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October 30, 2002
Ref.: 0653-800

The Honorable Donald Evans
Secretary of Commerce
United States Department of Commerce
Herbert C. Hoover Building
14th and Constitution Avenue NW
Washington, DC 20230

Dear Secretary Evans,

The International Dolphin Conservation Program Act requires that studies be undertaken to address the question of whether the purse-seine fishery for tunas is having a significant adverse impact on any depleted dolphin stock in the eastern Pacific Ocean (EPO). In making a finding on this, the Act calls upon you to consider, in addition to the above studies, information obtained under the International Dolphin Conservation Program, and any other relevant information.

The Act also requires that, in the conduct of this study, the Secretary consult with the Inter-American Tropical Tuna Commission (IATTC) and the Marine Mammal Commission. In this regard, on September 18, 2002, I received from Dr. Michael Tillman, Director of the Southwest Fisheries Science Center (SWFSC) of the National Marine Fisheries Service (NMFS), a copy of the "Report of the Scientific Research Program under the International Dolphin Conservation Program Act" (SWFSC report) for review and comment by the IATTC.

The IATTC is an international organization that has for more than 50 years been responsible for research into the tuna fisheries of the EPO, and since 1978 it has assumed responsibility for research of the effects of the fishery on dolphin stocks and the means of mitigating those. The members of the IATTC are Costa Rica, Ecuador, El Salvador, France, Guatemala, Japan, Mexico, Nicaragua, Panama, Peru, the United States, Vanuatu, and Venezuela.

The best available scientific evidence supports the conclusion that the purse-seine fishery is not having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean, specifically that the intentional deployment on or encirclement of dolphins with purse seine nets is not having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean. This evidence does not support a finding that the purse-seine fishery is having a significant adverse impact on any dolphin stock in the eastern tropical Pacific Ocean. This statement is based on the information presented in the SWFSC report, and our independent analyses of the status of dolphin stocks and observations of their interactions with the tuna fishery over the last 30 years. We have prepared, for your consideration, as part of the process in making your finding, a Scientific Report setting forth the IATTC analysis of the status of the dolphin stocks in the EPO. The Scientific Report is attached to this letter.

The SWFSC report seems to suggest that there is a significant adverse impact on certain dolphin stocks, despite its data that show that these dolphin stocks are increasing, and that, if their recovery is being hindered, the cause is not related to the fishery. The SWFSC report argues that the stocks are not recovering at an "expected" rate, and that a plausible explanation for this is unobserved mortality due to the fishery, but it emphasizes only evidence that there may be an impact from the fishery, and discounts evidence that there is not, and relies on highly-speculative assumptions about what was and is taking place. Moreover, its conclusions are based on a small amount of data, which, as the report itself admits, cannot be used to draw reliable inferences on population levels. The data in the report that suggest that fishing is not having a significant adverse impact were largely ignored. In any case, the SWFSC conclusion that some unobserved mortality is the reason for low population growth rates requires that the unobserved mortality be more than 20 times (2,000 percent) the observed mortality. It is highly unlikely that this could be the case. Further, the results from the abundance surveys undertaken by the SWFSC indicate that the dolphin stocks have been stable or increasing for more than 20 years.

An additional point that this Commission believes you should take into account is the standard the United States uses, the Potential Biological Removal (PBR) system, mandated by the Marine Mammal Protection Act, for conserving marine mammal populations associated with fisheries. The current mortalities associated with the fishery are well below the PBR limits calculated in the SWFSC report that are considered sustainable under US management policy. Also, if it were concluded that the purse-seine fishery for tunas is having a significant adverse impact on the dolphin stocks, it would mean that virtually all of the many US fisheries with marine mammal associations are having even more deleterious impacts, calling into fundamental question the validity of the US approach to management of its fisheries.

I would be remiss if I did not bring to your attention one non-scientific point that is important to consider in addressing this matter. That is the fact that any development that leads to the continued closure of the US market to tuna labeled as dolphin-safe under the program of the Agreement on the International Dolphin Conservation Program (AIDCP) would put the AIDCP, which is recognized as one of the most successful international marine conservation programs in the world, in jeopardy, as it is not clear that all the governments would continue with its stringent regulations to protect dolphins if the catches could not be marketed as dolphin safe. Any weakening of the program could lead to increased dolphin mortality and to a reduction in information available for research necessary to conserve dolphins.

It has been well documented by this Commission[1] that if the tuna fisheries associated with dolphins shifted to the other main method of capture, fishing on floating objects, the effect on the marine ecosystem as a whole could be devastating, given the large catches of juvenile tunas and other species, such as sharks, billfishes, and sea turtles, which result from this alternative fishing method. I recognize that this matter is not directly relevant to the finding, but it is an important backdrop to the issue and a principal impetus behind the passage of the International Dolphin Conservation Program Act in 1997.

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[1] Joseph, J. 1994. The Tuna-Dolphin Controversy in the Eastern Pacific Ocean: Biological, Economic, and Political Impacts. Ocean Development and International Law, Vol. 25, pp 1-30.
Hall, M. A. 1998. An ecological view of the tuna-dolphin problem: impacts and trade-offs. Reviews in Fish Biology and Fisheries 8, 1-34.

In summary, it is the IATTC's conclusion that the purse-seine fishery for tunas is not having a significant adverse impact on any of the dolphin stocks in the EPO. The Commission is aware that the report that you have received from the SWFSC does not appear to share our conclusion. However, once the speculations have been winnowed from the report, and the focus shifts to that which we ***do*** know and ***can*** demonstrate scientifically, you will find that the data support a finding of no significant adverse impact. While it is logical to think that the fishery is one of several factors that could be having some impact on the stocks, since some dolphin mortality does occur, there is simply no evidence to conclude that this impact is *significant*, particularly in light of the very low mortality levels and no information showing problems from stress on these dolphin stocks. We are, of course, aware that "significant adverse impact" is not defined, and that you therefore have considerable discretion in deciding the meaning of these words in terms of what is happening with the dolphin stocks.

In the course of preparing this report, the scientific staff of the Commission and the Parties to the IATTC Convention conducted an extensive analysis of not only the SWFSC report and documents, but also the underlying comments from outside experts and the available body of relevant research. Importantly, the attached IATTC report has been reviewed by, and incorporates the scientific views and comments of two eminent scientists (Professor S. Buckland, St. Andrews University, Aberdeen, Scotland, and Dr. A. Parma, Centro Nacional Patagónico, Puerto Madryn, Argentina) who are very familiar with this subject and are widely recognized as experts in the scientific disciplines relevant to this analysis.

The Commission appreciates the opportunity to present its views to you. Attached is the Commission's *Scientific Report on the Status of the Dolphin Stocks in the EPO*, which I trust you will give due consideration to in examining the information available to you as you make your finding.

Yours sincerely,

Robin Allen
Director

INTER-AMERICAN TROPICAL TUNA COMMISSION

SCIENTIFIC REPORT OF THE ON THE STATUS OF DOLPHIN STOCKS IN THE EASTERN PACIFIC OCEAN

EXECUTIVE SUMMARY

1. The SWFSC survey results show that the populations of northeastern spotted dolphins and eastern spinner dolphins are increasing slowly, and that, if recovery is being hindered, the data are inconsistent with a fishery-related cause. The simplest of the SWFSC's models of population change shows estimates of northeastern offshore spotted and eastern spinner dolphins growing at rates of 1.7% and 1.4% per year, respectively. The more complex two-stage interpretation of the abundance estimates indicates an increase in the two stocks during the late 1980s and declines or stability during the 1990s. This interpretation, taken at face value, would exclude the fishery as a cause of the presumed lack of recovery. For the period 1979-2000, the largest research survey estimates of abundance of the stocks of north-eastern offshore spotted and eastern spinner dolphins (1988-89) occurred just after the highest estimates of fishery mortality (1985-87) and the greatest numbers of sets on dolphin-associated tuna. During the late 1980s and early 1990s the mortalities of dolphins due to the fishery declined dramatically, and the number of dolphin sets (the presumed cause of any hypothetical unobserved mortality) declined by about 25%, and yet the dolphin populations declined or remained stable. It is difficult to explain how the dolphin populations could flourish when subjected to high mortalities and yet decline as the fishing pressures eased if setting on dolphins were having an adverse impact. The SWFSC abundance data demonstrate that, even if the populations are not currently increasing rapidly, it is not because the fishery is responsible for this.
2. In fact, the survey results, taken at face value, indicate that the dolphin stocks have been quite stable over the last 20 years. Also, the SWFSC report notes that for northeastern offshore spotted dolphins, none of the model runs in which fishery mortality was hypothetically increased performed better than the base model, which included actual reported mortality, and if the future mortality were set at zero, the estimated future population trajectories would be indistinguishable from those with the current mortality level projected into the future. In other words, a level of mortality equal to the current reported level has no detectable impact on the stocks.
3. The IATTC has some concerns about the analysis of the research vessel survey data. In particular, the use of different models fitted to the sighting data for each year probably affected the annual estimates of population density. This will have affected the comparison among years, affecting estimates of population growth rates. The estimated precision of the research survey abundance estimates is likely to be an underestimate of the true uncertainty. The effects of large rounding errors in the bearing measurements, inadequate survey coverage of the range of the stock in some years, and unexplained large variability in herd size within the same survey period have not been adequately incorporated into the estimates of survey precision. It is likely that the precision of the estimates of abundance is overstated, resulting in an overestimate of confidence in population growth rates.
4. There is no credible evidence that stress associated with the chase and encirclement of dolphins has had a significant adverse impact on the populations. In fact, all the data presented in the SWFSC report support the hypothesis that there has been no significant adverse impact. The SWFSC report focuses on the indications of muscle damage in dolphins

that were chased, encircled, and then grabbed by swimmers and placed in a raft for blood sampling. However, they showed that the stress hormones and enzymes are at levels from which the dolphins would fully recover from chase and encirclement, and the necropsy study showed that healed heart and muscle lesions are not life-threatening and are commonly seen in dolphins in the wild that are not associated with the purse-seine fishery. The SWFSC relies on speculation to come to the heavily-qualified conclusion that findings from stress research "*support the possibility* that purse seine fishing involving dolphins *may have* a negative impact on the health of *some individuals*." [italics added]

