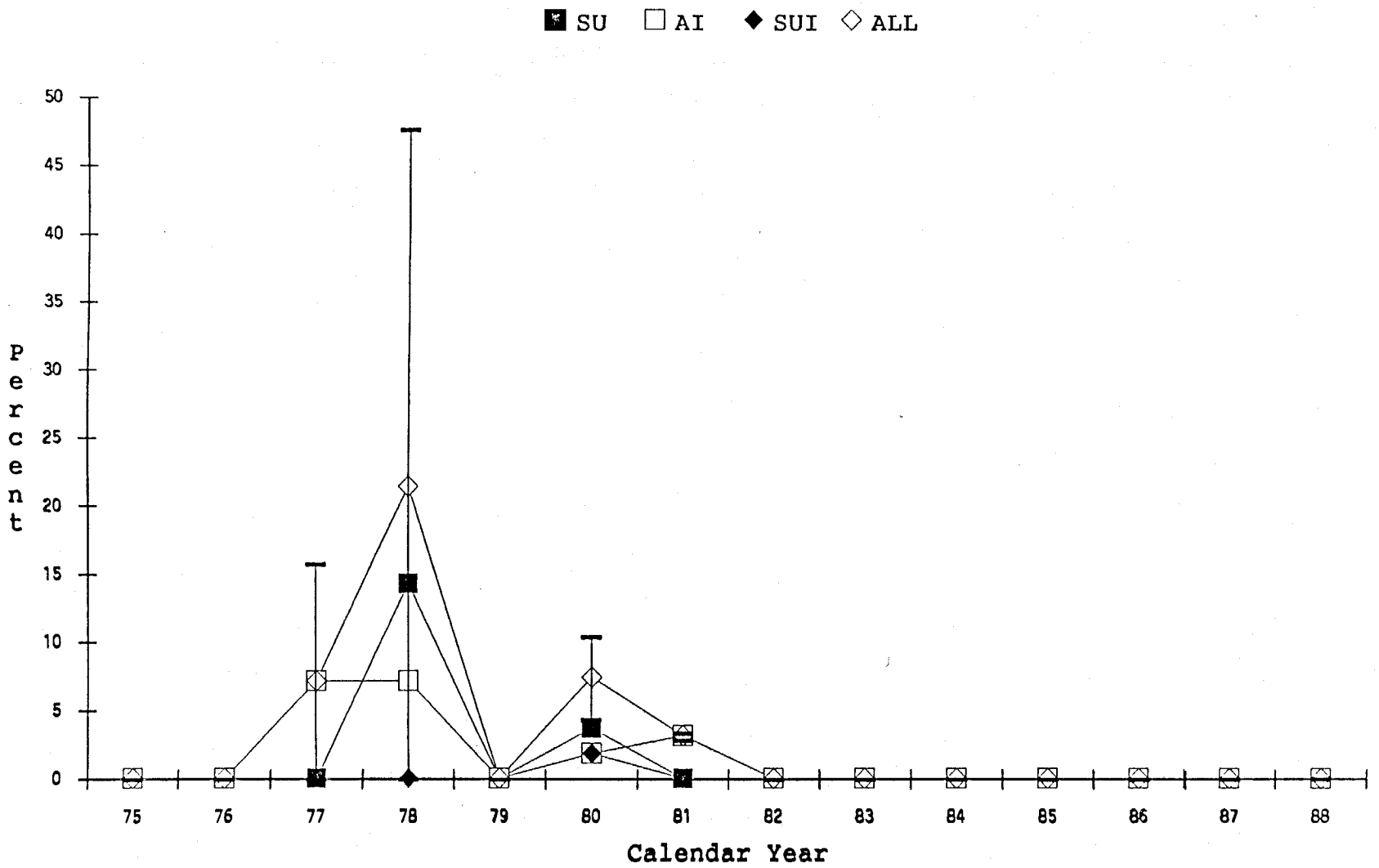

Figure 8. Percent increase in tallied kill of Unidentified Spotted dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

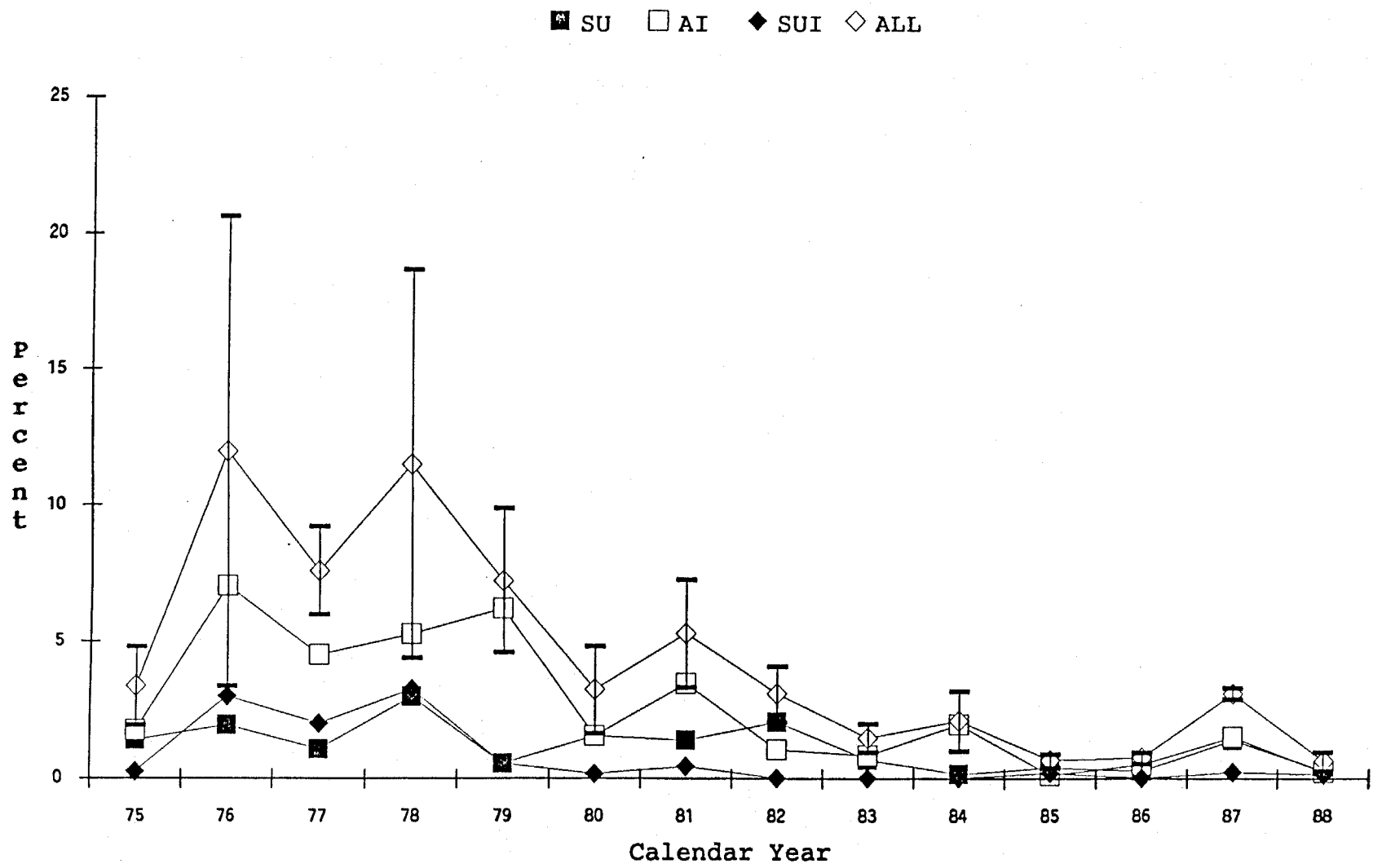

Figure 9. Percent increase in tallied kill of Whitebelly Spinner dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

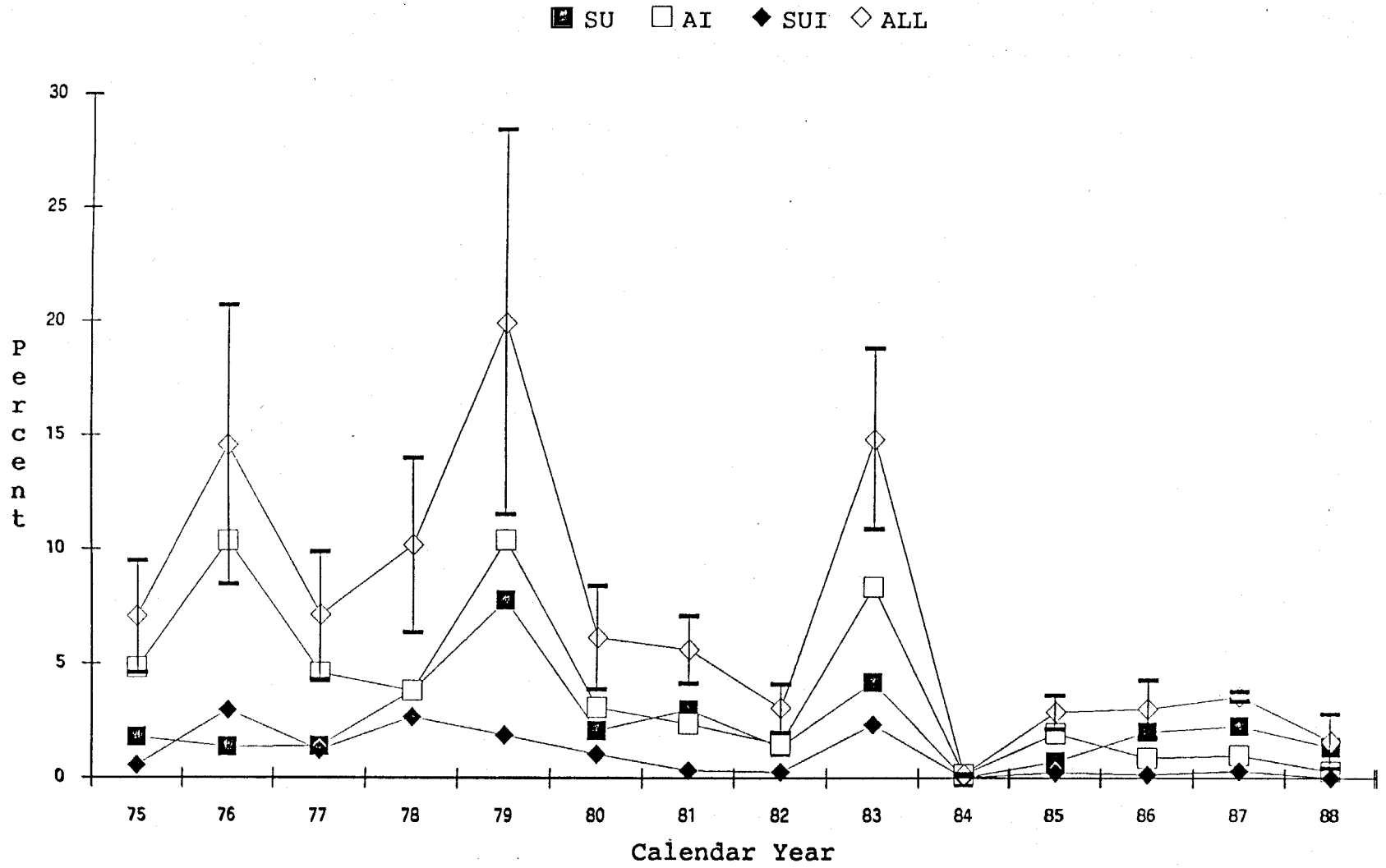

Figure 10. Percent increase in tallied kill of Eastern Spinner dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

