Center for Independent Experts Review of NMFS Studies of ETP Ecosystems

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Executive Summary

1. This review of the "Eastern Tropical Pacific Ecosystem Study" aimed to assess whether there have been changes in environmental conditions in the ETP that may have influenced trends in the abundance of spotted and spinner dolphins.

2. The review panel consisted of five independent scientists, with expertise in physical and biological oceanography, and the ecology of fish, seabirds and marine mammals. Our review was based on the review papers in Annex I, and a meeting of the panel at the NMFS SWFC from 6th – 8th March 2002.

3. Ecosystem studies were conducted during two main periods ("MOPS" 1986-1990 and "STAR" 1997-2000), alongside cruises designed to estimate the abundance of spotted and spinner dolphins. Data were collected on oceanographic conditions, cetaceans, seabirds, larval fish and potential fish and squid prey.

4. These studies used appropriate survey and analytical techniques, and provide important information on the abundance and distribution of several key faunal groups in the ETP. However, the short and broken time series of data remains insufficient to clearly determine whether there have been temporal changes in different components of this ecosystem. This is particularly so for mobile species where local changes in abundance may represent either population change or movement.

5. Several recommendations are made for additional analyses that may clarify some of the comparisons between groups and/or years. However, these are unlikely to address the underlying problem that a longer time series is required to assess the extent of decadal variation when there is such high variability at shorter, ENSO, time scales.

6. Further recommendations are therefore made to explore the potential for extending these time series, and for obtaining data on reproductive and growth parameters that should be more sensitive to environmental change. In particular, the absence of recent biological samples from by-caught dolphins represents an important gap in our understanding of these animals' response to changing environmental conditions.

Background

In the 1960's and early 70's, up to 500,000 spotted and spinner dolphins were killed each year by tuna purse seiners in the Eastern Tropical Pacific (ETP). Changes in fishery practice led to a decline in this incidental mortality through the 1970's and, by the late1990s, <1000 dolphins were being killed each year. Nevertheless, historical levels of takes led to a severe depletion of these stocks, and the 1997 International Dolphin Conservation Program Act directed NMFS to conduct research to assess whether continued fishing on dolphins was still having a significant adverse impact on these stocks. The Marine Mammal Protection Act (MMPA) specified that this research should include both dolphin abundance surveys and directed studies to determine levels of stress in dolphins that had been captured and released by the fishery. In addition, data on oceanographic conditions and the abundance of other marine fauna were collected during dolphin abundance surveys.

Initial findings from these studies were presented to Congress in March 1999. These preliminary analyses of abundance trends employed Bayesian analyses that included several key sources of uncertainty. However, the short time series, together with other sources of uncertainty and potential bias that could not be explicitly incorporated into the analyses, meant that the evidence for or against a lack of recovery was limited. Nevertheless, the report adopted a conservative approach, and concluded that depleted stocks of both NE offshore spotted dolphins and eastern spinner dolphins were not increasing at the rate expected based on reported mortalities and the reproductive potential for these populations.

If further studies confirm this lack of recovery, it is likely to result either from unrecognized impacts of the continued fishery upon ETP dolphins, from some other change in environmental conditions that has reduced the reproductive potential or survival of these animals, or from a combination of these two factors. These issues have been explored through a series of inter-related research programmes, co-ordinated through the National Marine Fisheries Service SW Fisheries Center (NMFS SWFC). The purpose of this review was to evaluate the findings of one of these programmes; the "Eastern Tropical Pacific Ecosystem Study". This programme aimed to assess whether there have been changes either in oceanographic conditions or other components of this marine ecosystem which, in turn, might indicate that environmental conditions experienced by NE offshore spotted dolphins and eastern spinner dolphins had also changed.