5. The SWFSC report provides evidence that mothers and calves are separated when mortality of the mothers, but not the calves, occurs during sets. This is based on observations of dead lactating females without calves during 1973-1990. Given the current low mortality rates, even in the worst-case scenario, the addition of this cause of unobserved mortality would be sustainable by the population under the same Potential Biological Removal (PBR) limit criteria required for US fisheries. The SWFSC report goes on to speculate that mothers and calves may be separated during the chase, that the mothers may become separated from the calves, and that the calves then may die. There is no evidence to support this contention, and much evidence that refutes it from well-known observations of mammalian mothers staying with and protecting their young at the risk of their own lives to the tracking studies of female spotted dolphins with calves demonstrating that the mother-calf bond remained intact even after seven sets over seven days.

6. The SWFSC calculations of PBR shows that the observed mortality is 36% of PBR for eastern spinner dolphins and 28% of PBR for northeastern spotted dolphins. Thus, even if the unobserved mortality increased the mortality by almost 300% relative to the observed mortality, the total mortality in the fishery would still be below the PBR for these stocks. In other words, the level would be acceptable in the risk-averse approach that the NMFS uses in every other case in which there is an interaction between a commercial fishery and marine mammal populations. However, in calculating the PBR as per NMFS guidelines, the SWFSC adopts the observed values of population growth (1.7% and 1.4% for northeastern spotted and eastern spinner dolphins) as the maximum population growth rates, effectively undermining the argument made in the report that the expected rate should be 4%.

7. The SWFSC report compares the observed population growth rates with an "expected" maximum recovery rate of 4% per year. However, no dolphin population has been known to increase at a rate that high. Further, the law does not require a 4% recovery rate; a lower rate would be acceptable, so long as the fishery was not having a "significant adverse impact." The SWFSC assumption that the growth rate should be 4%, plus extrapolation from the estimated population sizes from 1979 back to 1959, using the assumed mortality rates discussed in paragraph 8, and the absence of any recognized (by the SWFSC) environmental changes that might significantly affect dolphin stocks, leads to the conjecture of an unreported mortality of thousands of dolphins. These conjectures are first presented in the SWFSC report as being credible, and subsequently are used as an expectation, and then a standard that cannot be achieved.

8. The SWFSC tested its population dynamics models against three separate hypotheses of actual mortality: 1) that the actual mortality is the observed mortality, 2) that the actual mortality is 150% of the observed mortality, and 3) that the actual mortality is 200% of the observed mortality. Of the three, the hypothesis that fit best with the population models was the actual mortality observed in the fishery. While the preference was slight, it clearly

demonstrates the speculative leap required to reach the conclusion that SWFSC appears to believe likely, that is, that the actual mortality is more than 20 times [2,000 percent] that observed, or 14,400 offshore spotted dolphins and 11,300 eastern spinner dolphins.

9. Assumptions about the status of the stocks over 40 years ago drive the conclusions reached about whether "recovery" to these hypothetical levels is occurring. The SWFSC report suggests the dolphin stocks are not recovering at the "expected" rate, based on assumptions that the mortality rates in the early years of the fishery were as high as previously assumed. Given the stable sizes of these populations and the stable age distribution of northeastern spotted dolphins, the assumption and the related conclusion that six million dolphins were killed in the tuna fishery during the past 40 years must be re-examined. The high mortality estimates from the early years of the fishery (1959-1972) are based on extrapolations from a small sample of 20 fishing trips. Only three of those were made before 1971, and the data from them were not collected in the framework of a scientific sampling scheme. Thus a very significant decision may hinge on data judged to be of "little or no statistical value" by a committee convened by the National Research Council's Commission on Life Sciences[2] to review scientific and technical information relevant to the fishery.

10. One alternative to the fishery having a significant adverse impact on dolphin populations is that changes in the ecosystem have had significant effects on those populations. Although the SWFSC report concluded that it was unlikely that there has been sufficient change in the eastern Pacific ecosystem to cause low population growth rates for spotted and spinner dolphins, the SWFSC abundance data and the IATTC fishery data demonstrate that large changes have indeed occurred for other species of upper-level predators. Based on the survey data, we estimate that over 200,000 more pilot whales, over 750,000 more common dolphins, over 7,000 more Bryde's whales, and more than 70% more yellowfin tuna were added to the ecosystem from 1986-2000. The increases of these populations of large predators could increase competition for fish and squid that the spotted and spinner dolphins feed upon. The SWFSC discounted the likelihood of environmental changes being great enough to affect the dolphin stocks. However, the observations of ecosystem changes are consistent with the views of the members of the NMFS expert panel on Ecosystem Effects. All of the members of the Panel agreed that ecosystem variation clearly could have a significant impact on dolphin populations in the eastern Pacific Ocean, and three of them perceived the changes as having a depressing effect on the populations.

    "...such changes provide a credible explanation for at least part of the observed slow recovery of dolphin stocks ..." Landry

    "Consequently, the argument is persuasive that the carrying capacity of the ETP, relative to the ecologies and life histories of northern offshore spotted dolphins and eastern spinner dolphins, is lower now (and the past several or more years) that it was prior to and during the early phase of the fishery." Stewart

    "... require that we do not rule out the possibility that the carrying capacity of the ETP for dolphins has declined and that this has affected the recovery of the population." Barber

Attached are several appendices that elaborate upon our analysis.

[2] page 54 NRC 1992. Dolphins and the Tuna Industry. National Academy Press. 176 p.

Appendix 1. Estimation of Stock Sizes

General comment

A great deal of work has been carried out to improve the line transect estimation procedures for the research vessel surveys, but there are still difficulties associated with the quality of the data and the techniques of analysis. Differences between the old and new series of estimates of absolute abundance of the northeastern offshore spotted dolphin (Figure 1.1), and of the eastern spinner dolphin, depend on assumptions that have not been substantiated, and the standard errors of the new estimates do not account for the differences caused by the choices of model assumptions. It is therefore difficult to know how well the power analyses of trends capture the true ability of these time series to detect different levels of population changes. These points lead us to the view that the estimates are still subject to change, depending on the choices made by the analysts, and that precision of the surveys is likely to be overestimated.

Specific comments

1. Horizontal bearing data suggest some preferential rounding. Horizontal sighting angles for the 1998-2000 surveys show a large proportion of sightings at 5º and 10º (Kinzey *et al.*, 2002: Figure 1a). Rounding to 5º is evident across the full range of sighting angles, and smearing was used to adjust for the effects of rounding to 5º increments. However, from the data shown, rounding to 5º increments does not appear to be an entirely random process because of the high frequency of sighting angles reported at 5º and 10º. It is not clear that smearing is the appropriate technique to deal with this preferential rounding. The cause of this preferential rounding was not discussed, and it is not known if the cause was identified.

2. A half-normal model is used for the detection function without adequate justification. An excess of offshore spotted and/or spinner dolphin sightings near the trackline can be seen in the perpendicular distance data for 1979, 1980, 1983, 1987, 1998, 1999, and 2000 (Gerrodette and Forcada, 2002: Figures 5-6). Forcada (2002, p. 19) cautions that "…research on the problem of why the data is spiked may discard or justify the use of models that over fit, such as the hazard rate." and " In the example analysis, however, it is not clear whether the spike was purely a sampling artifact or if the true detection function was in fact spiked." Gerrodette and Forcada (2002: p. 10) used the half-normal model for the detection function, apparently because "Fitting the probability density function to this spike with exponential or hazard-rate models gave unreasonable values for the effective strip width." However, the "unreasonable" values of effective strip width were not presented or discussed. No analysis of the perpendicular-distance data to support a claim that the excess of detections near the line was, in fact, a sampling artifact is in the report. Thus, it has not been established that fitting this excess in detections near the line is an undesirable property. Comparison of half-normal models and hazard-rate models (Forcada 2002: Table 1a-c,) shows that, for the example data used, the difference in $f(0)$ for the hazard-rate, as compared to the half-normal (same covariates), was often greater than the range of $f(0)$ estimates based on the half-normal model (different covariates), but was less than the range of $f(0)$ estimates obtained with the hazard-rate model (different covariates). In addition, with the exception of 1983, the effective strip widths estimated from the hazard-rate model (Wade, 1994) and mixed hazard-rate, half-normal model (Gerrodette, 1999, 2000, core area) are between 1.8 and 4.3 km, similar to the range of effective strip widths of 2-4 km presented by Gerrodette and Forcada (2002). Thus, it is not clear whether it is the use of the hazard-rate model, or the use of the

hazard rate model with multiple covariates, that gives unreasonable estimates of the effective strip width. Comparison of pooled estimates of $f(0)$ for 1979-1999, based on the hazard-rate model (or mixed models) to pooled estimates based on the half-normal model showed differences of approximately –50% to +40%, with an average difference of approximately –10% (estimates from: Wade, 1994: Table 3.4, northeastern spotted; Gerrodette 1999, 2000, Table 3, offshore spotted, core area; Gerrodette and Forcada, 2002: Table 4, northeastern spotted), suggesting that the choice of the form of the detection function may be important. Choice of the hazard-rate model or the half-normal model must be based on an analysis of whether the excess of sightings near the trackline was the result of a sampling artifact.

