SOUTHWEST FISHERIES SCIENCE CENTER

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IDCPA RESEARCH PROGRAM ANALYSIS DECISION FRAMEWORK CONSULTATION, SOUTHWEST FISHERIES SCIENCE CENTER, LA JOLLA, CALIFORNIA, 27-28 APRIL 2000

by

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IDCPA Research Program
Analysis Decision Framework Consultation
Southwest Fisheries Science Center, La Jolla, CA
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Summary

Participants:
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Inter-American Tropical Tuna Commission: Pablo Arenas, Rick Deriso, Michel Dreyfus (Mexican National Program), Martin Hall, Brian Hallman, Cleridy Lennert and Michael Scott

Marine Mammal Commission: Michael Gosliner and Bob Hofman

National Marine Fisheries Service
Office of Protected Resources: Donna Wieting
Office of Science and Technology: Bill Fox
National Marine Mammal Laboratory: Doug DeMaster and Paul Wade
Southwest Regional Office: Judson Feder, Jim Lecky and Allison Routt
Southwest Fisheries Science Center: Eric Archer, Lisa Ballance, Jay Barlow, Norm Bartoo, Bob Brownell, Susan Chivers, Barbara Curry, Andy Dizon, Meghan Donahue, Elizabeth Edwards, Paul Fiedler, Jaume Forcada, Tim Gerrodette, Peter Perkins, Bill Perrin, Wayne Perryman, Bob Pitman, Steve Reilly, Barbara Taylor, Michael Tillman

Background and Objective: This meeting is part of a series of consultations held by the Southwest Fisheries Science Center (SWFSC) with the Marine Mammal Commission (MMC) and the Inter-American Tropical Tuna Commission (IATTC) regarding the development of an analysis decision framework to integrate the scientific results of various research programs carried out under the International Dolphin Conservation Program Act (IDCPA). The IDCPA, a 1997 amendment to the Marine Mammal Protection Act (MMPA), mandates that the Secretary of the Department of Commerce, the parent agency of the National Marine Fisheries Service (NMFS), determine "whether the intentional deployment on or encirclement of dolphins with purse seine nets is having a significant adverse impact on any depleted stock in the eastern tropical Pacific Ocean." This consultation sought to further develop the analysis decision framework in which all the results of multiple studies being conducted under the SWFSC's IDCPA research program will be integrated for the final research report.

Norm Bartoo chaired the meeting and Meghan Donahue served as rapporteur. The following summary of the proceedings is structured on the agenda found in Appendix 1.

1. Introductions and Opening Comments

After the introduction of participants, opening comments were solicited from the IATTC, MMC and SWFSC. The SWFSC welcomed the participants to this important consultation, one in a series required under the IDCPA. The MMC expressed its long-standing interest in the issue and was eager to continue its participation through these consultations. The IATTC submitted a written opening comment (Appendix 2) and encouraged the group to consider the views and analyses therein. Attached to that letter was a paper entitled "Estimates of growth rates of eastern spinner and north-eastern spotted dolphin populations of the eastern tropical Pacific" dated 26 March 1999. This paper was presented by Rick Deriso of the IATTC and was discussed under section 4 of the agenda.

2. Review of present state of the framework development in Goodman (1999)

The analysis decision framework serves to provide a formal objective strategy for combining various types of scientific results collected under the IDCPA research program and their associated levels of uncertainty to arrive at a determination of whether "the intentional deployment on or encirclement of dolphins with purse seine nets is having a significant adverse impact on any depleted dolphin stock in the ETP" (MMPA, Section 304). The development of this framework includes establishing decision rules that will be applied to each piece of information included in the analysis. In order to preserve the objectivity of this method, it is critical to define these decision rules prior to having the results available from the various research projects. The overall approach is to define a decision quantity that will be estimated from each data set, specify a decision rule or threshold for that quantity, and, recognizing that there is uncertainty associated with all analyses, agree upon an acceptable level of uncertainty for each rule.