Review Activities

The review panel consisted of five independent scientists, with expertise in physical oceanography (Dr Ken Drinkwater, DFO, Canada), biological oceanography (Dr John Dower, University of Victoria, Canada), tropical fish ecology (Dr Hazel Oxenford, University of the West Indies, Barbados), seabird ecology (Dr George Hunt, University California at Irvine) and marine mammal ecology (Dr Paul Thompson, University of Aberdeen, Scotland). The panel therefore contained expertise that covered all aspects of this broad inter-disciplinary programme, although individual comments and reports inevitably focus on our own areas of specialism. For most of the panel, our research work has focused on temperate and/or Atlantic systems, and this was both our first visit to the NMFS SWFC and our first involvement with studies within the Eastern Tropical Pacific. Consequently, the group was able to provide an independent and objective assessment of this work.

The review was based on an initial examination of nine papers that were specifically written for this review (Annex I a) and a further six background papers (Annex I b). The content of these papers was then explored further during presentations made at a meeting of the review panel with NMFS staff at the SWFC on March 6th and 7th 2002. Several further background papers were either provided or requested during these presentations. During the third day of our meeting the panel (apart from Dr Hunt who had to leave on March 7th) met in the morning of March 8th to discuss outstanding questions. This was followed by a round table discussion involving both the panel and key NMFS staff who had led different aspects of the programme. As part of this session, the panel requested an additional presentation on the techniques used to assess group size and size structure during cetacean surveys. Finally, in the afternoon of March 8th, individual panel members met with key NMFS staff to discuss the work within their particular area of expertise in more detail.

Summary of Findings

Ecosystem studies were conducted during two main periods, alongside cruise programmes that were designed primarily to estimate the abundance of the dolphin stocks targeted by the tuna fishery. The first series of cruises were carried out annually between 1986 and 1990 under the “Monitoring of Porpoise Stocks” (MOPS) project. There was then a seven year gap in data collection before a second series of annual cruises were conducted under the “Stenella Abundance Research” (STAR) project between 1997 and 2000. In both periods, surveys were carried out between July and December using the same two NOAA ships, except in 1998 when a third vessel was used for part of the survey.

Surveys were designed to systematically cover the vast study area (20 million km^2) required to encompass the known range of stocks of NE offshore spotted dolphins and eastern spinner dolphins. The NMFS SWFC has pioneered the development of techniques to provide accurate and precise estimates of cetacean abundance from line transect surveys, and have collaborated closely with other world leaders in this field such as Professor Buckland’s group at the University of St Andrews. As a consequence of the constant development of techniques to improve estimates of the key target stocks, survey design varied slightly between the MOPS and STAR studies. Nevertheless, survey areas were broadly similar and, with appropriate post-stratification, it is possible to compare the results of studies of other components of the ecosystem both between years and between the MOPS and STAR survey periods.

Oceanography

Oceanographic data collected during MOPS and STAR studies were presented alongside a review of other sources of information on oceanographic change in the Pacific region (Annex I a, Papers 2 & 3). In the North Pacific, changes in both oceanographic variables and biological systems provide clear evidence for a regime shift in the late 1970s, with some authors arguing that there have been similar regime shifts since. In the ETP, ENSO variability dominated the time-series of data, but the NMFS studies did find statistically significant, though small (-0.27° C), changes in Sea Surface Temperature (SST) between MOPS and STAR studies. Recent work at another NOAA laboratory has identified a slowdown of wind-driven circulation between tropical and sub-tropical oceans, linked to a rise in equatorial sea temperature of 0.8° C over the past 50 years (McPhaden & Zhang 2002). As discussed at the review meeting, it is difficult to determine whether or not such subtle differences in temperature are likely to result in significant biological consequences. However, in a paper published since the review meeting, bacterial growth and primary production were measured on a north-south transect of the Atlantic Ocean, suggesting that these systems are rather unstable, and react quickly to changing environmental conditions (Hoppe *et a*l. 2002). It would seem worthwhile exploring whether these new findings provide further insight into the possible biological consequences of the small measured changes in sea temperature in the ETP.