3. Different covariate models fitted to the detection data for each year possibly added unwanted inter-annual variability to the estimates of $f(0)$. Although the SWFSC scientists use the same form for the detection function (half-normal) in all years, different sets of covariates are selected in each year. Thus, the models fitted to the perpendicular distance data do not remain the same across years. It is not clear to what extent the use of different models in different years contributed to inter-annual variability in the estimates of $f(0)$. A better choice for building a covariate model for the detection function would be to pick a common "best" set of covariates for all years based on a statistic such as the Aikike's Information Criterion, and extensive data analysis focused on understanding correlation between the independent variables and the relationships between independent variables and probability of detection. Stability of the "best" model could be explored through cross-validation or "bagging" (Brieman, 2001 and references therein).

4. Large inter-annual within-survey-period fluctuations in herd size remain unexplained. While inter-annual variability in the abundance estimates among years has been greatly reduced with the new methodologies, the greatest inter-annual variability among estimates of abundance for the northeastern spotted dolphin still occurs within the 1986-1990 survey period. No explanation is offered for this inter-annual within-survey variability by either Wade (1994) or Gerrodette and Forcada (2002). It would appear from the data presented in Table 4 of Gerrodette and Forcada (2002) that the increase in abundance of northeastern spotted dolphins in 1988-1989 is due largely to an increase in herd size—approximately 40% increase in those two years, as compared to the other years within the same survey. It is surprising that such inter-annual variability in herd size was not investigated.

5. The sampling coverage of spatial strata used to estimate the abundance of the eastern spinner dolphins has not been consistent among surveys. In particular, as noted in the recommendations made by the line transect expert group to the IATTC Scientific Working Group Review of Dolphin Abundance Estimates, held on October 19-20, 2000, in La Jolla, California, there was insufficient survey effort in the outer area stratum in 1999. The panel noted that "In 1998, around 20% of the abundance estimate of eastern spinner dolphins was in the outer area.," and that the lack of sightings in the outer area in 1999 was likely caused by lower survey effort in that stratum. It does not appear that the sensitivity of the abundance estimates to sampling inadequacies was explored by Gerrodette and Forcada (2002).

6. The revisions to the abundance methodologies and to the data led to considerable changes in the estimates of abundance, and it is therefore surprising that the authors do not attempt to determine which changes made the most difference and why. While a number of the revisions were well-motivated (but see (1)-(3) above), and simulations were used to give guidance in selecting among estimation procedures, it would appear from these manuscripts

that no detailed dissection of the contributions of the various modifications to the changes in the estimates of abundance was undertaken with the complete data. Such analyses are essential before the new estimates can be regarded as being improvements over the previous estimates.

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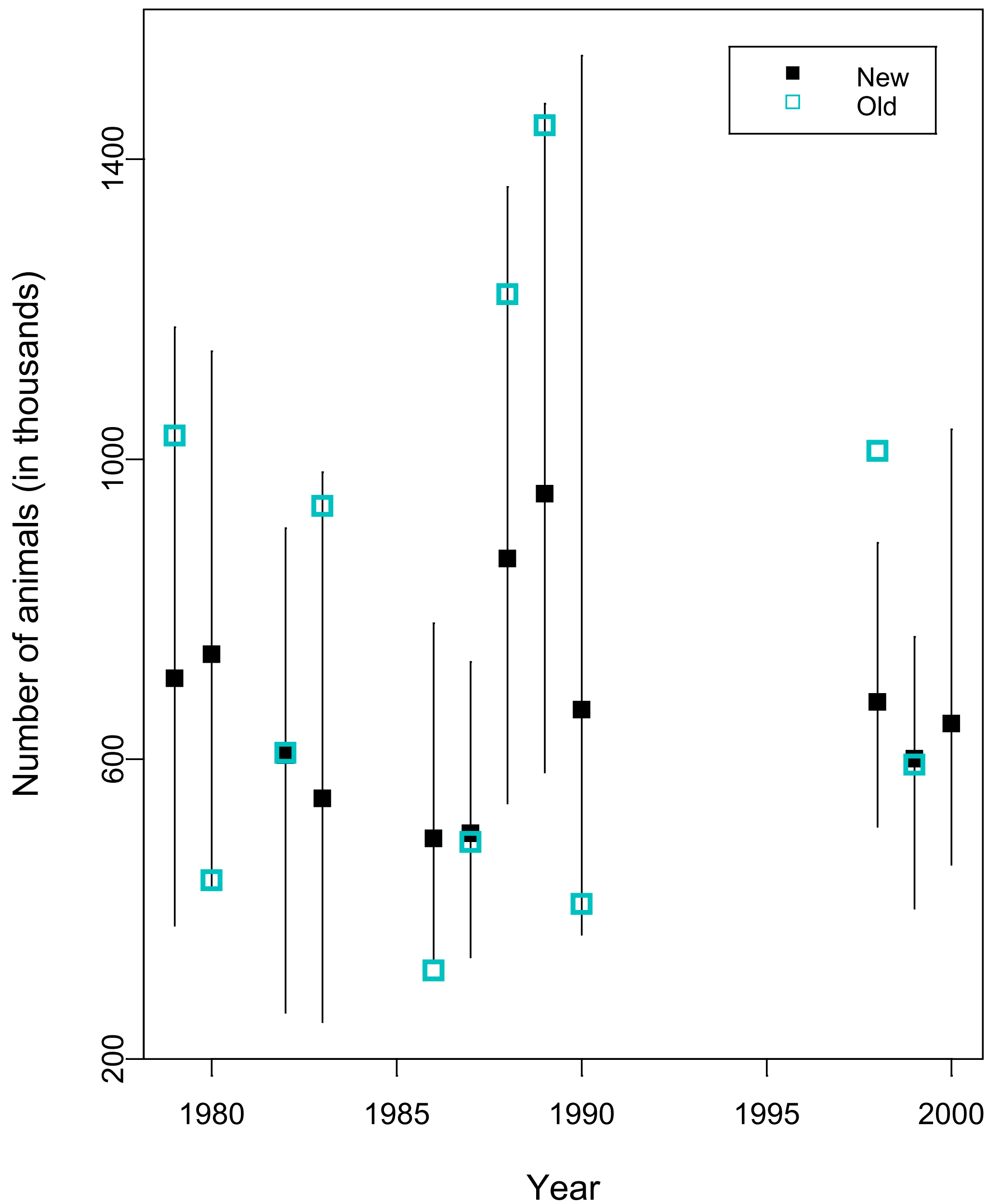

Figure 1.1. Estimates of abundance of northeastern offshore spotted dolphin, and approximate 95% confidence intervals, based on the new methodologies (Gerrodette and Forcada, 2002) and old methodologies (Wade, 1994; Gerrodette, 1999 and 2000).

Appendix 2. Analysis of Stress and Other Fishery Effects

To provide a fair basis for his decision, the SWFSC should present the Secretary not only evidence that suggests that a significant adverse impact might be occurring, but also evidence that it is not. The SWFSC emphasized in the Executive Summary of its report only evidence that suggested that unreported mortality might be occurring; negative evidence is buried in the Appendices or individual reports and not compiled in support of the hypothesis that the fishery has no significant adverse impact. In this section, we discuss the evidence that the SWFSC has presented in favor of the hypothesis that unobserved mortality is occurring, but also a list of the evidence that supports the alternative view that the fishery has no significant adverse impact.

Evidence Supporting a Finding of a Significant Adverse Impact

The SWFSC marshaled the evidence that may be interpreted as supporting a finding of a significant adverse impact on page 25 of its report:

> "However, in the aggregate, the findings from the available data *support the possibility* that tuna purse-seining activities involving dolphins *may have* a negative impact on *some* individuals. [italics added for emphasis] Some evidence was found for potential stress-related injury or unobserved mortality of dolphins involved in purse seine fishing operations, based on the combined documentation of: (a) moderately elevated stress hormones and enzymes indicative of muscle damage observed in live dolphins examined in the nets; (b) evidence of past (healed) muscle and heart damage in dolphins killed during fishing operations; and (c) fatal heart damage in virtually all fishery-killed dolphins, which most likely was related to elevated catecholomines. The responses observed in the samples of live animals were well within those ranges from which dolphins are expected to recover fully; however, it is possible that some dolphins may experience stronger responses, such as during occasional 'catastrophic' aspects of fishery operations when dolphins may become trapped under a canopy in the net."