The IATTC staff expressed concerns that the decision framework adopted for the initial Report to Congress had not resolved issues of objectivity regarding the analysis. It was their view that the decision analysis framework had only changed the point in time at which subjective choices could be introduced. The group agreed to take this view into account in developing the decision framework for the final finding (the subject of this and subsequent consultations) so that all participants had the opportunity to contribute to the decision rules and criteria, in order to reach the goal of adopting a framework by consensus.

This decision framework was applied to the limited data available in 1999 in the preliminary Report to Congress[1] prepared by the SWFSC. In that report the analysis decision framework was applied to the issue of whether the depleted dolphin stocks in the ETP were failing to recover. Because of the limited data available at that point in the multi-

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[1]Anon. 1999. Report to Congress on the initial finding, required under the Marine Mammal Protection Act of 1972 as amended by the International Dolphin Program Conservation Act of 1997, regarding whether the intentional deployment on or encirclement of dolphins with purse seine nets is having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean. Prepared by the Southwest Fisheries Science Center, National Marine Fisheries Service, 25 March 1999.

year research program, the decision framework was not applied to the issue of attribution (*i.e.*, the cause of the apparent failure to recover). The goal ahead is to quantitatively fold into this framework the other components of the research program including data from stress-related, oceanographic and ecological studies to address whether the apparent failure to recover is attributable to the fishery or to other possible causes. The IATTC staff reminded the group that they did not accept the analyses and conclusions of the initial Report to Congress that there had been an apparent failure to recover. The IATTC staff were reminded that these analyses and conclusions had been accepted by the March 1999 Congressionally-requested independent peer review.

3. Interpretation of "significant adverse impact"

Neither a clear operational definition of nor clear precedent for interpretation of "significant adverse impact" exists. Therefore, some NMFS and MMC participants recommended that in the absence of specific guidance and because there does exist a domestic history for what constitutes "significant" and "adverse" and "impact" (especially for depleted stocks), the framework should reflect what has been developed for marine mammals under the MMPA and Endangered Species Act (ESA). It was further added that, although population effects are being sought in the context of the IDCPA, impacts on individual animals should not be excluded. Although such impacts may not be included quantitatively in the framework, it was argued that they should still be relayed to those responsible for making the decision for the final finding. IATTC participants reminded the group of the international context of the International Dolphin Conservation Program (IDCP) and that there was a lack of agreement on the definitions of such terms as "significant adverse impact" and "depleted" amongst the nations involved in the IDCP. Others commented that although the issue at hand was obviously international in nature, the International Dolphin Conservation Program Act is a U.S. law that amends the Marine Mammal Protection Act (also a U.S. law). It is under the IDCPA that the question of "significant adverse impact" has been posed and that the research activities and consultations being conducted by the SWFSC has been mandated.

With regard to interpreting "significant adverse impact," the IATTC staff expressed concern that the model used to conclude that there has been a failure to recover in recent years includes the assumption that the populations should recover to the carrying capacity that existed over 40 years ago. Their view was that carrying capacity was difficult to estimate and may have changed for a number of reasons. Therefore, the IATTC staff questioned the expectation that depleted populations would show signs of recovery to this level, even given the large reductions in fishery mortality. Specifically, they suggested the reasons for this included a paucity and low quality of mortality data from the first decade of the fishery, the long-lived nature and low reproductive rates of dolphin species, and the possibility of time lags in responses of the dolphin populations and changes in the ecosystem. Other participants, however, pointed out that this was in contradiction to methods used generally in fisheries and wildlife management and used specifically by the IATTC to provide management advice on the resources for which it is responsible. That is, IATTC's management strategies are based on this same assumption that populations reduced

by exploitation will increase their net production in response to a reduction or elimination of fishing mortality. The IATTC stated that they do not assume that in the absence of fishing the yellowfin tuna population will recover to the carrying capacity that existed over 40 years ago, rather they believe that the yellowfin tuna dynamics indicate a change in the environment in recent decades.

4. Trend and abundance component of the determination

4.1 Structure of assessment model

The methods used in the population analysis have been previously presented to the IATTC and MMC and can be found in more detail in Wade (1994) and Wade (1999). The population model and Bayesian methods are described in detail in the SWFSC's 1999 Report to Congress to estimate depletion levels of northeastern spotted dolphins and eastern spinner dolphins.