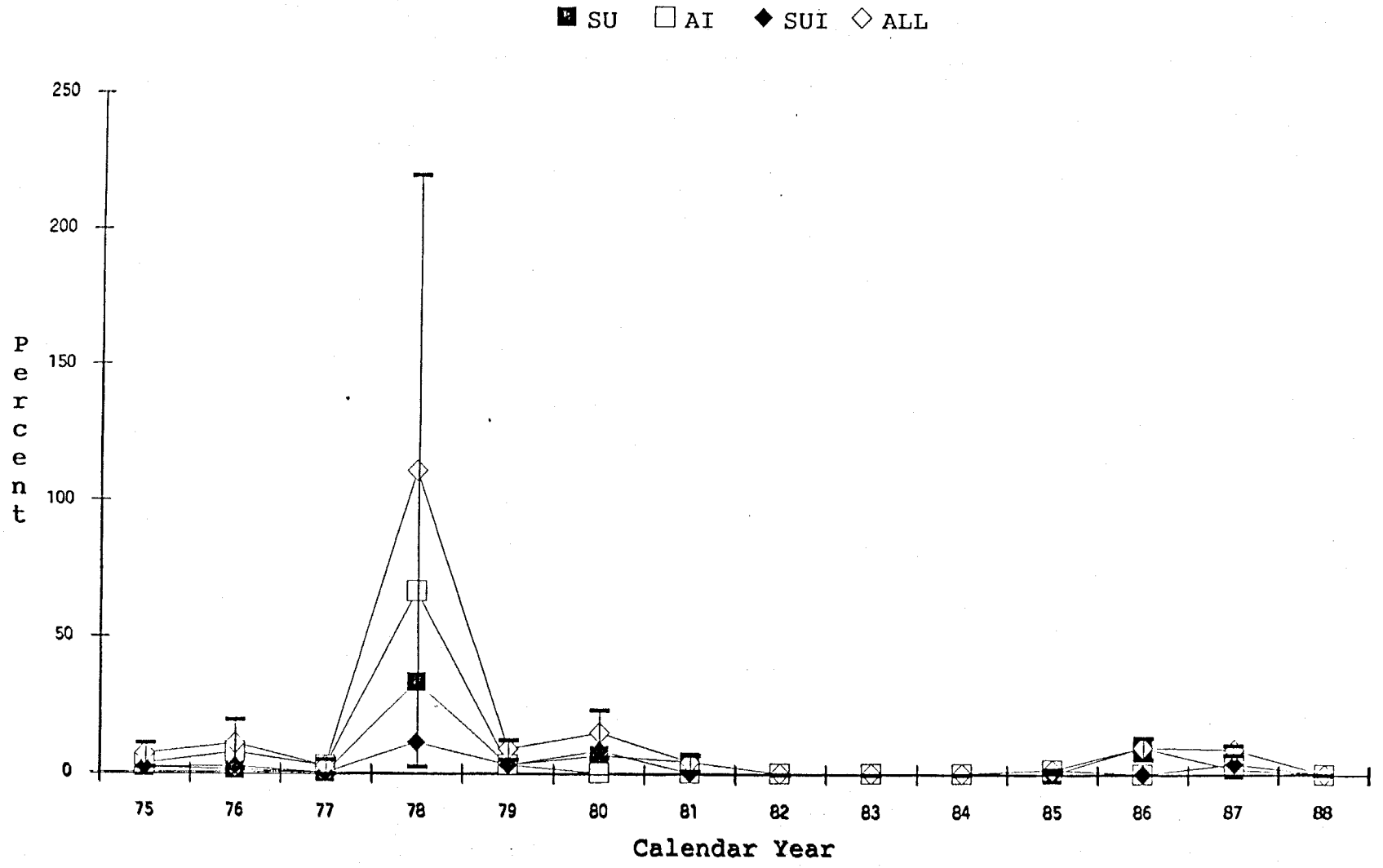

Figure 11. Percent increase in tallied kill of Unidentified Spinner dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

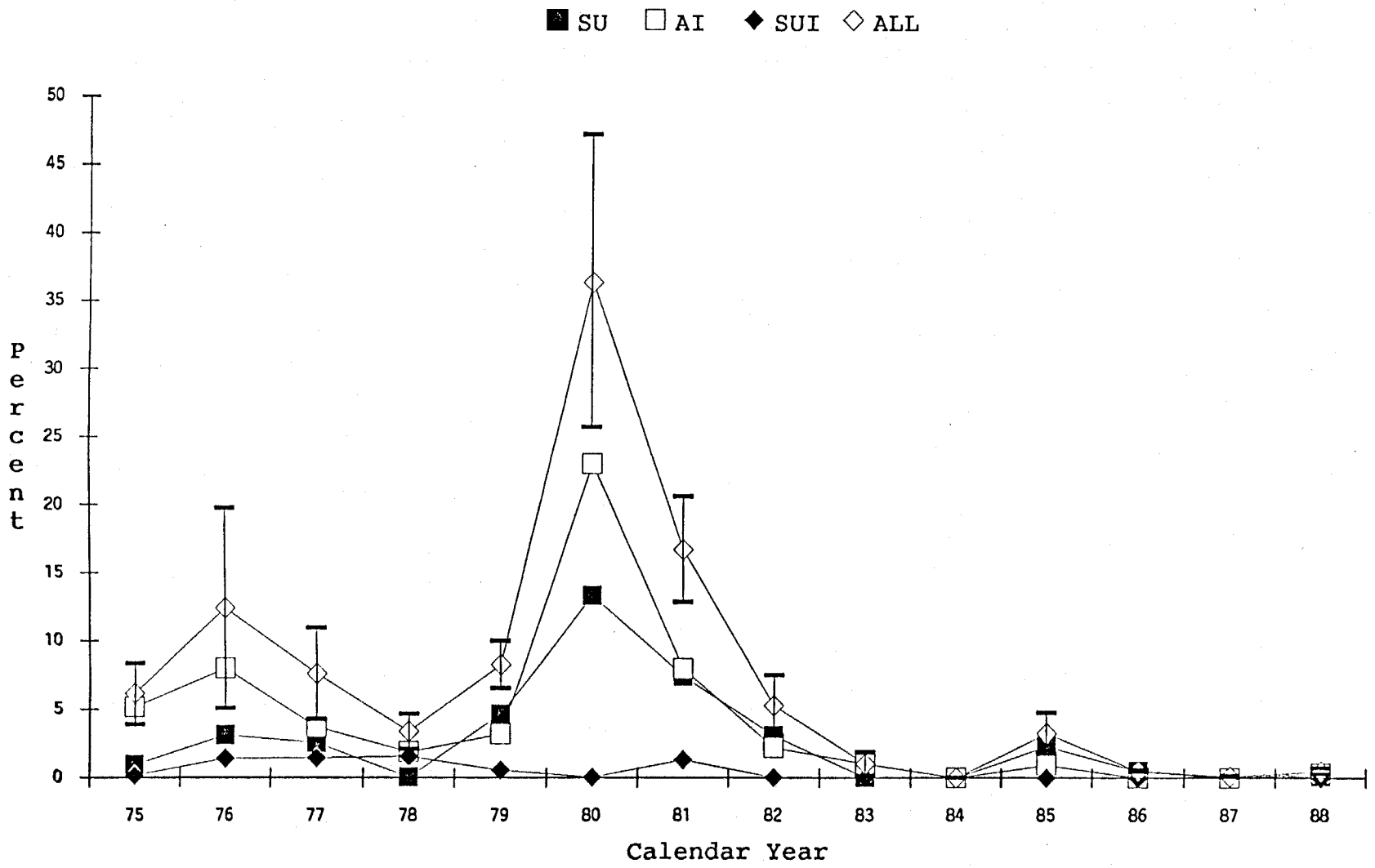

Figure 12. Percent increase in tallied kill of Common dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