First, this heavily-qualified conclusion is so laden with uncertainties that a finding of significant adverse impact cannot be based on it. The conclusion is based on a mixture of data and speculation. But the data cited (as opposed to the speculation) do not support a finding of significant adverse impact. On the contrary, all the data mentioned indicate that no significant adverse impact is occurring. The stress hormones and enzymes are at levels from which the dolphins would fully recover from chase and encirclement; the healed heart and muscle lesions are not life-threatening and are commonly seen in dolphins in the wild that are not associated with the purse-seine fishery. Thus they cannot be attributed with any certainty to purse-seine fishery interactions (Cowan and Curry 2002), nor assumed to result in the stress-related mortality of dolphins. The rest of this conclusion is based on speculation.

Second, the report cites the conclusion by Archer *et al*. (2001) that separation of mothers and calves is occurring, and that this could result in deaths of the calves and a significant adverse impact on the population. Again, this conclusion is based on a mixture of data and speculation. The data indicate that in one sample collected during 1973-1990 it appeared that calves were orphaned after their mothers were killed in the fishery, but that even in the worst-case scenario, the resulting additional mortality would be inconsequential and the total mortality would still be sustainable and well below the Potential Biological Removal (PBR) limits that are currently used to manage US fisheries (2,367 northeastern spotted and 1,298 eastern spinner dolphins). In

2000, this would amount to an additional mortality of 117 calves out of a population of 641,153 northeastern spotted dolphins.

The speculative part of the SWFSC report's argument is that perhaps a large number of mothers and calves are separated during the chase, that the mothers may become separated from the calves, and that the calves may then die. However, there is no evidence that supports this contention, and much evidence that refutes it. In general, mammalian mothers are known to go to extreme lengths to stay with and protect their young, even while being chased by predators. Whalers have used the protective behavior of mothers toward their calves to increase their catches (Caldwell and Caldwell, 1966). Adult dolphins have been observed defending young calves against sharks, despite the risk to themselves (Springer, 1967). Thirty years of short chases and encirclement of bottlenose dolphins in Florida have not resulted in any permanent separations of mothers and calves; even when one member of the pair was temporarily encircled and the other was not, the free dolphin remained just outside the net until the encircled one was released. Capture-recapture studies of three female spotted dolphins with calves showed that the mother-calf bond remained intact, even after up to seven sets over seven days (Chivers and Scott, 2002).

Evidence Refuting a Finding of a Significant Adverse Impact

The SWFSC Chase Encirclement Stress Studies (CHESS) cruise conducted some studies examining various aspects of stress, and the results of most of these studies were either negative (no evidence of significant stress-related injury) or equivocal. The studies showing no significant adverse impact are listed and described.

Behavioral studies – The study of the behavior of spotted dolphins encircled by purse seines noted that these dolphins are well-habituated to set operations (Santurtún and Galindo 2002). This corroborates the findings of the IATTC (1986) and Pryor and Kang-Shallenberger (1991) that indicate that the dolphins have learned behaviors that reduce the risk of entanglement and allow them to anticipate events in the fishing operations.

Heat stress studies - One of the CHESS studies (Pabst *et al.* 2002) examined the thermal stress by measuring deep-core temperatures and surface temperatures and heat flux from the dorsal fins of the dolphins (the dorsal fin functions as a radiator to release excess heat). None of these measurements showed any indications that adverse impacts due to heat stress were occurring. The data for one dolphin were puzzling because it displayed the highest deep-body temperature after being involved in the shortest chase (12 min.) of the study. It is most likely that the temperature reading was confounded by the long process (17 min.) required to capture this particular dolphin just prior to sampling.

Lymphoid study - A study of the lymphoid organs conducted as part of the SWFSC Necropsy Program (Romano *et al.* 2002) showed no signs of stress or of a compromised immune system.

Blood analysis study – Analyses of the blood collected from dolphins captured during the CHESS studies were largely equivocal, being hampered by small sample sizes and few recaptures of tagged and sampled dolphins (St. Aubin 2002). In general, "certain changes were noted signaling a stress response, but none that suggested distress at the time of second capture." The SWFSC report suggests that capture myopathy may be a cause of delayed mortality (p. 68), but the blood analyses during the CHESS cruise reported by Forney *et al*. (2002) indicated that recaptured dolphins had lower values of the muscle-specific enzyme CK, rather than the higher values that would be encountered if capture myopathy were occurring.

Population modeling study - Models of the population "that included simple mortality terms did not perform as well as the models without the additional mortality," indicating that "undocumented mortality is unlikely to have occurred" (SWFSC report: p. 68).

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Appendix 3. Population Modeling

General conclusions

To be able to conclude, from the population modeling used in the SWFSC study, that the tuna fishery is having an adverse impact (suggested in the SWFSC papers being demonstrated by the rate of recovery being less than expected) on the dolphin populations four conditions are required:

1. The dolphin population has a current productivity rate of *X*.
2. If the current productivity rate is *X*, then the maximum productivity rate is *Y*.
3. The expected maximum productivity rate is 0.04.
4. If *Y* is less than 0.04 it is due to the effect of the tuna fishery.

All four of these conditions are unknown for the eastern spinner dolphin and northeastern offshore spotted dolphin populations. The estimates of the current productivity rates are dependent on highly-uncertain estimates of abundance obtained from surveys. The surveys show unrealistic changes from year to year and change with the assumptions made in the analyses. The estimate of the maximum productivity rate is based on assumptions, uncertain estimates of population depletion, and assumptions about density dependence for which there are few empirical data and uncertain theoretical foundations. The expected maximum productivity rate of 0.04 is based on very few data, and could be even less than 0.02. The analyses presented by the SWFSC indicate that no additional mortality can be attributed to the tuna fishery. Furthermore, the methods used for inference can substantiate multiple interpretations when the information provided by the data is insufficient, as in these applications. Finally, the assumptions about the prior distributions may influence the results.

We agree with the referee (McAllister 2002), who stated that "Disappointingly, no useful insights can be gathered from this stock assessment regarding potential changes in growth rates, carrying capacity, and unobserved mortality rates due to chase and encirclement."

The details behind our conclusions are given in the following sections, one for each of the required conditions and one for the inference methodology. ES is used to represent eastern spinner dolphin and NEOS is used to represent northeastern offshore spotted dolphin.

1. The dolphin population has a current productivity rate of *X*

All three models used by the SWFSC scientists produce similar estimates of current productivity rates, around 0.010 and 0.017 for ES and NEOS dolphins, respectively (Wade *et al*. 2002). These estimates are dependent on the survey data providing reliable estimates of biomass. The limitations of the survey data are discussed in Appendix 1 of this report, Estimation of Stock Sizes. Additional comments are presented below.

Comparison of trends in mortality and abundance

Comparison of mortality and abundance trends (Figure 3.1) for NEOS shows that the abundance decreased from 1977 to 1987, during a period of low mortality (1977-1984), and then increased from 1987 to 1989, just after a period of high mortality (1985-1987). This indicates that (1) the mortality is not a main factor driving the observed trends in survey estimates of abundance or (2) the estimates of the population sizes are unreliable (see next paragraph). If the mortality is affecting a portion of the population that is not part of the survey, but which becomes part of that population at a later date (*e.g.* juveniles), then models that do not assume time lags (exponential and general logistic) are inappropriate for modeling this population. The fits to the survey abundance estimates show an opposite trend to those for the data for 1980-1989, illustrating the above points (Figure 3.2). A pattern in residuals, as seen for the NEOS, is used as an indication of inadequate assumptions in the analysis, suggesting that "an alternative model might be appropriate" (Wade *et al*. 2002).

Either the population models are inadequate or the survey does not adequately represent the abundance.

Unrealistic changes in abundance estimates

The change in abundance from 1986 and 1987 to 1988 and 1989 for the NEOS is unrealistic. The estimates of population size nearly double in one year, which is inconsistent with a population that is suggested to have a maximum population increase of 4% per year. The abundance estimates have large uncertainty, and this change does not appear to be statistically significant. However, the rate of increase between 1986 and 1989 estimated from these data is significantly higher than 0.04 (95% confidence intervals of 0.09 and 0.46). Alternatively, given the low growth rate of the population, consecutive years can be considered to be estimates of similar quantities. If 1986 and 1987 are used to estimate one abundance level and 1988 and 1889 are used to estimate a second abundance level, then this produces an even greater difference between these years that is not consistent with 0.04 (95% confidence intervals of 0.21 and 0.99).

Either there is more uncertainty in the abundance estimates than acknowledged, or there is considerable bias in some of the abundance estimates, or there is considerable movement of dolphins into and out of the survey area.