In essence, a population model was projected from 1958 to 1998 fitting available abundance and mortality estimates. Abundance estimates are available from research vessel surveys in ten years from 1979 to 1998. Estimates used from 1979 to 1990 were from Wade (1994), with an additional estimate available for 1998 (Gerrodette 1999). Estimates of relative abundance from data collected on tuna vessels (TVOD) are available from 1975 to 1997 (Anganuzzi *et al.* 1993; C. Lennert, IATTC, pers. comm.). Log-normal likelihoods were used for both fitted series of abundance estimates. The TVOD were scaled to absolute abundance using a scale parameter. Fisheries mortality estimates used in the model are available for every year from 1959 to 1997. The model was an age-structured density-dependent model in the form of a Leslie matrix (Breiwick *et al.* 1984). The maximum growth rate for the population was estimated and as one of several fitted parameters from the population model . The growth rate for a given population size was estimated from the underlying logistic population model using the estimates of carrying capacity and Rmax. After estimating the maximum growth rate, the population is then projected through 1998 with the expected growth rate, given the estimated model parameters and estimated depletion level (population level relative to the equilibrium population level). Any difference between the expected model trajectory and the estimated 1992-1998 population trajectory (as fit to the 1992-1998 abundance data) represents an estimate of a change in the population growth rate. An additional parameter (μ) was specified to represent this potential change from the expected population growth rate from 1992-1998, acting through additional mortality (mortality in addition to the natural mortality accounted for by juvenile and adult survival parameters).

4.1.1 Definition of μ
4.1.2 r_{max} estimation
4.1.3 Other model issues

The parameter μ represents an estimate of the difference between the expected

population growth rate and the observed population growth rate in the years 1992-1998. The IATTC thought the location of the breakpoint was critical and was concerned about the sensitivity of the model to this selection. Analyses conducted using a breakpoint one year on either side of 1991 were presented by NMFS and the results indicated a robustness to these variations. It was also reiterated that 1991 was a logical point to chose because it is the time at which one expects to see an increase in the populations because fishery mortality at that time became so low. The IATTC staff expressed concern about the choice of 1991 for the breakpoint and recommended the effects of changing this breakpoint be analyzed beyond the previous (*i.e.*, testing one year in each direction). The NMFS staff agreed to conduct these more extensive sensitivity tests before completing the final Report to Congress.

Another model issue of concern to the IATTC staff was potential time lags. They felt this was relevant in view of some results showing gaps in the age distribution of spotted dolphin mortality that suggested the absence of a large proportion of juveniles. In response it was noted that the model used for the initial report did in part deal with time lags, given the age structure information included there. It was also noted that the age structure analyses referred to analyzed data collected during the 1970s and early 1980s and that no recent age structure information is available because relevant data have not been collected by the international observer programs (*i.e.*, non-U.S.). Consequently, there is no means to determine if the apparent gap in age distribution has continued during the most recent 10-15 years.

The IATTC was also concerned about the observed correlation between μ and fishing effort. In addition, they noted that μ represents a constant and does not take into account multiple mortality components that can be a function of other factors. Suggested components included mortality from stress, cow/calf separation, facilitated predation, injuries, and unreported mortalities (including those not seen and those seen but not reported). It was noted by the NMFS that, in order to be able to separate μ into multiple components, data on the annual number of sets per stock from the IATTC were required and those data have not been made public. Even if those data were available, they could be confounded by factors such as fishing area, which would make them complicated to incorporate. The IATTC indicated that number of dolphin sets by stock can be made available to the NMFS.

4.2 Data issues

4.2.1 Research vessel abundance estimates

In the ETP, the SWFSC has collected research vessel sightings data suitable for line-transect analyses since 1970s. More recently, the SWFSC completed two of three years of abundance surveys required under the IDCPA. Abundance estimates from the first of these three survey years (1998) were incorporated in the 1999 Report to Congress. Abundance estimates from the 1999 survey will be available in June 2000. The sizes of the depleted

dolphin stocks were estimated using distance sampling (Buckland *et al.* 1993). More details of this analysis can be found in Gerrodette (1999).