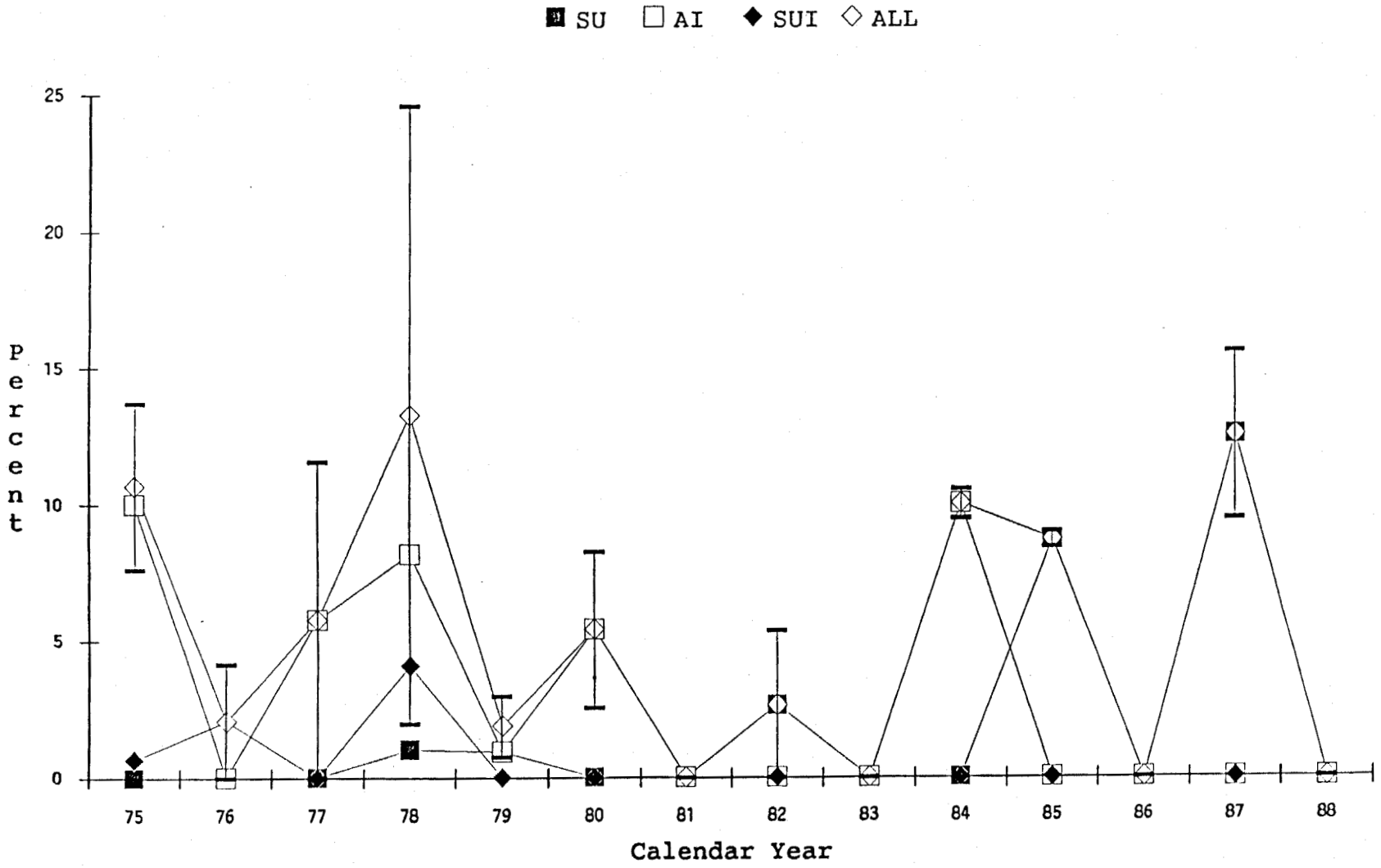

Figure 13. Percent increase in tallied kill of Striped dolphin due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

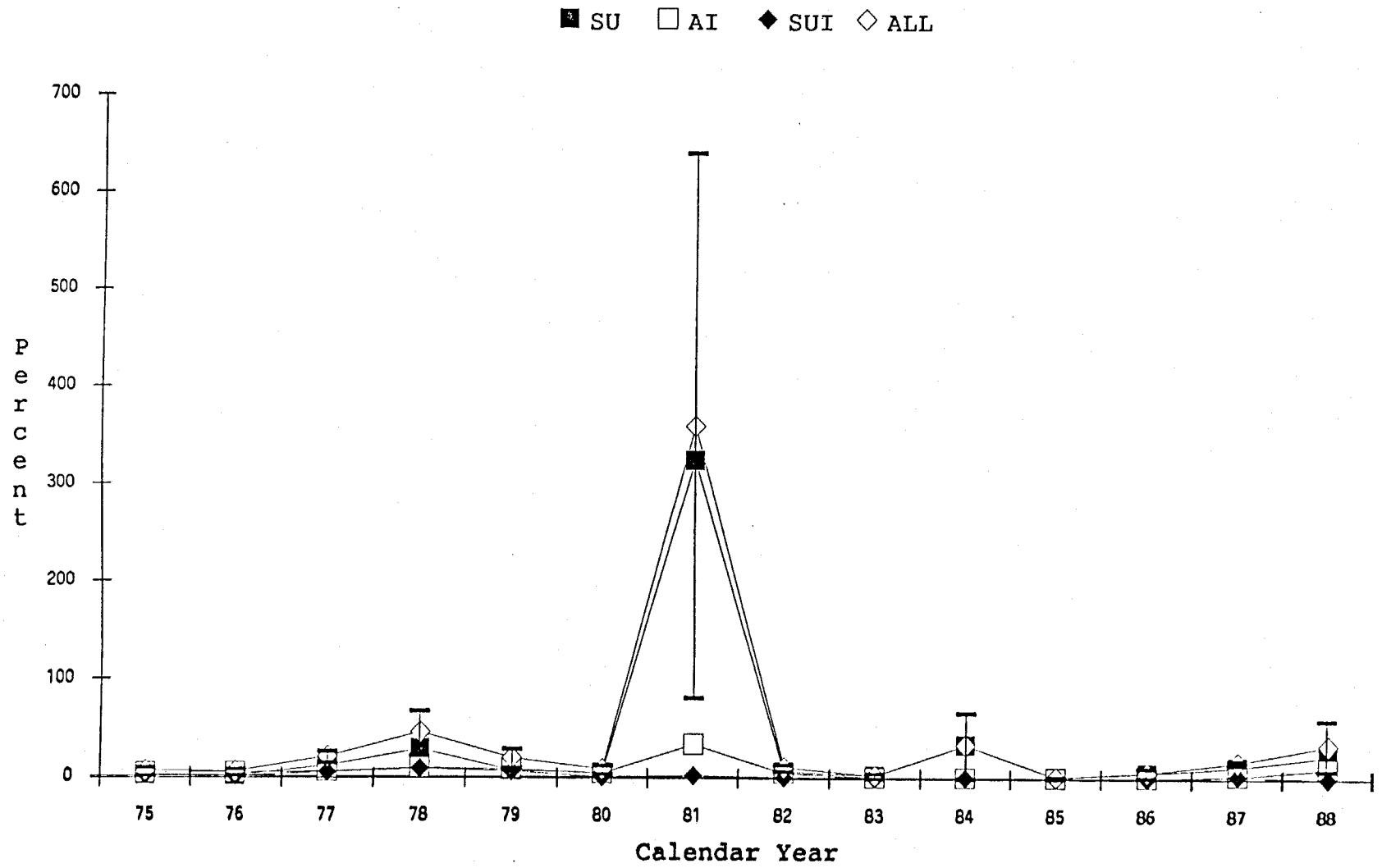

Figure 14. Percent increase in tallied kill of all other marine mammals due to including in the kill tally animals categorized as status unknown, status unknown injured, alive injured, and all three categories combined with one standard error (unadjusted).

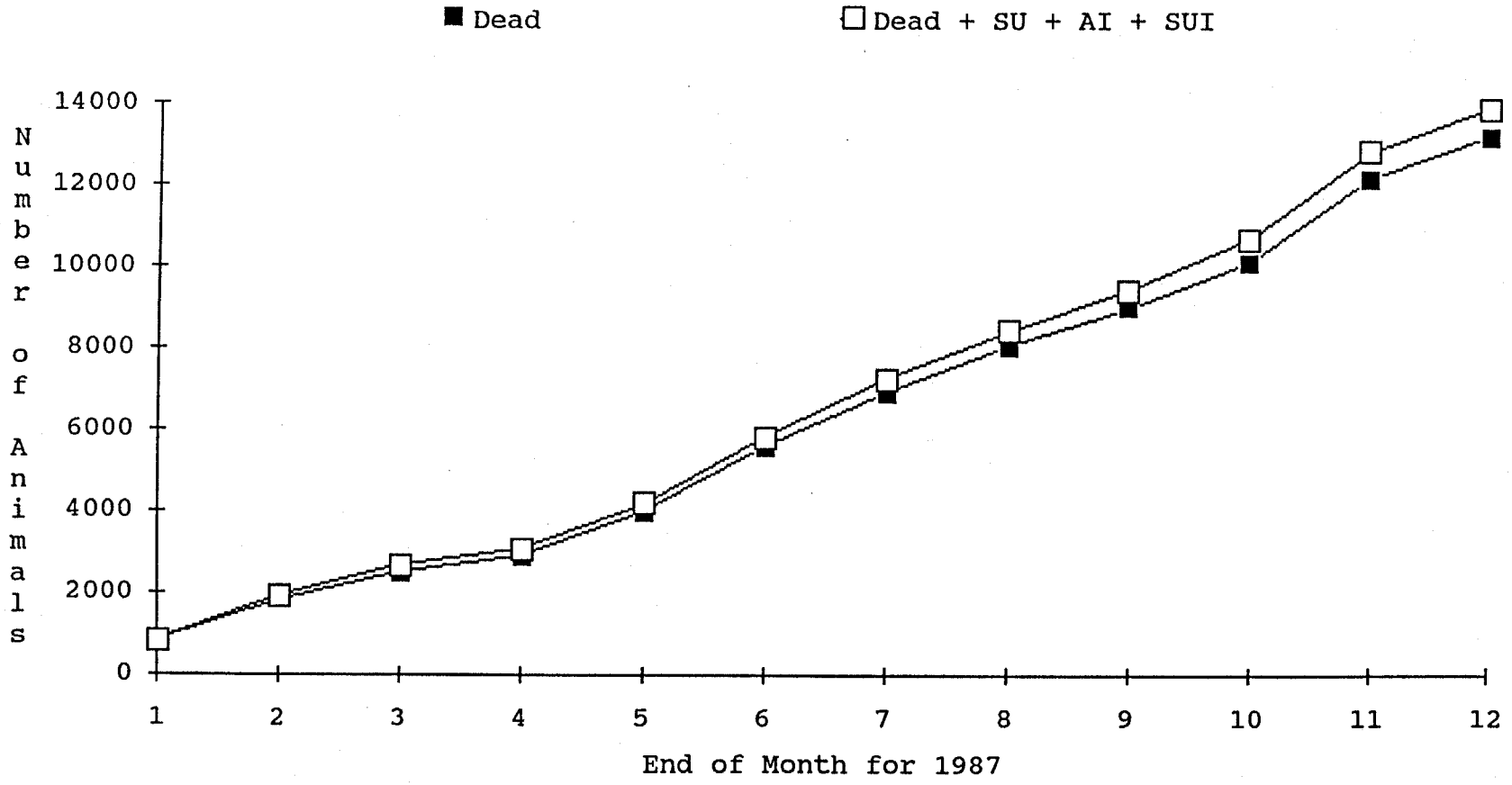

Figure 15. Comparison of within-year accumulations of "known dead" for all marine mammals combined, and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