Changes over time

The SWFSC analysis based on the exponential model with two productivity rates estimates that the growth rate of the population was much greater before 1990 or thereabouts (0.04 and 0.026 for ES and NEOS, respectively) than after 1990 (-0.021 and 0.002 for ES and NEOS, respectively) (Wade *et al.* 2002). The difference may have been even greater if the productivity rate were not restricted to be less than 0.08: "The 2-slope model would have fit these estimates even better if it had been allowed to, but the prior distribution did not allow the population to grow at [a rate] greater than 0.08, which is considered an extreme upper limit to the potential growth rate of a dolphin with its life history (Reilly and Barlow 1986)".

Either the productivity rate has large temporal variability or the survey data do not produce adequate measures of abundance.

Changes in estimates

The survey estimates of abundance provided by the SWFSC scientists have changed several times. These changes have caused the assessment results to change from being consistent with a maximum productivity rate of 0.04 (Alvarez-Flores 2002) to estimates that are less than expected (Wade *et al*. 2002). This indicates that the results are dependent upon key assumptions made in the analyses of the survey data. It would be informative to know what changes in assumptions caused these differences, but this cannot be determined from the SWFSC report.

Another example is provided by the results presented in the review by Haddon (2002), which differ from those presented in the final report: "In the exponential model, the 2-slope model predicts an initial population increase of 9.5%, while the density dependent model had the eastern spinner dolphins expanding in the early years at 8% per annum. These rates of increase appear high in terms of dolphin biology" (Haddon 2002). Using the SWFSC scientists' argument that if the estimate of the maximum rate of 0.02 is too small compared to the expected 0.04, then the rate of 0.08 is too high, indicating that the survey data may be biased.

Estimates of production are sensitive to assumptions made in the analysis of the survey data.

2. If the current productivity rate is *X*, then the maximum productivity rate is *Y*

The estimate of the maximum productivity rate is dependent on the estimated or assumed density dependence and the current depletion level. If the population is highly depleted then it should be growing at a rate close to the maximum productivity rate. If the population is only moderately depleted, then the population should be growing at only a fraction of the maximum productivity rate. The amount that the productivity is reduced depends on the amount of density-dependent effects that are occurring at that population size. Therefore, if we know the current productivity rate we need to know the amount of density-dependent effects that are occurring at the current abundance level to estimate the maximum productivity rate.

Depletion level

Due to the form of the production function and the density dependence that it represents, the closer the population is to the carrying capacity, the lower the productivity rate (as a proportion of the maximum productivity rate) (Figure 3.3). The SWFSC estimates that the current depletion levels are around 0.33 and 0.20 for eastern spinner and northeastern offshore spotted dolphins, respectively. These depletion levels are highly dependent on the historical mortality levels. A committee convened by the National Academy of Sciences of the United States (National Research Council 1992) discussed the early mortality estimates as follows:

> "Few data are available for the early years of the fishery (Lo and Smith, 1986). Former crewmembers who were concerned about high dolphin mortality provided data for the first two trips, and a government observer provided data for the third. Thus the data do not come from any valid sampling design. Trips were not selected at random or according to any pattern. The accuracy of the data is questionable because no standard procedure was used to collect information, and interpretation of the data cannot be determined to be correct. Estimating the standard errors is especially difficult.
>
> A substantial problem also exists with statistical bias in ratio estimates when sampling coverages are low. Using statistical simulations (IATTC, 1989c), the positive bias produced by ratio estimates at low sampling coverage results in overestimates of up to 4%-5% at 5% coverage even after a bootstrap procedure has been applied to reduce bias. It is likely that the overestimates were even greater at the much lower coverage—about 0.1%—used earlier and when no procedures to reduce bias were applied.
>
> In summary, the mortality estimates for the period before 1973 (peak values of up to 350,000-653,751 in a year by Perrin, 1968, 1969; Smith, 1979, 1983; Lo and Smith, 1986) **have little or no statistical value**, and the only conclusion that can be based on the data available is that mortality was very high. After a long hearing, the administrative law judge, Hugh Dolan, concluded that many errors had caused

> dolphin mortality to be seriously overestimated and dolphin abundance to be seriously underestimated by SWFSC in the 1960s and 1970s (Dolan, 1980).
>
> Nonetheless, these mortality data were used to calculate estimates of dolphin abundance for 1959-1970; these estimates were used later to conclude that some stocks of dolphins were depleted or were at a given proportion of their original abundance."

The main objections stated above remain valid. The more recent revised estimates of mortality (Wade, 1995) did not address the issues identified by the committee. Any attempt to use estimates of mortality for the years before the regular observer programs started will be limited by the lack of information from that period.

The IATTC staff has consistently maintained there was not enough information available to make reliable estimates of mortality for 1959 to 1970. Compounding the fact that the only data available for that period are from three fishing trips made before 1971, the data were provided in two cases by former crew members who were concerned at the high mortality, there was no sampling design for any of those data, there is no record in the vessel logbook data as to whether backdown was used, and there are too few data available to allow geographical stratification of the mortality rates.

Data for years after 1972 have been considered to be not representative of those for the earlier years due to the introduction of the Marine Mammal Protection Act of 1972, which is assumed to have changed the fishermen's behavior. In summary, the mortality estimates for 1959-1971, which have a large influence on the estimates of the current depletion level and the carrying capacity, are based on the assumption that the 20 trips (368 sets) carried out in 1971 and 1972 are representative of the 85,000 sets carried out during 1959-1971. The change in estimated mortality that occurred in 1973 could be due to (1) the fishermen being more motivated to save dolphins (Wade 1993), (2) 1971 and 1972 being anomalous years, or (3) the data for the early years being unrepresentative of the average mortality. The explanation based on the motivation of fishermen, which is preferred by the SWFSC, is only speculative. There is evidence of high inter-annual variation in the estimates (Wahlen 1986), which supports (2). Punsly (1983) showed that the proportion of sets on dolphins changes with area and time of year, so it is also likely that school size and mortality per set differ by area and time of year. The analysis of mortality per set did not include stratification by area and time of year, indicating support for (3).

Although the SWFSC scientists conducted sensitivity analyses to increased levels of mortality of 50% and 100% for the entire period and a 100% increase for 1992-2001, they did not consider any sensitivity analysis that reduced the historical mortality estimates. A 100% increase in the mortality before 1973 implies an increase in the average mortality per set from 65.8 to 131.6 for small vessels using the backdown procedure and from 130.8 to 261.6 for vessels not using the that procedure. If the values for 1973, for which there were twice as many samples obtained as there were for all years combined before 1973, were used for small vessels using the backdown procedure, which made up around half of the fleet for the early years, the mortality per set for these vessels would be reduced from 65.8 to 13.1. This would reduce the total mortality by about half. If such reduced early mortality estimates were used to fit the models, current abundance would increase relative to the unexploited population size. The higher the current abundance is relative to the carrying capacity, the higher the estimate of maximum productivity, which would bring the value closer to the expected value of 0.04.

The estimates of historical mortality have little or no statistical value, so estimates of the depletion level are highly uncertain.

Once it is acknowledged that the early mortality estimates are so problematic, we can look at the data without preconceptions about the level of depletion and the expected population growth rate. The survey results, if taken at face value, indicate stable or slightly increasing population trends (Gerrodette and Forcada 2002). The life history data suggest that the age distribution of the northeastern spotted dolphins is stable (Archer and Chivers 2002). The IATTC observer data show that the observed mortality rates are low, and the SWFSC Chase Encirclement Stress Studies and necropsy studies do not show any evidence of significant unobserved mortality (see Appendix 2). All of these data suggest that the populations are much closer to their carrying capacities than has been previously assumed.

Density dependence

Density dependence in the assessment models is controlled by the shape parameter z. z is not an interpretable value, so it is usually transformed into MNPL/K (Maximum Net Productivity Level as a proportion of the carrying capacity of the habitat), which is the abundance level relative to the carrying capacity that produces the greatest amount of additional abundance each year. However, the abundance level at maximum production is the most difficult model parameter to estimate (Pella and Tomlinson 1969), especially given the fact that during the period for which data are available there is no contrast in the abundance (Hilborn and Walters 1992). To estimate the value of z, values of production are needed for different levels of abundance. Because the estimates of abundance for both ES and NEOS populations from the survey data are all at similar levels, there is no information on the value of z ("there is little information about density dependent effects" (Haddon 2002)). The SWFSC scientists have assumed that MNPL/K (and the associated value of z) lies between 0.5 and 0.8 in their assessments. (see ***Bayesian Methodology*** for a description of the bias that the SWFSC prior distribution has for the higher portion of this range). The current production rate as a proportion of the maximum production rate is a function of z (Figure 3.4). Within the range of values assumed by the SWFSC scientists, as the abundance increases from highly depleted levels, the production rate decreases only moderately. Therefore, under those assumptions, the current estimates of the production rate are not consistent with a maximum production rate of 0.04. If, instead, the maximum production rate is fixed at 0.04 and z estimated, the estimate of z corresponds to a MNPL/K values of 0.42 and 0.43 for NS and NEOS, respectively. These values are only slightly less than the lower range of the values assumed by the SWFSC scientists. In other words, current estimates of the production rate could be consistent with a maximum of 0.04 if a different form of density dependence was assumed in the assessment models.