Cetacean Abundance

Both MOPS and STAR surveys were designed primarily to estimate the abundance of the “target” dolphin directly affected by the tuna fishery; NE offshore spotted dolphins and eastern spinner dolphins. However, these surveys can also be used to estimate the abundance of other “non-target” cetacean species within the study area; including species that are occasionally impacted by the tuna fishery (ie. striped and common dolphins) and others that do not interact with the fishery (ie. pilot, sperm and brydes whales). Line-transect analyses were used to estimate the abundance of both target and non-target species, with the resulting estimates becoming more reliable since the recent development of procedures (Annex 1 b, Paper 4) that include co-variates such as group size to model detection probabilities (f(0)). However, there remain two key differences in the abundance estimates for target and non-target cetacean species. First, survey tracks were designed to provide the best possible abundance estimates for stocks of target species. Thus, the latter STAR surveys were stratified to provide more intensive coverage of the core range of these target species, and estimates of non-target species are expected to be less precise. More importantly, the surveys could not encompass the whole geographical range of most of the non-target stocks (an exception being central common dolphins). Thus, inter-annual variations in abundance could result both from changes in the overall size of stocks, but also from a re-distribution of animals into or out of the survey area.

The resulting estimates of non-target cetaceans illustrate the high degree of year-to-year variability in abundance (Annex 1 a, Paper 4, Fig. 3). Confidence limits now need to be calculated for each annual estimate, but it is clear from the point estimates that year-to-year increases are sometimes far greater than is biologically possible based on existing knowledge of maximum potential population growth rates. Thus, while some of this variability may be due to sampling variation, it is likely to also result from movements of dolphins in and out of the study area. One other possibility is that some of this year-to-year variation results from differences in the choice of model used to model detection probabilities. In each year, AIC_c were used to select which model(s) should be used, and model averaging was used where these indicated that there were several top models. Thus, different co-variates were included in different years (Annex 1 a, Paper 4, Table 3). This may result from genuine inter-annual variation in the factors affecting probability of sighting, or it could itself result from sampling variation. An alternative approach might therefore be to use all those models that were ever selected as top models, and average across these in all years. If this has little impact on resulting inter-annual variability in abundance estimates, then the effects of model choice can be eliminated from the list of potential causal factors. This could perhaps be tried for just one species to explore whether this effect is significant.

Even if these modifications do reduce year-to-year variation, the available time series still seems too short to reliably determine whether there have been statistically significant changes in the abundance of non-target cetacean species in the study area. Furthermore, the implications of any such trend for the target species will remain difficult to assess given current information on the biological interactions between the different stocks. Let us suppose, for example, that the abundance of common and striped dolphins in the study area is shown to increase significantly during the 1990s when compared to the 1980s. Would this indicate that the area represents a good environment for target stocks of spinner and spotted dolphins, suggesting that fisheries might be constraining their recovery? Or could the increase in non-target species represent an increase in inter-specific competition, which might itself constrain recovery rates of target populations? These uncertainties highlight the need to conduct more detailed process studies on the ecology of these different species alongside the work that is assessing changes in their abundance.

Cetacean habitat-use

Cetacean sighting and oceanographic data collected during the MOPS and STAR surveys were also analysed to determine whether there had been changes in the habitats used by different dolphin species (Annex 1 a, Paper 5). Earlier analyses of the MOPS surveys provided one of the first quantified assessments of habitat use by oceanic cetaceans (Reilly 1990, Reilly & Fiedler 1994). These earlier studies used canonical correspondence analysis (CCA) to integrate a number of different oceanographic variables into one or two independent axes of environmental conditions that best separate the observed distribution of the different dolphin species. This approach was used again to analyses the more recent data on dolphin distribution from the STAR survey, and is also used extensively in this ecosystem research programme to analyse data from birds (Annex 1 a, Paper 6) and fish (Annex 1 a, Paper 7).

The key finding of this part of the study was that similar oceanographic variables explained the distribution of dolphins during both MOPS and STAR survey periods. The multi-variate techniques seem appropriate, and have already been subject to the journal peer-review process on several previous occasions. The similar findings from both survey periods therefore provide strong support for the overall conclusions on the habitats used by these species.