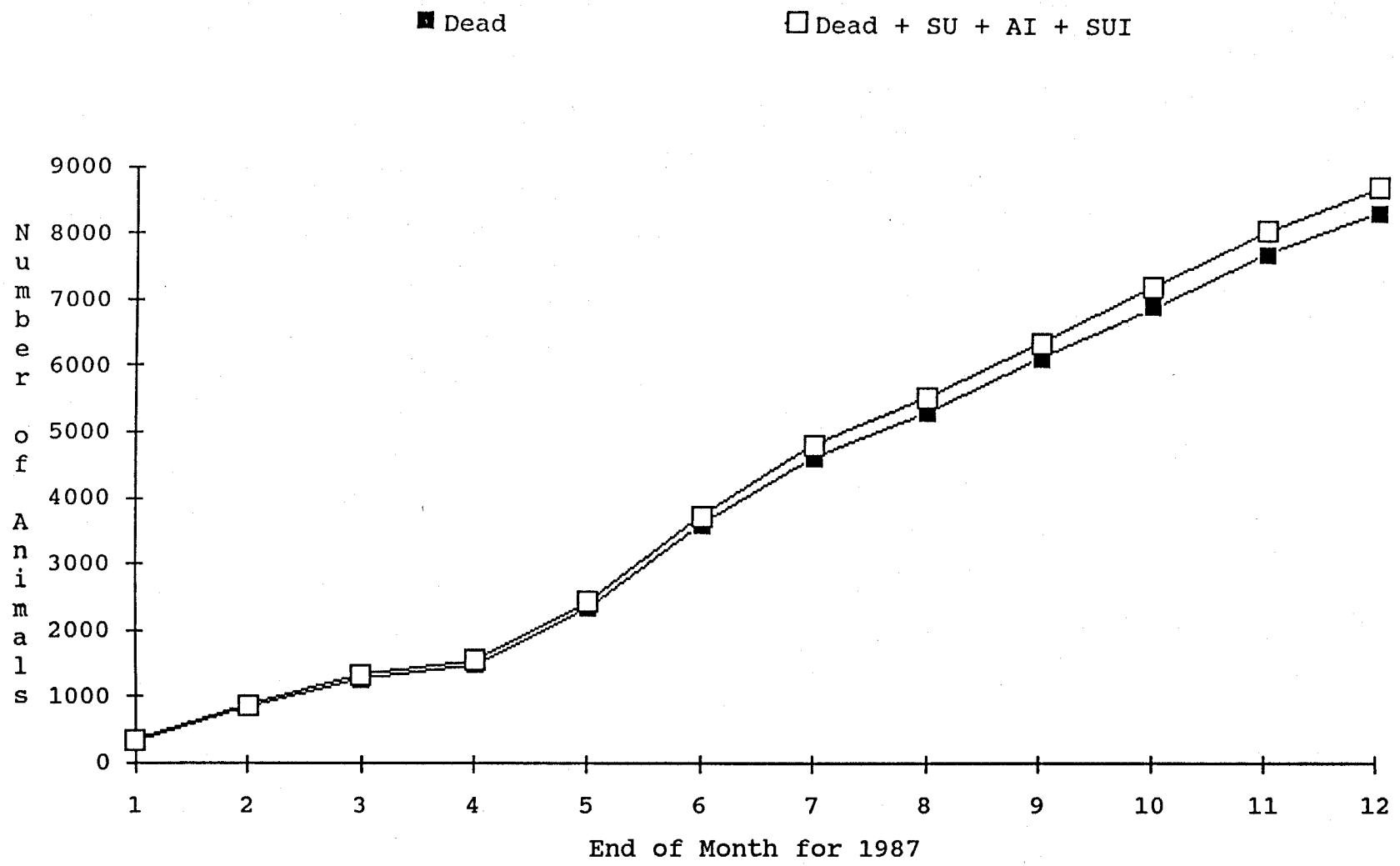

Figure 16. Comparison of within-year accumulations of "known dead" Offshore Spotted dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

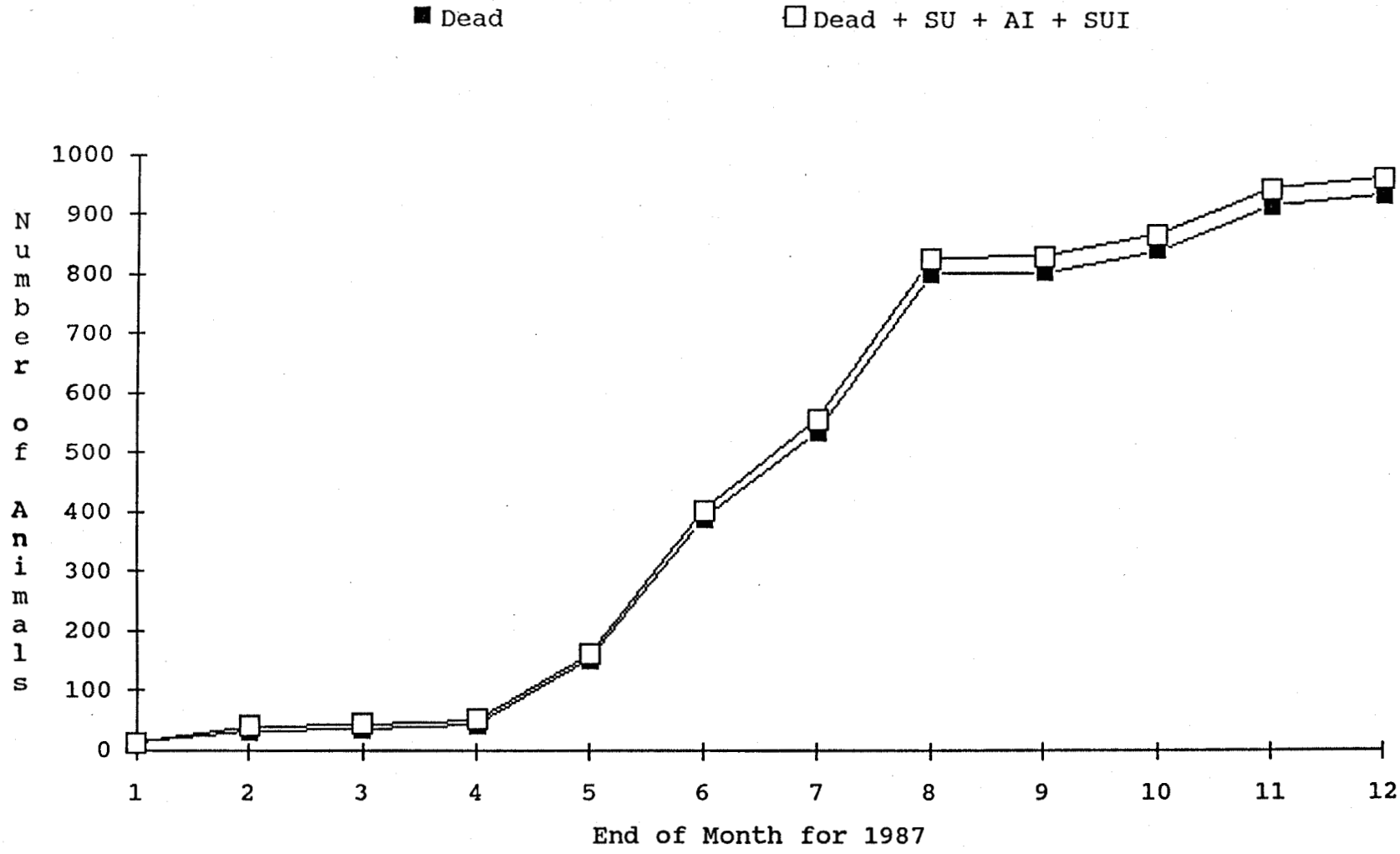

Figure 17. Comparison of within-year accumulations of "known dead" Whitebelly Spinner dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

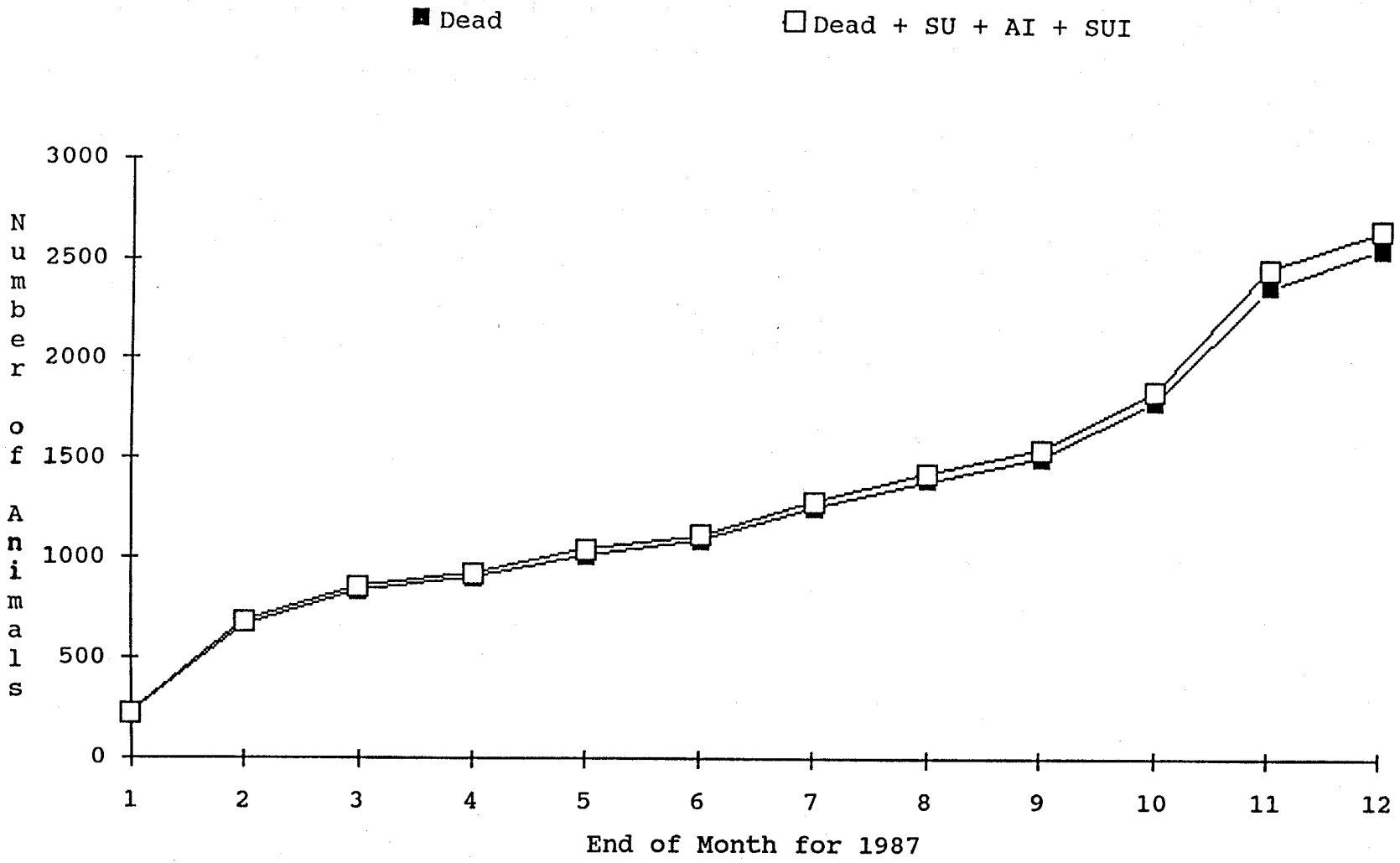

Figure 18. Comparison of within-year accumulations of "known dead" Eastern Spinner dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