We agree with the reviewers that "It remains uncertain whether this particular functional form [of density dependence] conforms closely to the actual surplus production function for ETP dolphins" (McAllister 2002). "…no empirical evidence exists to limit the range of values expected" (Taylor and DeMaster 1993). There is also "… a lack of sound theoretical basis for choosing from a variety of models that vary markedly in their prediction of MNPL or MNPL/K" (Ragen 1995). Analyses have shown that it is possible for MNPL/K to be less than 0.5 (Taylor and DeMaster 1993). There is also theory based on spatial distribution of habitat that supports levels less than 0.5 (MacCall and Tatsukawa 1994). This has caused some to suggest that "In fact, the lack of estimates for other species argues that MNPL is not a practical measure" (Ragen 1995).

It should be noted that the SWFSC definition of PBR uses the factor $0.5R_{max}$ because this is the expected rate of production at Optimal Sustainable Population for a logistic model (Wade 1998). For the generalized logistic model with maximum production occurring slightly above 60% of the carrying capacity, the expected rate of production at Optimal Sustainable Population is 76% of R_{max}. This indicates that the assumptions made by the SWFSC scientists for the assessment of ES and NEOS are not consistent with the definitions of PBR.

The level of density dependence for the ES and NEOS populations is unknown.

3. The expected maximum productivity rate is 0.04.

The expected maximum productivity rate can be estimated by using either theoretical calculations based on the population dynamics or empirical data for the rate of increase at low population size. "Determining "the expected rate" of recovery is also difficult, given a lack of biological information" (Haddon 2002). This is because of the difficulty in estimating all of the life history parameters for marine mammals (Wade 1998). There is also considerable variability in the estimates from empirical data (Wade 1998). However, Wade (1998) states that "The lack of evidence of higher rates suggests that 4% is probably a suitable default value for odontocetes and that 2% represents a reasonable worst-case scenario. However, some caution is required, as so few data exist on observed rates of increase of odontocetes. Also, although several odontocete populations have apparently declined from human-caused mortality, none have been observed to recover. Although this may be due to the difficulty in monitoring odontocete populations, it also suggests that maximum rates of increase for some odontocetes could be even lower than 2%."

The expected maximum productivity level is uncertain, and the levels estimated by the SWFSC scientists for ES and NEOS may be unreasonable.

4. If *Y* is less than 0.04 it is due to the effect of the tuna fishery.

The analyses presented by the SWFSC scientists support the view that the low level of recovery was **not** due to additional unreported or unobserved mortality in the tuna fishery. Increasing the mortality by 50% and 100% degraded the fit to the data for both ES and NEOS. The inclusion of additional mortality based on the number of sets per dolphin was about 80% less probable than without this additional mortality.

There is no support in the results presented by the SWFSC scientists for unobserved or unreported mortality attributed to the tuna fishery.

5. Bayesian Methodology

Wade *et al*. (2002), who used Bayesian analysis, considered this to be the most appropriate method of inference. A review by McAllister (2002) supports the use of this methodology. It may be true that Bayesian methodology is the most appropriate, but, like all inference methods, there are limitations to its use[3], which must be considered when it is applied. Results from

[3] Reference Guide on Statistics, in Reference Manual on Scientific Evidence, Second Edition, Federal Judicial Center 2000) "Although such posterior probabilities can pertain directly to hypotheses of legal interest, they are necessarily subjective, for they reflect not just the data but also the subjective prior probabilities - that is, the degrees of belief about various hypotheses concerning the coin [or the dolphin population dynamics in this instance] specified prior to obtaining the data. Such analyses have rarely been used in court, because "The results of the analyses may be substantially influenced by the prior probabilities, which in turn may be quite arbitrary." Pages 132-133

Bayesian analyses can be interpreted in many ways. Wade *et al.* (2002) chose to present medians of the marginal posterior distributions. However, other estimators, such as modes or averages, are also available. In analyses for which the data are uninformative, these estimates can differ substantially, and can be influenced by assumptions about prior distributions. This sensitivity is illustrated in Figure 4b of Wade *et al*. (2002), for which the upper bound of the prior distribution for the rate parameter of the early period of the two-rate exponential model has caused the median estimate (0.04) to be much less than the mode of the marginal (integrated across the other model parameters) posterior distribution (about 0.05). This, again, is different from the maximum likelihood estimate, which can be calculated from the mode of the joint posterior distribution when all priors have uniform distributions. If the upper bound of the prior distribution is increased to 0.15, the median estimate increases by about 25% (to around 0.05). Unfortunately, when the models become more complex (*e.g.* the general logistic or the age-structured model), it is difficult to determine the influence of prior distributions on the results from the information presented by Wade *et al*. (2002). One prior distribution that may have a large influence on the results is that for the shape parameter of the general logistic or the fecundity function in the age-structured model. There is no information about this parameter in the data, and therefore all the results are based on integrating across the prior distribution for this parameter for which the bounds are set at levels that give MNPL/K values of 0.5 to 0.8. The median estimate was at the middle of the bounds, and the 95% confidence intervals were at the lower and upper bounds of the prior distribution. In addition to the problems with setting the bounds of the prior distribution, there is the problem of invariance to parameter transformation. For example, the results obtained by using a uniform prior distribution on MNPL/K values between 0.5 and 0.8 will be different from those obtained by using a uniform prior distribution on *z* between the values of *z* that produce MNPL/K at 0.5 and 0.8. Wade *et al.* (2002) used a uniform prior on MNPL/K for the generalized logistic model and a uniform prior on z for the age-structured model, which gives higher probability to higher values of MNPL/K. This inconsistent use of priors is probably due to the difficulty of implementing a uniform prior on the MNPL/K for the age-structured model. The priors used in both models conflict with the findings of Taylor and DeMaster (1993), who suggested that MNPL/K value should be at the lower portion of the range. In these situations it is useful to provide results from analyses with MNPL/K set at several values to give an idea of the sensitivity to this parameter. Wade *et al.* (2002) did not provide a sensitivity analysis to the prior distributions used in the analysis (they do not even provide information about all the prior distributions that are used, and the information that they do provide can be obtained only from comments dispersed throughout the document). Therefore, the validity of the analysis cannot be determined, particularly considering that the data are totally uninformative about some of the model parameters, whose estimates are almost the same as the prior assumptions.

The use of the prior distribution for estimating unobserved mortality illustrates the preconception of the SWFSC analysis. The prior distribution provides a degree of belief that there is a significant amount of unobserved mortality. An indication of this problem with the interpretation of the Bayesian analysis is the point made by one of the reviewers (McAllister) that when using Bayesian factors there is evidence against the hypothesis of unobserved mortality, but the 95% confidence intervals for the parameters describing the unobserved mortality does not include zero. This result is probably obtained because there is little information in the data to determine the value of the parameter and because the prior distribution for this parameter has a lower bound of zero. Therefore, the 95% confidence interval has a lower bound just above zero, a consequence of the prior and the use of two-sided confidence intervals, rather than information in the data. The analysis, therefore, produces results that seem to be illogical, and is erroneously reported in the SWFSC report as evidence supporting the existence of unobserved mortality.

The inference technique used by the SWFSC scientists has several deficiencies and biases.

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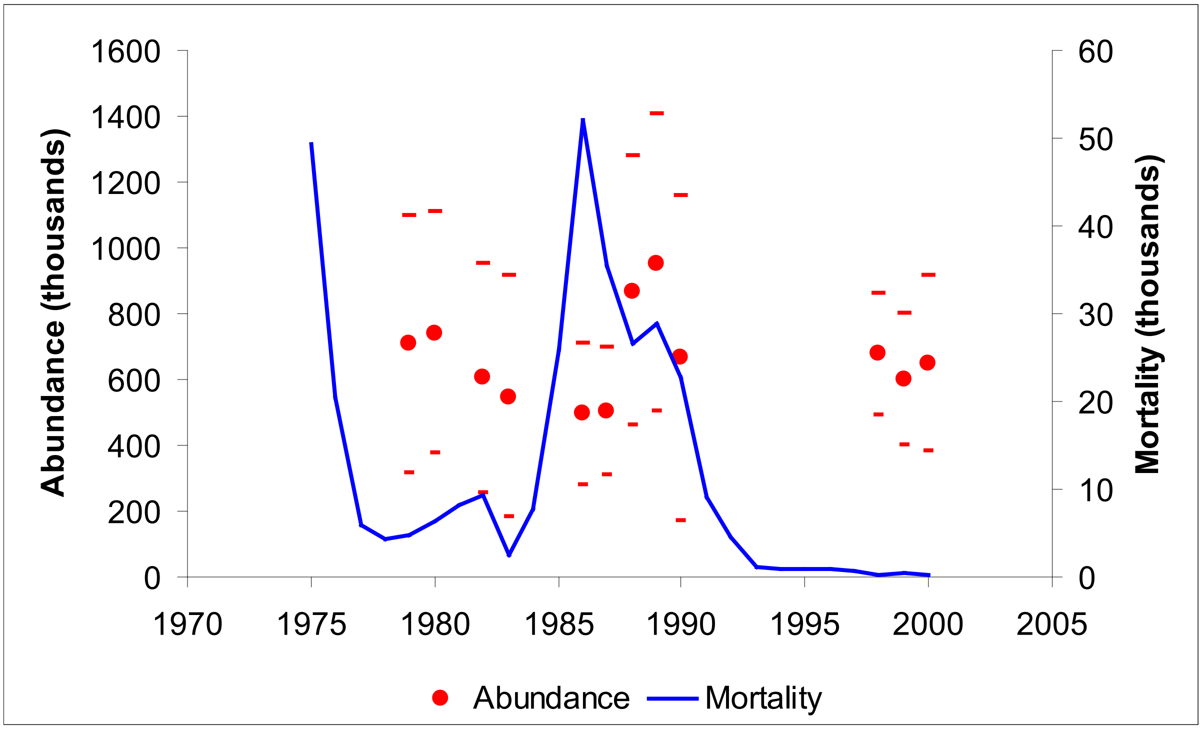

Figure 3.1. Abundance (with 95% confidence intervals) and mortality estimates for northeastern offshore spotted dolphins.