These findings therefore represent an important initial step in addressing the first question posed in section 6.1.3 of the 1999 report to Congress; i.e. has the extent of preferred dolphin habitat changed between 1986-90 and 1997-2000? Dolphins appear to be found in areas with similar oceanographic conditions, but further work is now required to assess whether the availability of these areas has changed. The use of CCA to identify key habitat variables from the data collected during MOPS and STAR surveys seems appropriate to answer the initial question, but it does make it difficult to subsequently assess the extent of similar habitats in areas that were not sampled directly. Whilst the CCA uses a number of different oceanographic variables, it appears that much of the explanatory power comes from a few key variables such as water temperature. To assess habitat availability, it may therefore be advantageous to reduce the suite of oceanographic variables used. If one includes only those variables that are also available over a wider scale from other sources, it becomes possible to determine whether the extent of preferred habitat has changed over time. Indeed this approach has already been used for earlier analyses of MOPS data which suggest that abundance estimates for some dolphin species are related to the extent of suitable habitat outside the main survey area (Fiedler & Reilly 1994). Similarly, analyses of bird distribution data using GAMs (Annex 1 b, Paper 2) used only those environmental variables that were widely available to improve the predictive power of these models to non-survey areas.

One other way in which these analyses could be extended is to incorporate other data that were collected on potential prey species, or indeed on the distribution of tuna sets or catches. Given that there still remains much uncertainty over the nature of the interaction between dolphins and tuna, it would seem particularly useful to develop analyses that directly compare their distribution and abundance patterns.

Abundance and habitat-use of other marine fauna

During both MOPS and STAR studies, additional information was collected on the abundance and distribution of seabirds (Annex 1 a, Paper 6), larval fish (Annex 1 a, Paper 7) and larger fish and squid (Annex 1 a, Paper 8). The detail of these papers is outside the scope of my review, and it was agreed that this would be covered by other members of the panel with more appropriate expertise. However, a few general points are made here, particularly where these relate to studies of the cetacean distribution and abundance.

Similar analytical methods were used to assess the distribution of the different groups of animals, but survey areas sometimes differed between groups and between years. Because of the nature of the distribution plots that are produced by the software "Surfer", it was not always possible to determine whether differences in the contour plots presented in the review papers represented real differences in distribution or slight differences in the sampling stations used. The use of GAMS to produce estimates of the distribution of seabirds (Annex 1 b, Paper 2) is an effective way to overcome this problem. Other simpler ways of presenting such distribution data (e.g. in Annex 1 a, Paper 8, Figs. 2-11) might involve comparing densities in different grid squares. Variations in the distribution of sampling plots may also bias annual estimates abundance for the whole study area (e.g. Annex 1 a, Paper 8, Fig. 9). This could be overcome by post-stratifying the study area and only including data from the core area used to estimate the abundance of target dolphin species. Alternatively, the study area could be post-stratified on the basis of water masses when comparing different faunal groups.

Conclusions

These studies have provided important information on the abundance and distribution of several key species and groups inhabiting the ETP. Working within the logistic constraints posed by the primary purpose of the surveys, and subject to the specific comments mentioned elsewhere in this report, they have used appropriate survey and analyses techniques. However, the relatively short time period over which the studies have been made make it extremely difficult to determine whether there have been temporal changes in different components of this ecosystem. Most of the time-series available (cetaceans, seabirds, larval fish, fish and squid) are of only 14 years (1986-2000), and have a seven year gap in the data set between the MOPS and STAR cruises. Even if the best possible estimation techniques are used for individual annual surveys, these time series still appear rather short to make robust conclusions about decadal trends in abundance. In particular, detecting decadal trends in this area appears particularly difficult due to the high level of variability in these systems at shorter, ENSO, scales. Inferences from most of these short time series are further complicated because of the difficulty of determining whether observed changes in abundance are the result of movements in or out of the study area or underlying changes in stock size.

Longer time-series of data are available for oceanographic data, because other sources can be used both to extend the time series further back in time and to obtain data from the period between MOPS and STAR cruises (Annex 1 a, Papers 1 & 2). Here, there is evidence of subtle warming within the core study area, which is further backed up by studies by other groups made at larger spatial and temporal scales (McPhaden & Zhang 2002). However, it remains difficult to determine whether such subtle ($< 1\ ^\circ C$) increases in temperature are likely to impact tropical marine communities in general, and marine top predators in particular. The only other time-series of data that covers the intervening years between MOPS and STAR studies is that of the Yellowfin tuna and Big-eye tuna that are themselves the target of the fishery. Only summary data on these species were presented in Annex 1 a Paper 9, but there does appear to be some indication of decadal changes in the standing stock biomass of these species that deserves further investigation. However, if one is to use such data to make inferences about the causes underlying recent trends in dolphin abundance, a better understanding of the nature of the interaction between tuna and dolphins is required.