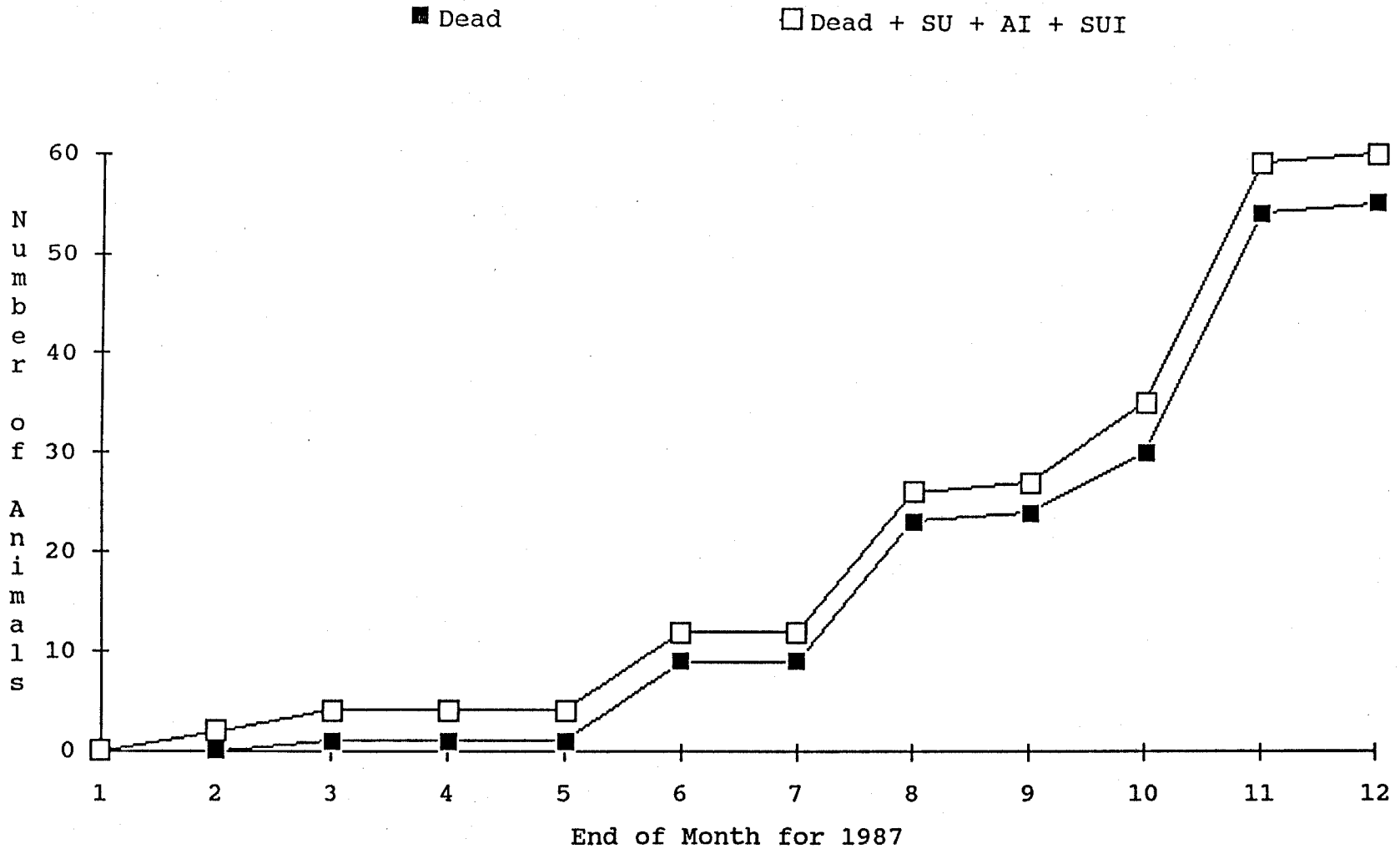

Figure 19. Comparison of within-year accumulations of "known dead" Unidentified Spinner dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

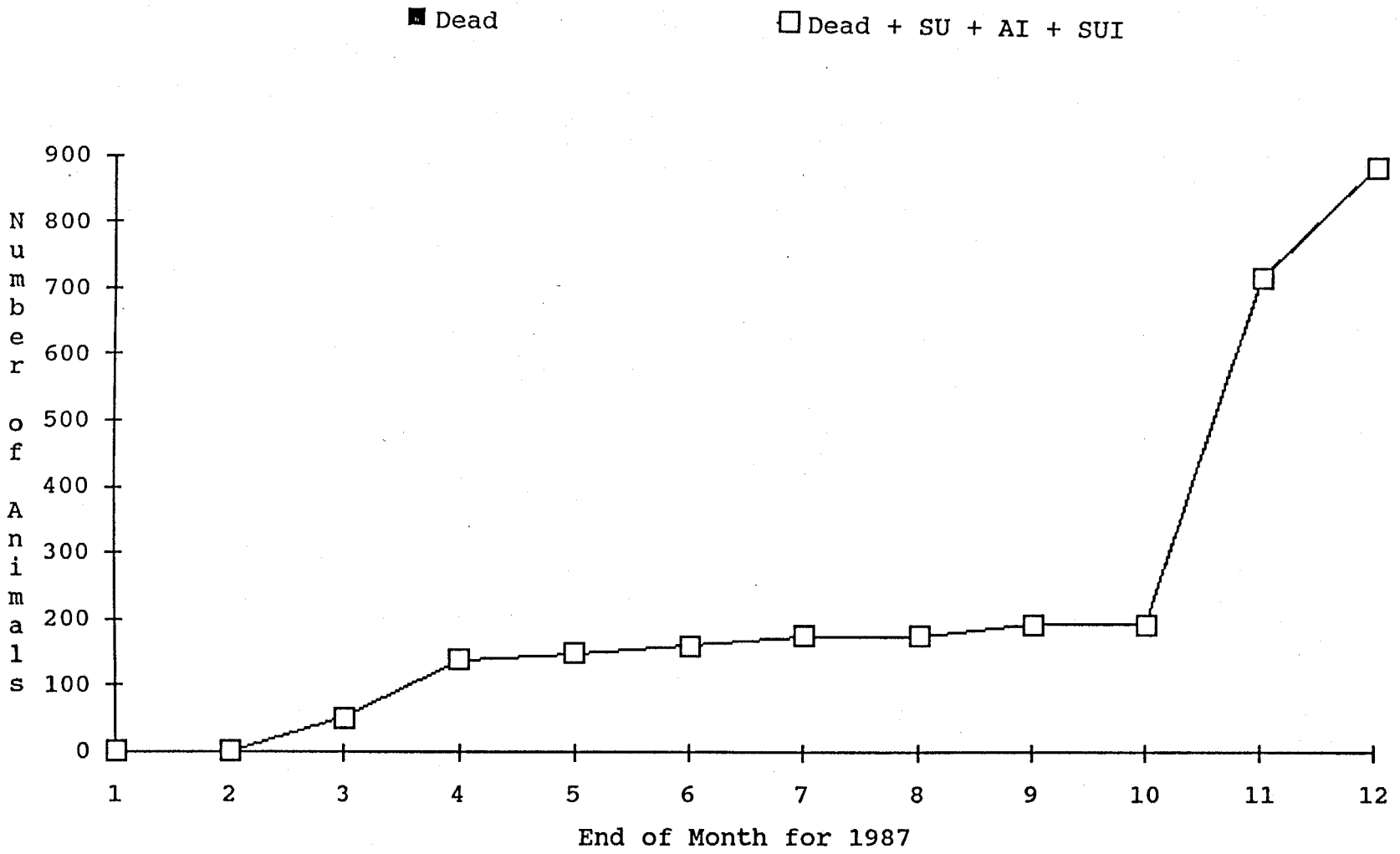

Figure 20. Comparison of within-year accumulations of "known dead" Common dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