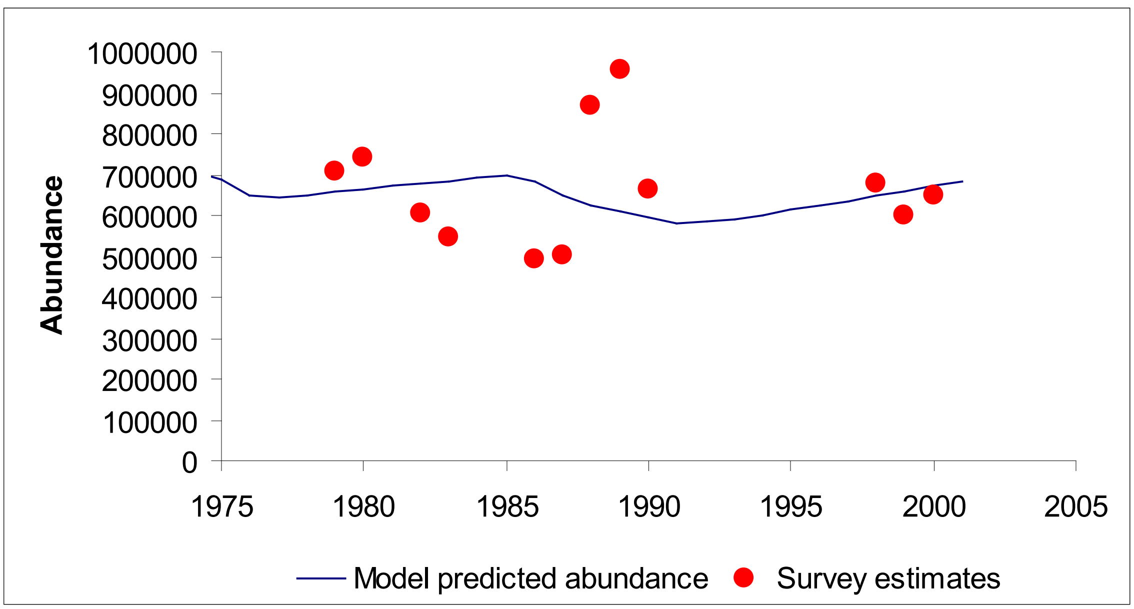

Figure 3.2. Generalized logistic fit to the abundance index data for northeastern offshore spotted dolphins.

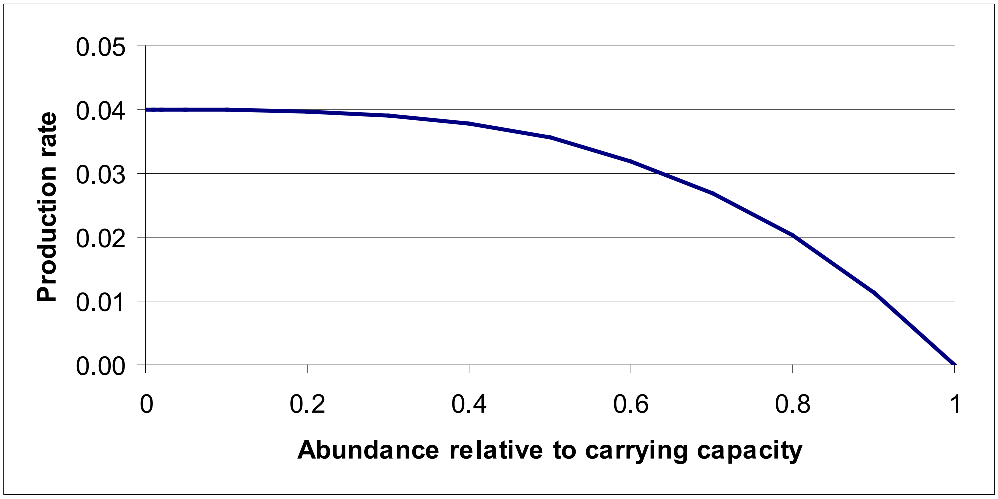

Figure 3.3. The production rate at different abundance levels relative to the carrying capacity for a generalized logistic model with a maximum production rate of 0.04 and an abundance level at the maximum production level that is 0.635 of the carrying capacity.

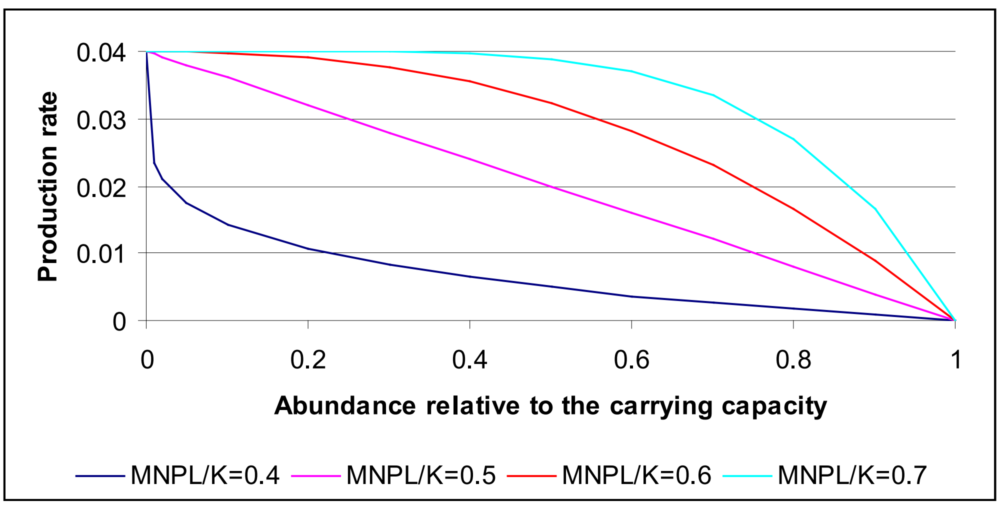

Figure 3.4. The production rate at different abundance levels relative to the carrying capacity for a generalized logistic model with a maximum production rate of 0.04 and for abundance levels at the maximum production level that are various levels of the carrying capacity.

Appendix 4. Ecosystem Changes and Population Trends

Scientists sometimes search for evidence of ecosystem change in long series of environmental variables. For instance, changes in upwelling intensity or sea-surface temperature may affect plankton populations, which, in turn, presumably affect the higher trophic levels. Based on such evidence, the SWFSC report concludes that "the information available indicates it is unlikely that the carrying capacity has been reduced to the degree required to explain the low growth rates of the depleted dolphin populations." More direct evidence from species that are at about the same trophic level as spotted and spinner dolphins does indicate, however, that significant ecosystem change did occur. The SWFSC survey results showed significant changes in the abundances of dolphins, small whales, and large whales, and the IATTC has observed changes in the abundance of yellowfin tuna.

The time series of abundance estimates for the short-finned pilot whale is shown below.

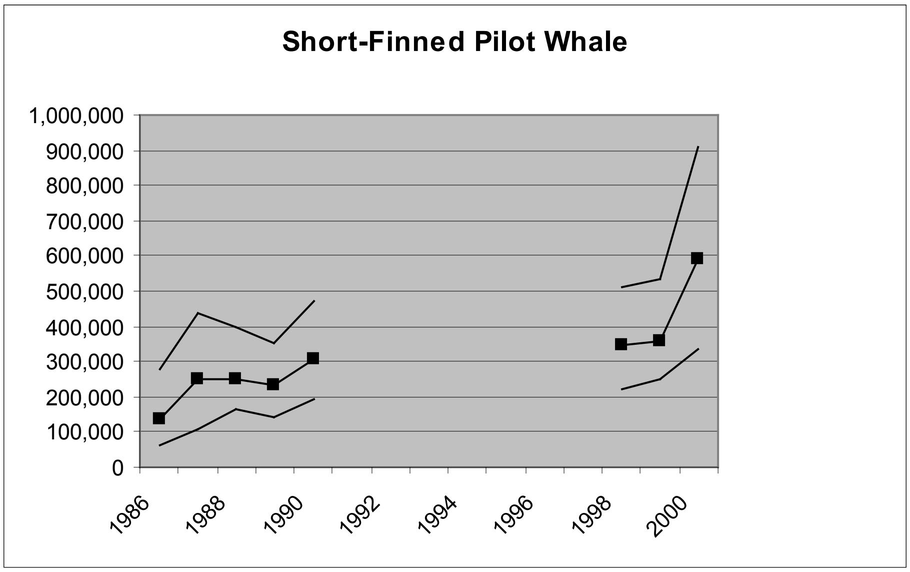

Figure 4.1. Trends in abundance for short-finned pilot whale (*Globicephala macrorhynchus*) from NMFS survey data, with 95% confidence limits.