Since the last major SWFSC survey effort in the ETP in the 1980s, there have been significant advances in data analysis methods. Consequently, the estimates from earlier surveys are being revised in order to make the analysis for all years consistent. This new series of abundance estimates is currently being produced and will be incorporated into the final report of the IDCPA research program.

Although the methods used in these abundance estimates are well-tested and considered standard, some judgement enters the analysis, for example, in the stratification process. The types of stratification, the rationale for those choices and the consequences of various stratifications were discussed. Stratification occurs both at the design stage and the analysis stage. The survey area was designed to include the entire range of coastal spotted, northeastern offshore spotted and eastern spinner dolphins. Within this area, searching effort was further stratified into four areas based on densities of the target dolphin stocks. Stratification can also be implemented in the analysis for the main line-transect factors (encounter rate, average school size and effective width that can be detected). Although the effect of stratification on the estimates varies depending on the stratification scheme, several variations have been tested and have been found to have an inconsequential effect on the estimates. The choice of stratification also appears to have little impact on the output of the population assessment model.

Noting that the data from the Monitoring of Porpoise Stocks (MOPS) surveys of 1986-1990 were not pooled in the current analysis but had been in some past analyses, the IATTC asked if the NMFS had assessed the impact of pooling data from multi-year surveys. The NMFS responded that these estimates had been treated in different ways for different specific purposes. For example, the best single estimate of abundance for the sampled period was obtained by pooling across years. This was done for setting dolphin mortality limits. When fitting a model over time to look at changes in population abundance, as is currently being done, pooling is not statistically sensible. It was also noted that variance is underestimated when pooling is used. Imprecision of individual year estimates increases when data are not pooled, but the NMFS is working to improve the precision of the abundance estimates. The IATTC staff mentioned a possible alternative to pooling suggested by Dr. Ray Hilborn in a recent discussion on the same data set involving a method called "contradictory data analysis". During a short discussion of this method it was noted by a NMFS scientist that the two data sets appeared neither contradictory nor incompatible.

4.2.2 TVOD trend estimates

The NMFS was compelled by both scientific and legal precedents to include TVOD estimates of relative abundance in the assessment done for the 1999 Report to Congress, prepared for the initial finding required by the IDCPA, for reasons described at length in that report. (Previous extensive discussions of this matter are not repeated here. Rather, interested readers are referred to the 1999 Report to Congress, especially section 5.4 on pp.

8-11 and the Report's Appendix 1, "Using tuna vessel observer data to estimate trends in dolphin abundance: a chronological description" pp. 41-46. Also see Appendix 3 here for views expressed by IATTC staff in response to the initial draft of this report).

Whether TVOD will be used in the future assessment work has not been determined. In December 1998, the IATTC first mentioned to the NMFS that it was concerned about the validity of using TVOD. A few months later, the IATTC expressed in a letter to the NMFS its reservations about the use of TVOD in these analyses because of apparent time-varying biases in the data. In response to these concerns, the NMFS assigned a full-time statistician in 1998 to initiate an evaluation of TVOD independent of the IATTC's own evaluation. In addition to work completed to date on a theoretical analysis of the TVOD, the NMFS will also undertake a numerical analysis of the abundance estimation process. The NMFS intends to have its analyses peer-reviewed so they may be factored into its determination of whether TVOD will be included in the population assessment model.

Work to date on the theoretical analysis of TVOD was presented by NMFS scientists. A summary is given in Appendix 4. Specifically, the data collection methods and statistical analyses were reviewed. Because the data are collected during commercial fishing operations, they are especially susceptible to three sources of error: sampling bias, measurement error and selective reporting. The IATTC has initiated a study to explore the possibility of correcting for some of the biases. However, if the magnitude of these errors has changed over time, one would need to account for different conditions between years. Two ways of dealing with this inter-annual variability were discussed: 1) treat it as a time-varying bias and correct for it by incorporating appropriate covariates or stratification into the abundance estimator and 2) treat it as random error and include this variation in the estimates of precision. However, because of the absence of quantitative methods to detect and correct for changing bias due to annual differences in the conditions under which the TVOD have been collected, treating inter-annual variability as random error was considered more feasible. Most importantly, it was thought that some errors would never be quantifiable and that the use of TVOD to estimate abundance and trends requires making a number of untestable assumptions.