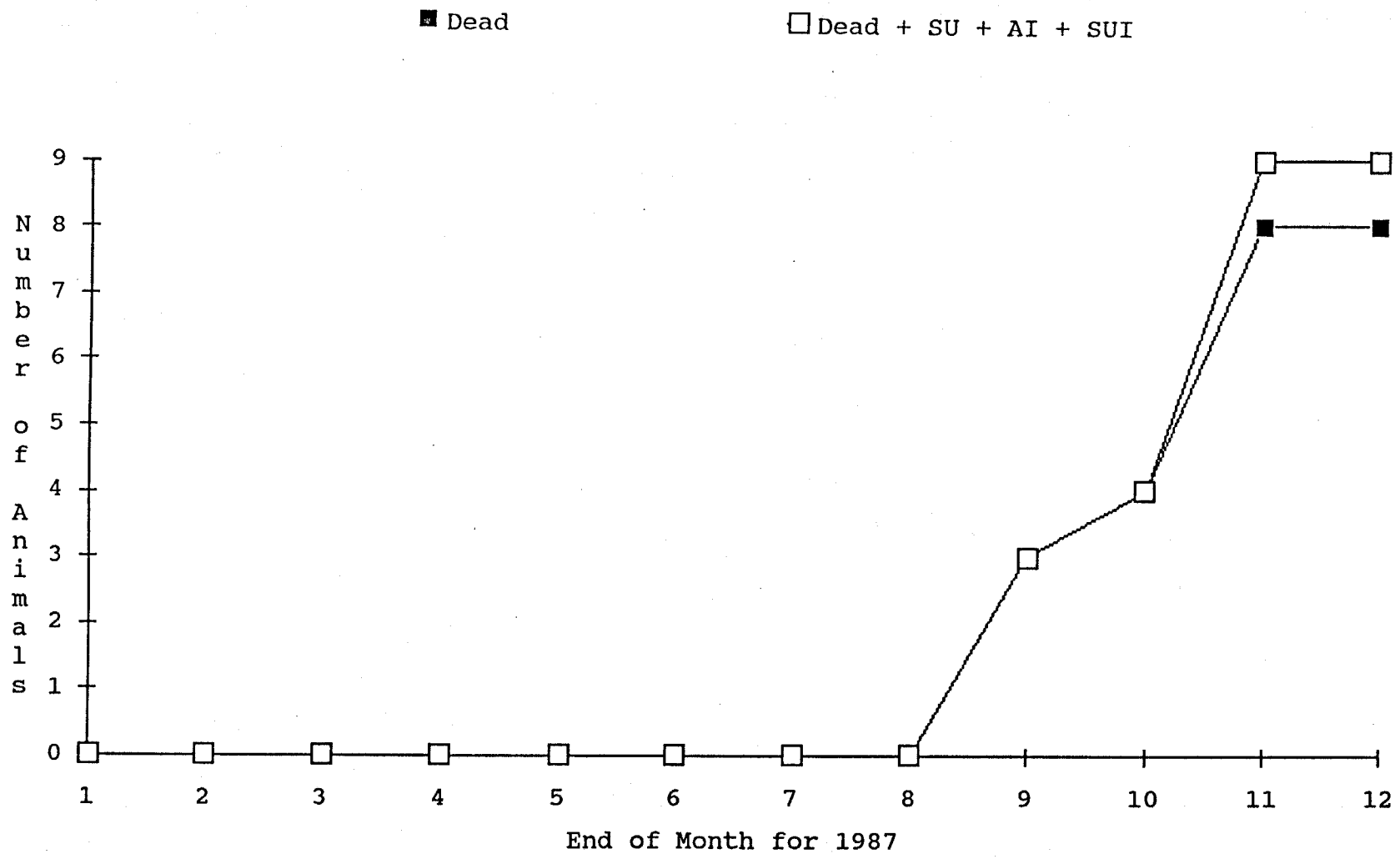

Figure 21. Comparison of within-year accumulations of "known dead" Striped dolphin and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

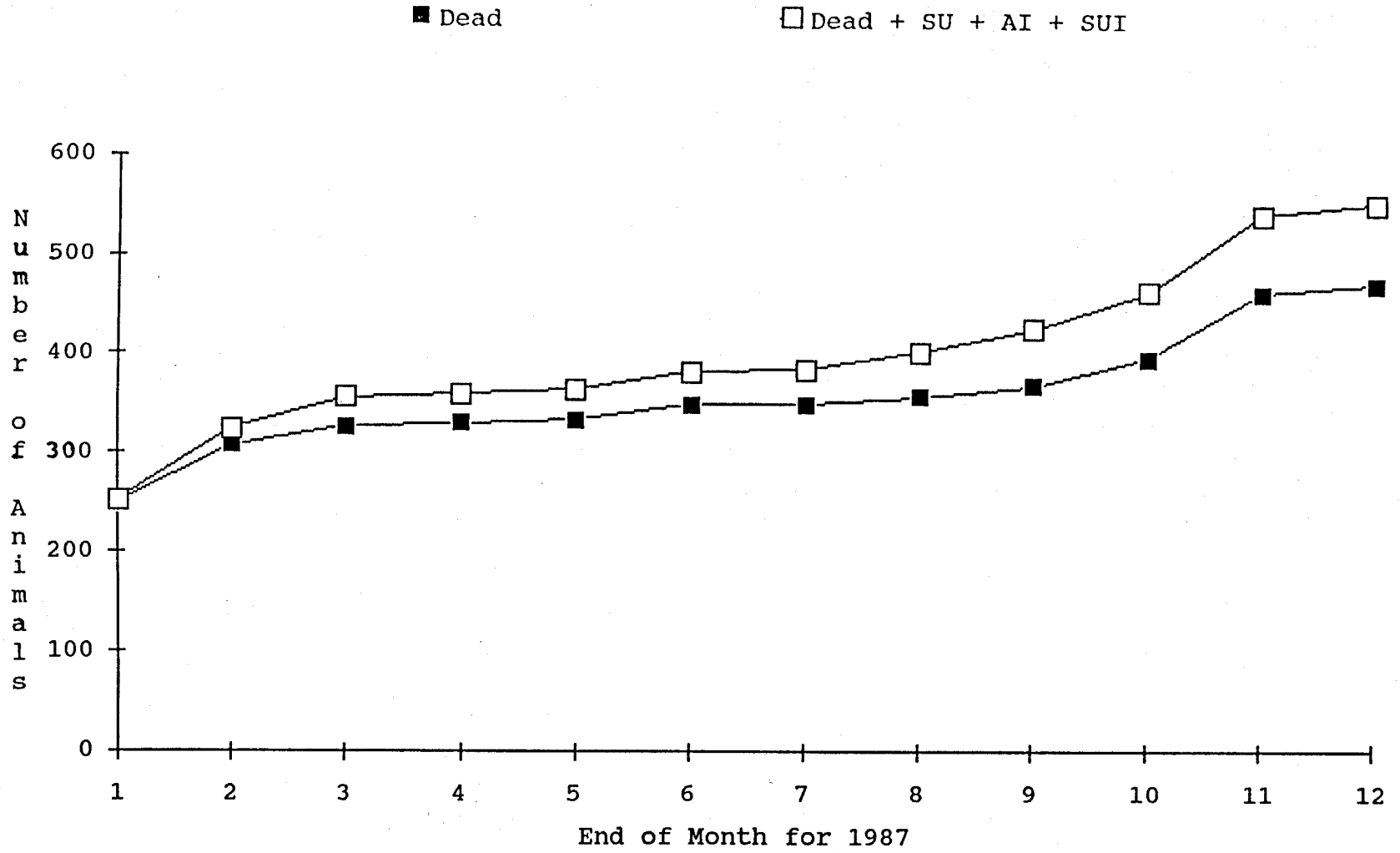

Figure 22. Comparison of within-year accumulations of "known dead" for all other marine mammals combined and the three additional categories status unknown injured, status unknown (unadjusted), and alive injured (unadjusted) for calendar year 1987.

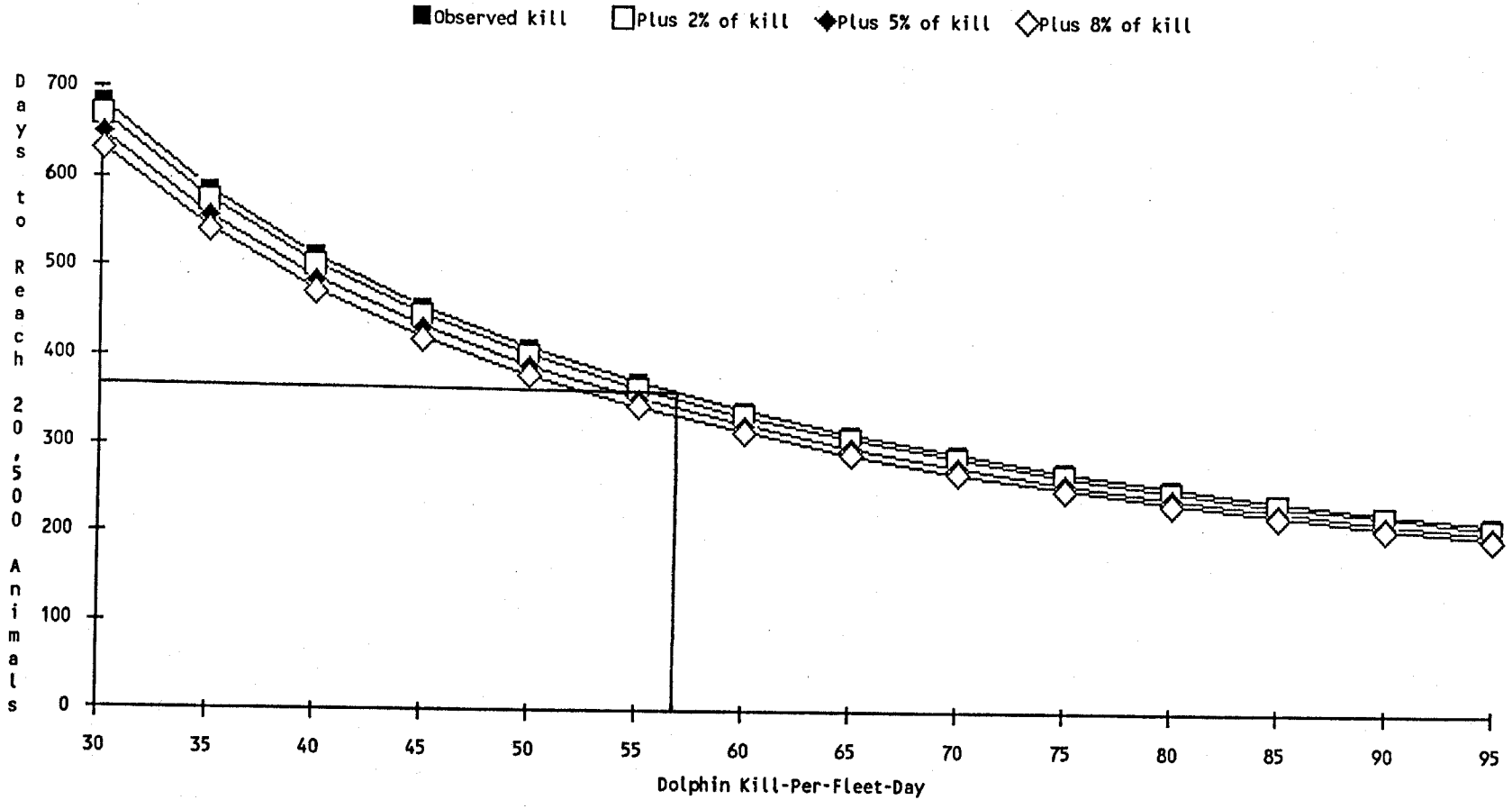

Figure 23. Number of days required to reach a quota of 20,500 animals, as a function of observed kill/fleet-day and percentage increase in observed kill that should be included in the kill tally if additional animals die. Calculations are presented for underestimated levels adding 2%, 5%, and 8% to the tallied kill. Vertical bar delimits mortality rates exceeding 56 animals/fleet-day. At these rates the annual quota of 20,500 animals would be reached before the end of the calendar year, leading to closure of the fishery for U.S.-registered vessels.