There is no significant exploitation or bycatch of this species in the region, and thus there is no reason to expect a "recovery" of this population. Yet, it is showing a very clear and highly-significant increasing trend, which must be due to the effects of environmental variability. This population appears to have been growing quite steadily over the years surveyed at an annual rate of slightly more than 5%, possibly due to migration into the area (Gerrodette and Forcada 2002a). Fitting an exponential model of population growth to the survey data showed a significant increase of about 220,000 pilot whales from 1986-2000. The average mass of an adult short-finned pilot whale (926 kg; Kasuya and Matsui 1984), is about 12 times that of an adult spotted dolphin, and so the increase in biomass is equivalent to the biomass of about 2.5 million dolphins. As pilot whales consume 15-18 times their body weight per year (Mercer 1975), this increase in pilot whales would require several million metric tons of food per year more in 2000 than in 1986, and thus possibly affecting populations of spotted and spinner dolphins

Another significant change is in the northern stock of common dolphins (Figure 4.2). The estimates range from a low of 50,000–70,000 in 1987–1988 to a high of more than 500,000 in 1998-2000. These changes are due to migration out of and into the area, presumably due to El

Niño-related environmental changes (Fiedler and Reilly 1994; Reilly and Fiedler 1994). We know this because SWFSC surveys off California showed a large increase in the numbers of this stock following a major El Niño event corresponding with low numbers off Baja California between 1986-1987, indicating that a large segment of the population moved to the north (Forney *et al*. 2000). The population returned in 1990, with population estimates off Baja California increasing from 80,000 in 1989 to 640,000 in 1990. Between the 1986-1990 and the 1998-2000 surveys, almost half a million more northern common dolphins moved back to the area in the area.

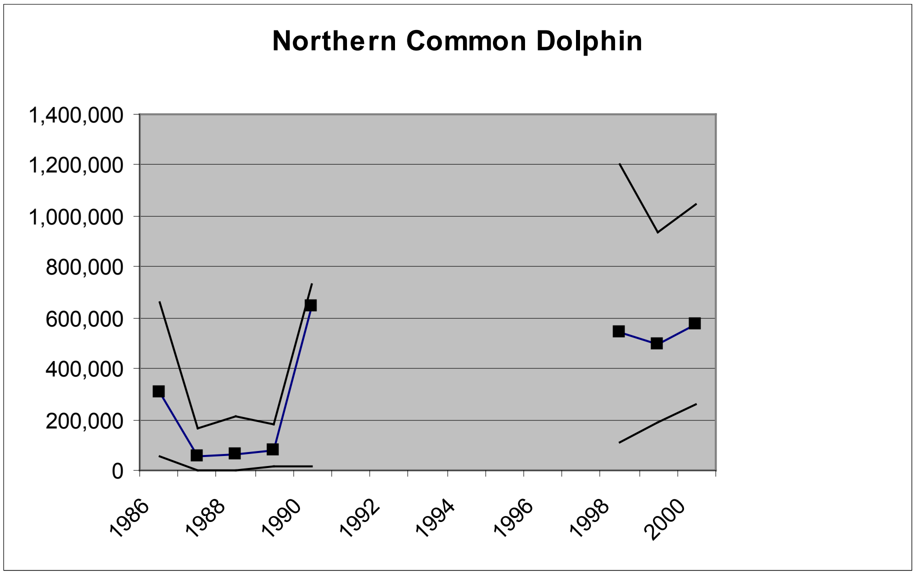

Figure 4.2. Trends in abundance for northern common dolphin (*Delphinus delphis*) from NMFS survey data, with 95% confidence limits.

This large increase in the common dolphin population in the northern section of the fishery and a similarly large increase of central common dolphins off Central America of over 300,000 (Figure 4.3), could have significantly affected the carrying capacity for spotted and spinner dolphins and hindered any recovery.

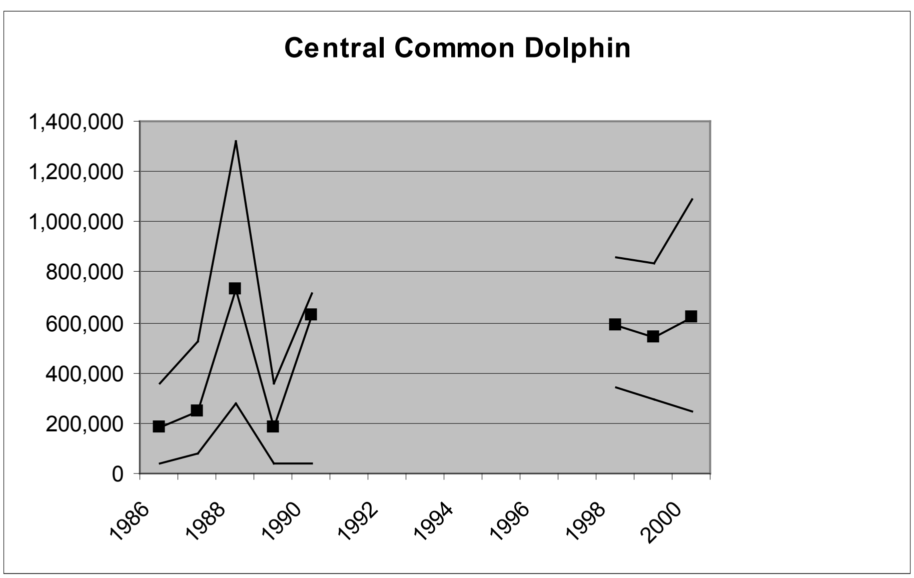

Figure 4.3. Trends in abundance for central common dolphins (*Delphinus delphis*) from NMFS survey data, with 95% confidence limits.

Another top predator that has experienced major changes is the yellowfin tuna. The IATTC staff has reported that the recruitment of yellowfin, and consequently the biomass of this species, increased after the mid 1980s. Currently, the estimated average stock size during 1985-2001 is more than 70% greater than during 1975-1984. In itself, this represents a marked change to the ecosystem.

The SWFSC report attempted to answer the question "Has the ecosystem changed substantially since the dolphin stocks were depleted?" and concluded that this was unlikely. The SWFSC data, however, clearly show that enough environmental change had occurred to allow the populations of several large predators to increase. If carrying capacities for these predators increased, why didn't other populations, particularly the northeastern spotted and eastern spinner dolphins, increase? Different species respond to environmental changes in different ways. While we do not understand those for this system, one point is that the populations that did increase were those whose distributions extended beyond the range of the surveys. These populations could respond rapidly to environmental changes by migrating into and out of the area. Spotted and spinner dolphins have more-tropical distributions in the eastern Pacific and do not range into the temperate waters, as do the common dolphins. The populations with the ability to migrate can respond quickly to more-favorable conditions than those populations that can increase their numbers only through reproduction. While the impact of these changes on the carrying capacity for northeastern spotted and eastern spinner dolphins cannot be assessed directly, it should be acknowledged that significant increases occurred in species that feed at similar trophic levels, and could compete for some prey items, and, in the case of pilot whales, may also feed directly on dolphin calves (Perryman and Foster 1980).

There are two ways to look at these data: (1) something changed in the ecosystem that allowed these increases which, in turn, could have affected the population growth rates of spotted and spinner dolphins; or (2) if a statistically-significant increase of this magnitude, for estimates with errors that are quite similar to the dolphin stocks affected by the purse-seine fishery is spurious, then the ability to detect changes in the ecosystem and the dolphin populations is problematic.

The SWFSC report acknowledges the existence of a Pacific-wide climate shift in the late 1970's and the fact that none of the indices used in its study includes data for years prior this shift. However, the SWFSC report concluded that the northeastern spotted and eastern spinner dolphins populations have failed to recover at expected rates and, thus, the populations must be well below current carrying capacities, because it was thought that it was unlikely that "relatively small changes in background physical conditions can have large ecological effects." That conclusion deals with only one biological component of the ecosystem and ignores the possibility of switching of species composition, which can take place without large changes in total carrying capacity of the ecosystem. In this conclusion, the report ignored the opinions of three of the Ecosystem Expert Panel members who judged that lower carrying capacities were a credible explanation for the lower recovery rates. A fourth reviewer based his minority opinion on the assumptions that tuna stocks have declined over the last 50 years (they have actually increased – see above) and that the early estimates of dolphin mortality are valid (which, as the National Academy of Science Report has observed, is not the case).

Since the large-scale climate shift in the 1976, the northeastern spotted and eastern spinner dolphins have displayed stable population sizes (Gerrodette and Forcada 2002b) and the northeastern spotted dolphins have a stable age distribution (Archer and Chivers 2002), the known mortality rates are low, and evidence is lacking for any significant unknown mortality. The issues of the validity of using problematic mortality estimates and the assumption that the current populations are not near carrying capacity must be re-examined.

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