The constraints posed by these short, and broken, time series highlight the importance of exploring all possibilities for extending the available data sets. The review panel heard that data on some of the key species examined may be available from older surveys such as the EASTTROPAC fisheries oceanography surveys of the 1960's. If the ETP has seen a similar regime shift to the North Pacific in the late 1970's this may only be detectable by comparison with data from these early surveys. I would not necessarily advocate wholescale re-analysis of these archive data, but an initial assessment of data availability, together with an exploratory analysis of data for a few key species or areas would provide an indication of the potential for extending some of these biological time-series further back in time. As importantly, there is a clear need for a strategic long-term monitoring programme that will permit the development of a sufficiently long time-series of data with which to detect trends in these key biological indices in future. This is perhaps most necessary for monitoring trends in the abundance of the target dolphin stocks, but can also be designed to continue the collection of data on the other key groups discussed in this review.

Determining changes in the abundance of key stocks is crucial for a number of ecological questions, but even high quality data on variations in overall abundance will not provide the most sensitive indicator of a population's response to environmental change. This is particularly so for long-lived, slow reproducers such as cetaceans, whose populations are likely to be buffered against short-term variations in the environment. I would therefore argue that attempts to assess the impacts of environmental variation on dolphin populations should, where possible, collect data on a broad suite of population parameters and, ideally, individual growth parameters; several of which should show a faster response to environmental change. Indeed, the complex relationship between environmental variation and overall abundance in marine top predators may only become apparent once one has a developed a good understanding of the environmental effects on individual population parameters (Thompson & Ollason 2001). If there has been a major change in environmental conditions in recent decades, the biological parameters that seem most likely to have changed in these dolphin stocks are pregnancy rates, calf growth rates and early survival. Several related studies at the NMFS SWFC could be extended to explore whether some of these parameters have changed over recent decades. Samples collected from dolphins killed in the tuna fishery during the 1970s and 1980s have been used to estimate female reproductive rates (Chivers 1992; Chivers & DeMaster 1994). Although fewer dolphins are currently killed in the ETP, sample sizes would be more than sufficient to compare reproductive rates by sampling these incidentally captured animals. It would also be possible to study growth and reproductive histories through analyses of whole carcasses (Chivers & Myrick 1993) or of tooth growth layers (Boyd & Roberts 1993). Teeth can provide a long-term proxy record of early growth conditions, age at sexual maturity and abnormal environmental conditions such as El Nino (Manzanilla 1989), while biochemical analysis of sampled tissues could provide an indication of changes in prey types and foraging areas (Hirons et al. 2001; Hooker et al. 2001). Many countries have now taken steps to maximise the biological information obtained from cetaceans that have been by-caught in fisheries, particular where these data can be used to help understand or mitigate these interactions. It seems quite remarkable to me that so few data are collected from the hundreds of animals still caught in the tuna fishery, especially when there remain so many fundamental gaps in our knowledge on the ecology of these species.

Where analyses of carcasses and biological samples are not possible, the aerial photogrammetric estimates of group size that are used for abundance estimates (Annex 1 a, Paper 4) can provide important information on calf ratios or size structure (Perryman & Lynn 1993). Such work could form the basis of studies that would increase understanding of geographical and inter-annual variability in reproductive success that could underpin more detailed studies of decadal variation in such parameters. Similarly, information on plankton community structure, or fish growth rates may also provide a more sensitive indication of these groups response to changing environmental conditions than can be obtained from indices of abundance. In most cases, appropriately stored samples are probably not available from previous surveys, but the group did highlight the value of comparing within-year variation in the growth rates of key prey species such as flying fish. Future surveys, or sampling of commercial tuna fisheries should also consider storing fish otoliths using methods that will allow subsequent analysis of growth rates.