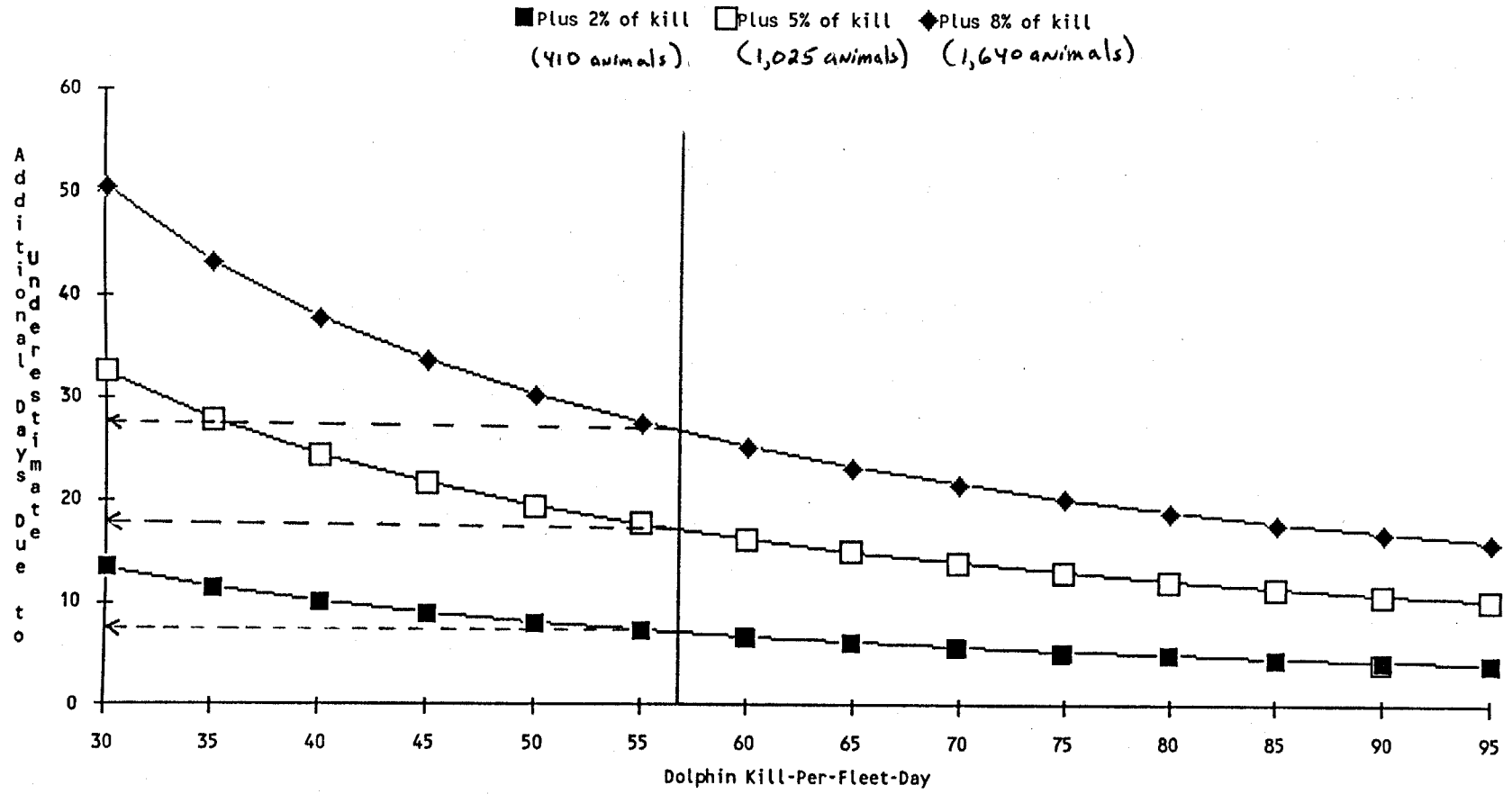

Figure 24. Additional days it would take to reach a quota of 20,500 animals, if true mortality included tallies of "known dead", "seriously injured" and "status unknown" animals, but is underestimated because only "known dead" were included in the cumulative estimate of kill.

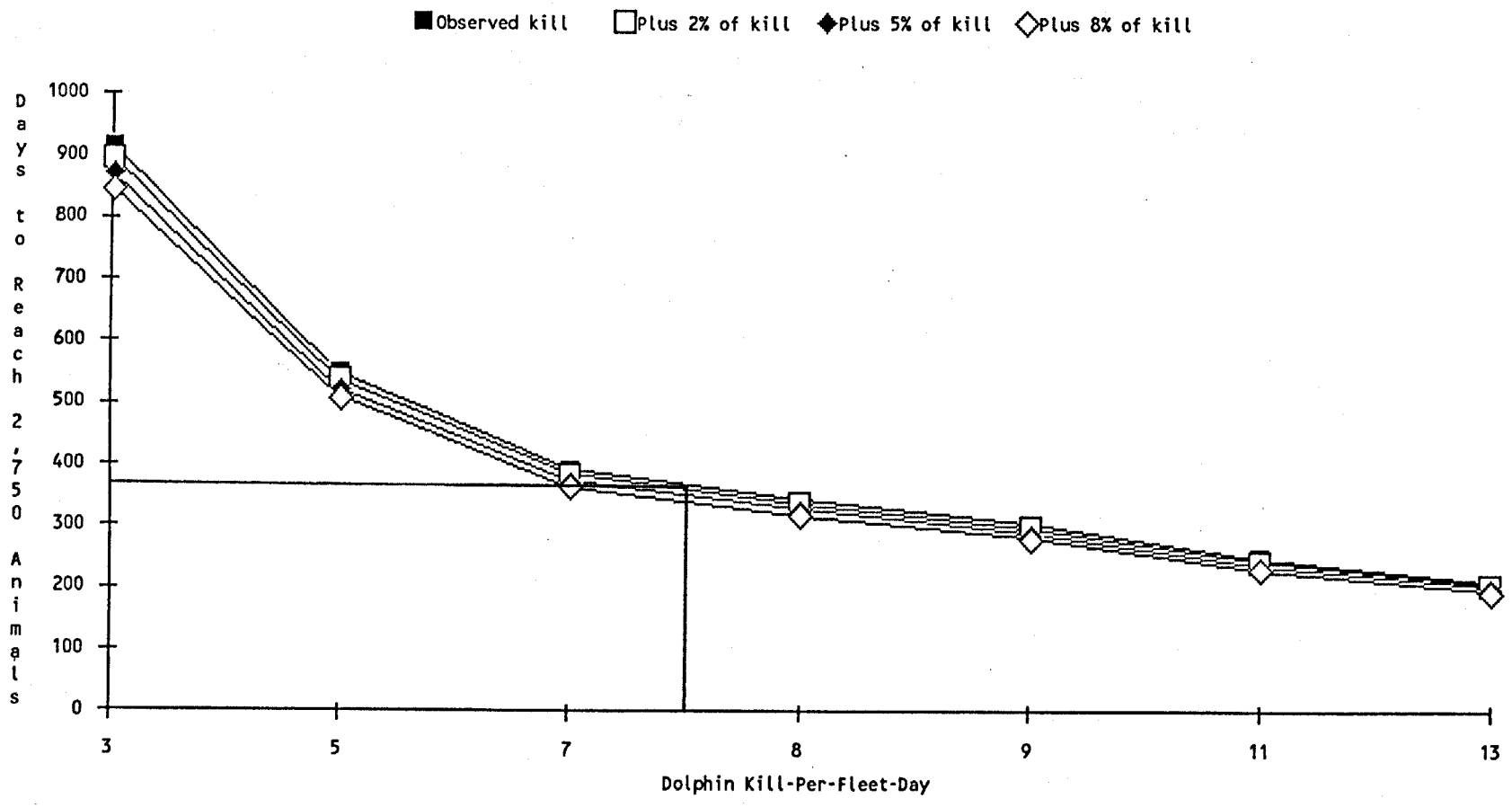

Figure 25. Number of days required to reach a quota of 2,750 animals, as a function of observed kill/fleet-day and percentage increase in observed kill that should be included in the kill tally if additional animals die. Calculations are presented for underestimated levels adding 2%, 5%, and 8% to the tallied kill. Vertical bar delimits mortality rates exceeding 7.5 animals/fleet-day. At these rates the annual quota of 2,750 animals would be reached before the end of the calendar year, leading to closure of the fishery for U.S.-registered vessels.

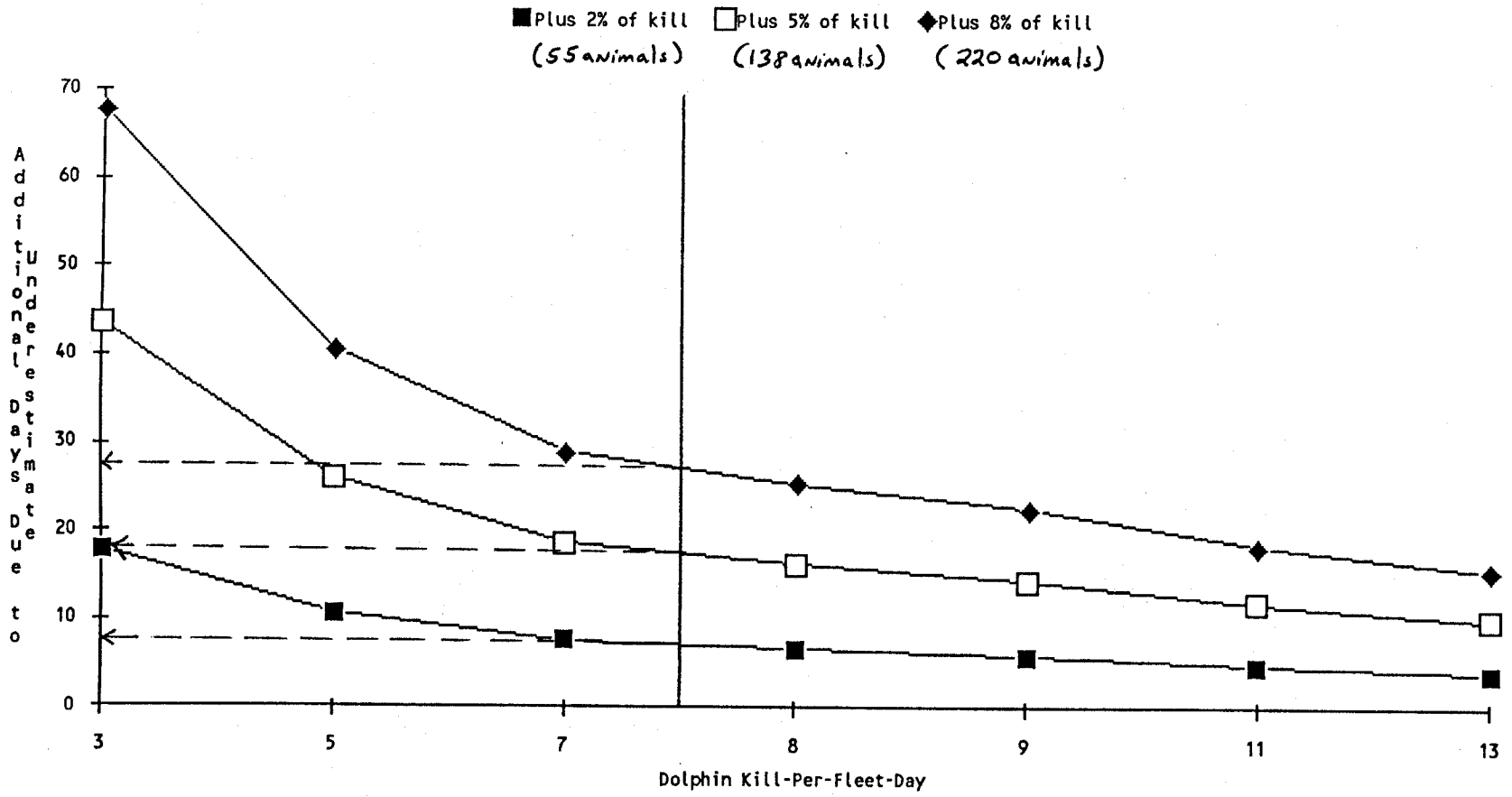

Figure 26. Additional days it would take to reach a quota of 2,750 animals, if true mortality included tallies of "known dead", "seriously injured" and "status unknown" animals, but is underestimated because only "known dead" were included in the cumulative estimate of kill.