Summary of Recommendations

1. The effects of inter-annual differences in model choice on inter-annual variation in estimates of cetacean abundance should be investigated (p 4).

2. Where possible, future studies of abundance trends should be supplemented with studies of the diet and other aspects of the ecology of these species to better understand potential interactions between different indicator species (p 5).

3. Assessments of cetacean habitat use should consider using a smaller suite of environmental variables, and using only those variables that are also available from other sources so that temporal changes in the availability of preferred habitats across the whole ETP can be assessed (p 5).

4. Additional analysis of cetacean distribution patterns should consider incorporating both oceanographic variables and information on potential prey and tuna catches to improve their predictive power (p 6).

5. Alternatives to the software package Surfer should be investigated for providing a more representative picture of inter-annual patterns in the distribution of key faunal groups (p 6).

6. The opportunities to extend any of these time-series further back in time should be explored, for example, through examination of historic data from EASTROPAC surveys in the 1960s (p 7).

7. Given the likely need for further assessments of this kind, every effort should be made to develop a long-term survey strategy that permits more regular estimates of the abundance of key indicator species within the ETP ecosystem (p 7).

8. Where possible, future studies of abundance of both dolphins and other key indicator species should be integrated with the collection of data on growth and reproductive parameters that provide more subtle indicators of these populations responses to environmental change (p 7).

9. Whenever possible, morphometric data and key biological samples should be obtained from by-caught dolphins to facilitate studies on the responses of individual dolphins to environmental change (p 8).

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Annex I. Bibliography

a) Review Papers

1. Lisa T. Ballance, Paul C. Fiedler, Tim Gerrodette, Robert L.Pitman, and Stephen B. Reilly *Eastern Tropical Pacific Ecosystem Studies: Introduction*

2. Paul C. Fiedler and Valerie Philbrick *Environmental Change in the Eastern Tropical Pacific Ocean: I. Observations in 1986-1990 and 1998-2000*

3. Paul C. Fiedler *Environmental Change in the Eastern Tropical Pacific Ocean: II. Review of ENSO and Decadal Variability*

4. Tim Gerrodette and Jaume Forcada *Estimates of Abundance of Striped and Common Dolphins, and Pilot, Sperm and Bryde's Whales in the Eastern Tropical Pacific Ocean*

5. S.B. Reilly, P.C. Fiedler, T. Gerrodette, J. M. Borberg, and R.C. Holland *Eastern Tropical Pacific Dolphin Habitats - Interannual Variability 1986-2000*

6. L.T. Ballance, R.L. Pitman, L.B. Spear, and P.C. Fiedler *Investigations into Temporal Patterns in Distribution, Abundance and Habitat Relationships within Seabird Communities of the Eastern Tropical Pacific*

7. R.L. Pitman, L.T. Ballance, and P.C. Fiedler *Temporal Patterns in Distribution and Habitat Associations of Prey Fishes and Squids*

8. H. G. Moser, P. E. Smith, R. L. Charter, D. A. Ambrose, W. Watson, S. R. Charter, and E. M. Sandknop *Preliminary Report on Ichthyoplankton Collected in Manta (surface) Net Tows on Marine Mammal Surveys in the Eastern Tropical Pacific: 1987–2000*

9. Reilly, S,B,. Balance, L.T., Fiedler, P.C., Gerrodette, T., Pitman, R.L., Moser, H.G., Spear, L.B. & Borberg, J.M. *Information to evaluate regime shifts in the eastern tropical Pacific Ocea*n.

b) Background Papers

1. Stephen B. Reilly and Paul C. Fiedler *Interannual Variability of Dolphin Habitats in the Eastern Tropical Pacific. I: Research Vessel Surveys, 1986-1990*

2. E.D. Clarke, L.B. Spear, M.L. McCracken, F.F.C. Marques, D.L.Borchers, S.T. Buckland, and D.G. Ainley *Application of Generalized Additive Models to Estimate Size of Seabird Populations and Temporal Trend from Survey Data Collected at Sea*

3. David W.K. Au and Robert L. Pitman *Seabird Interactions with Dolphins and Tuna in the Eastern Tropical Pacific*

4. Jaume Forcada *Multivariate Methods for Size-Dependent Detection in Conventional Line Transect Sampling*

5. W.F. Perrin. *Using porpoise to catch Tun*a

6. D.W.K. Au & W.L. Perryman. *Dolphin habitats in the Eastern Tropical Pacific*

Annex II. Statement of Work

Consulting Agreement Between The University of Miami and Dr. Paul Thompson

Background

Scientists of the Protected Resources Division at the Southwest Fisheries Science Center, National Marine Fisheries Service (NMFS, NOAA) are currently engaged in a suite of studies designed to assess the impact of the eastern tropical Pacific yellowfin tuna purse seine fishery on dolphin stocks which associate with these tuna. One component of these studies is an assessment of the population size of the potentially affected dolphin stocks. Population assessments have been made for the following years: 1986, 1987, 1988, 1989, 1990, 1998, 1999, and 2000 with a primary goal being to determine if populations that were historically reduced in size are increasing over time. Should the assessments indicate no increase (lack of recovery), three broad categories of factors could be the cause: a) effects from the fishery; b) effects from the ecosystem; c) an interaction between the proceeding two factors.

This need to attribute causality for a potential lack of recovery serves as the primary justification for ecosystem studies. By investigating the physical and biological variability of the ecosystem of which the dolphin stocks are a part, we establish a context that can be used to better interpret trends in dolphin abundance. A lack of recovery that is not mirrored by some other change in the ecosystem would largely eliminate an ecosystem hypothesis, leaving fishery effects as the most likely cause.

It should be noted that this issue is controversial and particularly relevant to persons involved with NMFS, the US and non-US tuna industry, and environmental groups.

General Topics for Review

This review includes a suite of studies subsumed under the general topic of “Ecosystem Research in the Eastern Tropical Pacific”. Our basic approach will be to compare ecosystem parameters over time with a primary goal being to look for indications of a potential ecosystem shift. The power of these ecosystem studies will increase with the number of environmental variables, taxa, and trophic levels included, and with the time period spanned (although most ecosystem data available for these investigations were collected concurrently with dolphin assessment data aboard NOAA research vessels and are restricted to the late 1980s and late 1990s).

The general components included are as follows:

- Physical and Biological Oceanography: sea surface temperature, thermocline characteristics, phytoplankton and zooplankton distribution and relative abundance;
- Larval Fishes: distribution and relative abundance;
- Flyingfishes: distribution, relative abundance, and habitat relationships;
- Seabirds: distribution, absolute abundance, and habitat relationships;
- Cetaceans: distribution, absolute abundance, and habitat relationships.

Potential reviewers should be familiar with one or more of the following general disciplines: physical oceanography, biological oceanography, pelagic (oceanic) ecology of plankton, fish, birds, and cetaceans. Analysis methods will include use of certain multivariate techniques such as Canonical Correspondence Analysis and Generalized Additive Models. Familiarity with one or more of the taxa listed above will be helpful. Due to the broad scope of components included within this investigation, no single reviewer will be expected to have expertise in all relevant areas.

Documents supplied to reviewers will include draft manuscripts on topics listed above. A number of background papers (relevant publications and reports) will also be supplied.

Specific Reviewer Responsibilities

The reviewer's duties shall not exceed a maximum total of two weeks: several days to read all relevant documents, three days to attend a meeting with scientists at the NMFS La Jolla Laboratory, in San Diego, California, and several days to produce a written report of the reviewer's comments and recommendations. It is expected that this report shall reflect the reviewer's area of expertise; therefore, no consensus opinion (or report) will be required. Specific tasks and timings are itemized below:

1. Read and become familiar with the relevant documents provided in advance;

2. Discuss relevant documents with scientists at the NMFS La Jolla Laboratory, in San Diego, CA, for 3 days, from March 6-8, 2002;

3. No later than March 22, 2002, submit a written report of findings, analysis, and conclusions. The report should be addressed to the "UM Independent System for Peer Reviews," and sent to David Die, UM/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149 (or via email to ddie@rsmas.miami.edu).