APPENDIX 1. NMFS "Marine Mammal Set Log Tally Sheet".

NOAA FORM 88-124
FSW 34 11-78

1979 MARINE MAMMAL SET LOG TALLY SHEET

CRUISE # _____ NOAA - U.S. DEPT. OF COMM.

SET # _____

NOTE: "INJURED" MEANS
1) BLEEDING
2) HAVING OBVIOUSLY BROKEN BONES
3) HAVING GONE THROUGH THE POWER BLOCK

SYMBOLS TO USE:
\ = DEAD
+ = ESCAPED OR RELEASED ALIVE
⊕ = ESCAPED OR RELEASED ALIVE BUT INJURED
? = STATUS UNDETERMINED
② = STATUS UNDETERMINED BUT INJURED

SPOTTED																									SPINNERS												OTHER SPECIES (1)			OTHER SPECIES (2)			UNID	ANIMALS DUMPED	ANIMALS PROCESSED	SUBTOTALS \	+	⊕	-	②
NEONATE			TWO-TONE			SPECKLED			MOTTLED			ADULT			AGE UNK	EASTERN			WHITEBELLY			OTHER OR UNID																													
M	F	?	M	F	?	M	F	?	M	F	?	M	F	?		M	F	?	M	F	?	M	F	?																										

Spotted Stock Name _____ Other Spinner Name _____ Other Species/Stock (1) Name _____ Other Species/Stock (2) Name _____

APPENDIX 2. Number of animals by "Marine Mammal Set Log Tally Sheet" category, species or stock, and year for the period 1971-1988 from National Marine Fisheries Service and Inter-American Tropical Tuna Commission data. Data for 1988 do not contain NMFS data after June, nor IATTC data after September.

Category DEAD (D)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OFFSHORE SPOTTERS	0	0	0	0	0	0	5349	4957	3516	4549	4859	6232	1436	2203	5492	5910	8313	3404
COASTAL SPOTTERS	0	0	0	0	0	0	49	0	87	0	1	0	1	0	0	0	0	0
UNIDENTIFIED SPOTTERS	1742	6714	6380	7586	9775	8669	14	14	20	54	64	59	0	0	0	0	1	4
WHITEBELLY SPINNERS	31	263	566	803	2520	3096	1396	1138	580	1356	1580	1556	1213	714	1088	1620	931	1455
EASTERN SPINNERS	0	2	713	2953	2739	755	593	345	492	295	644	821	216	702	1294	698	2552	374
UNIDENTIFIED SPINNERS	1458	1318	2609	192	352	807	39	9	101	61	24	39	1	176	65	41	55	12
COMMON DOLPHINS	12	401	2052	602	785	653	1636	328	2101	165	539	227	99	733	431	199	882	1406
STRIPED DOLPHINS	0	0	16	30	150	97	52	98	106	37	25	190	1	10	23	22	8	41
OTHER-SPECIES DOLPHINS (IDENTIFIED OR NOT)	225	587	357	908	471	778	337	122	187	134	63	264	40	12	192	542	469	56
TALLY TOTALS	3468	9285	12693	13074	16792	14855	9465	7011	7190	6651	7799	9388	3007	4550	8585	9032	13211	6752

Category STATUS UNKNOWN AS TO DEAD OR ALIVE but NOT INJURED (SU)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OFFSHORE SPOTTERS	0	0	0	0	0	0	136	438	119	108	138	286	47	30	23	98	226	58
COASTAL SPOTTERS	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
UNIDENTIFIED SPOTTERS	25	13	164	126	195	193	0	2	0	2	0	0	0	0	0	0	0	0
WHITEBELLY SPINNERS	0	0	0	5	35	60	15	34	3	21	22	32	8	1	4	4	13	4
EASTERN SPINNERS	0	0	0	31	48	10	8	13	38	6	19	11	9	0	9	14	58	5
UNIDENTIFIED SPINNERS	0	7	19	0	6	8	0	3	3	4	1	0	0	0	0	4	1	0
COMMON DOLPHINS	2	1	9	31	7	20	41	0	96	22	40	7	0	0	10	1	0	2
STRIPED DOLPHINS	0	0	0	0	0	0	0	1	1	0	0	5	0	0	2	0	1	0
OTHER-SPECIES DOLPHINS (IDENTIFIED OR NOT)	37	0	30	10	6	6	38	34	12	6	205	16	1	4	2	31	56	13
TALLY TOTALS	64	21	222	203	297	297	238	525	276	169	425	357	65	35	50	152	355	82

APPENDIX 2. continued

Category ALIVE and INJURED (AI)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OFFSHORE SPOTTERS	0	0	0	0	0	0	208	155	144	231	182	143	27	39	50	43	109	26
COASTAL SPOTTERS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
UNIDENTIFIED SPOTTERS	0	0	0	0	449	463	1	1	0	1	2	0	0	0	0	0	0	0
WHITEBELLY SPINNERS	0	0	0	0	44	218	63	60	36	21	55	16	10	14	1	8	14	3
EASTERN SPINNERS	0	0	0	0	131	78	27	13	51	9	15	12	18	1	25	6	25	1
UNIDENTIFIED SPINNERS	0	0	0	0	11	60	1	6	3	0	0	0	0	0	1	0	2	0
COMMON DOLPHINS	0	0	0	0	40	52	60	6	66	38	43	5	1	0	4	0	0	5
STRIPED DOLPHINS	0	0	0	0	15	0	3	8	1	2	0	0	0	1	0	0	0	0
OTHER-SPECIES DOLPHINS (IDENTIFIED OR NOT)	0	0	0	2	15	31	16	11	14	5	21	12	0	0	0	2	12	6
TALLY TOTALS	0	0	0	2	705	902	379	260	315	308	318	188	56	55	81	59	162	41
NMFS BEFORE BACKDOWN	0	0	0	0	0	0	217	132	147	46	29	66	19	30	24	27	96	21
TOTALS	0	0	0	2	705	902	596	392	462	354	347	254	75	85	105	86	258	62

Category ALIVE and NOT INJURED (A)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OFFSHORE SPOTTERS	0	0	0	0	0	0	7913	5830	3916	1923	3160	2931	154	212	1203	1870	4757	1148
COASTAL SPOTTERS	0	0	0	0	0	0	52	0	0	0	2	0	0	0	0	0	0	0
UNIDENTIFIED SPOTTERS	98	426	1127	1829	1047	2142	54	46	38	19	11	13	0	0	0	0	0	0
WHITEBELLY SPINNERS	0	12	5	87	77	141	383	832	87	188	410	138	9	54	294	312	130	41
EASTERN SPINNERS	0	0	18	312	157	79	194	48	221	56	239	105	36	23	144	84	367	16
UNIDENTIFIED SPINNERS	178	87	218	15	25	59	17	7	10	28	13	1	0	5	14	11	9	0
COMMON DOLPHINS	0	32	167	412	29	41	1428	88	211	11	173	33	29	1	1	0	40	40
STRIPED DOLPHINS	0	0	0	14	2	0	449	19	13	0	0	0	0	0	0	0	0	0
OTHER-SPECIES DOLPHINS (IDENTIFIED OR NOT)	4	120	32	156	787	2513	2184	487	369	332	387	573	2	27	69	1694	1595	37
TALLY TOTALS	280	677	1567	2825	2124	4975	12674	7357	4865	2557	4395	3794	230	322	1725	3971	6898	1282
IATTC AFTER BACKDOWN	0	0	0	0	0	0	0	0	1522	2464	3130	2859	1264	930	2789	2055	1657	784
TOTALS	280	677	1567	2825	2124	4975	12674	7357	6387	5021	7525	6653	1494	1252	4514	6026	8555	2066

APPENDIX 2. continued

Category STATUS UNKNOWN AS TO DEAD OR ALIVE but INJURED (SUI)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
OFFSHORE SPOTTERS	0	0	0	0	0	0	117	85	21	30	35	11	8	1	10	3	36	6
COASTAL SPOTTERS	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
UNIDENTIFIED SPOTTERS	0	0	1	0	99	155	0	0	0	1	0	0	0	0	0	0	0	0
WHITEBELLY SPINNERS	0	0	0	0	6	93	28	37	3	2	7	0	0	0	2	0	2	2
EASTERN SPINNERS	0	0	0	0	14	22	7	9	9	3	2	2	5	0	3	1	8	0
UNIDENTIFIED SPINNERS	0	0	0	0	7	18	0	1	3	5	0	0	0	0	0	0	2	0
COMMON DOLPHINS	0	0	0	0	1	9	23	5	11	0	7	0	0	0	0	0	1	0
STRIPED DOLPHINS	0	0	0	0	1	2	0	4	0	0	0	0	0	0	0	0	0	0
OTHER-SPECIES DOLPHINS (IDENTIFIED OR NOT)	0	0	0	0	6	2	15	10	10	0	1	0	0	0	0	0	12	0
TALLY TOTALS	0	0	1	0	134	301	190	151	57	41	53	13	13	1	15	4	61	8

Number of sets from which "TALLY FORM" data was retrieved

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
TOTALS	59	263	759	1130	1100	1303	3415	1780	2923	2213	2273	1929	998	831	1954	1382	4306	1206

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