The IATTC mentioned that at one time much work was done to investigate several of the biases in the TVOD but over the past several years this research was stopped. The IATTC is currently undertaking a study to determine if biases that seem to have appeared in the last several years are correctable. A spatial component to assess environmental variability is also part of this study. However, given the exploration of these issues to date, the IATTC is not optimistic regarding a future ability to eliminate critical biases in the TVOD.

The IATTC presented some preliminary information indicating that the TVOD are subject to time-varying biases. The following factors were mentioned as possible sources of such biases: 1) the effect of individual vessel dolphin mortality limits on selective reporting and on sighting and selection of schools to be set upon, 2) the advent of "dolphin-safe" fishing which changed the relative frequency of the different fishing modes (*e.g.*, log

and FAD fishing) and changes in fishing effort, 3) technological advances (*e.g.*, bird radar and helicopters), and 4) environmental events (*e.g.*, El Niño) that may affect search time.

The IATTC staff presented a figure with annual estimates of TVOD abundance and number of dolphin sets in the northeastern spotted area for each year. In their view the figure indicated a lack of correlation during early years, up to about 1988 or 1989, with an apparent correlation in subsequent years. The IATTC staff noted that the abundance estimation methodology had been developed and assumptions tested for the early period only. However, several participants suggested this analysis also appeared to show a correlation within earlier years, albeit at a different rate. The IATTC stated that the factors causing the apparent correlation have not been clearly identified and no correction method has been determined.

The NMFS took this opportunity to comment on the manner in which the IATTC shares potentially important information such as this. In response to consultations such as this one and to the 1999 Report to Congress and its related documents, the NMFS has received commentary and additional data analyses in a series of letters from the IATTC. The NMFS urged the IATTC to combine these elements into publishable manuscripts and submit them to external peer-review to ensure that the assertions made in those letters are scientifically sound, and to have a bearing on the scientific deliberations and the report prepared for the final finding under the IDCPA. The NMFS emphasized the importance of this in terms of the perceived validity and ultimate utility of the points raised in these letters. The IATTC staff responded that the letters were sent to identify problems, but that any subsequent research papers should offer a more complete picture of the problems and any possible means of correction. The opinions of those involved in the development and review of the methodology were not in total agreement about the possibility of solving those problems, and it was believed that some additional research was needed. Plans have been made to conduct this research in the near future, but until this work is finalized, the IATTC staff did not think that a paper with a cursory examination would be very useful. The NMFS staff replied that given only the existing cursory examinations, they were left with little in comparison to the body of peer-reviewed papers published by the IATTC and its contractors asserting strongly that the abundance estimates are valid for monitoring trends (see summary in Appendix 1 to the 1999 Report to Congress). It was agreed that NMFS may face the unhelpful situation of having no peer-reviewed papers documenting the problems noted in the IATTC letters at the time (late 2001) it has to conduct the assessments for the final Report to Congress. (Note: later in the meeting it was suggested that a peer review assessing the scientific issues related to including or excluding the TVOD. See section 6, item 1.c for a discussion of this workshop that the NMFS, MMC and IATTC agreed to convene.)

4.2.3 TVOD mortality estimates

Estimates of fishery mortality are available from 1959 to 1997 from various published sources. Since 1987, annual estimates have been published by the IATTC. Estimates of fishery mortality are available from 1959 to 1997 from various published sources. Since 1987, annual estimates have been published by the IATTC. Bias and

variance in these estimates varies over this time period. The stock specific estimates of mortality are not done by enumeration but rather are based on estimates of stock specific composition of the observed kill and the estimate of total kill. This estimate is highly stratified by area. The IATTC has done little research on bias in the estimates. Though under-reporting is thought to be a relatively minor problem by the IATTC, the group concluded that under-reporting was a possible factor in explaining the lack of recovery should a lack of recovery be documented through the surveys. It was recommended that the IATTC should put more effort into estimating bias in the estimates of mortality. At a minimum, the estimated kill-per-set from national programs should be compared with corresponding IATTC observer data. This analysis should be stratified at least by year, area and stock. The IATTC staff reviewed all the potential sources of fishery mortality that had been mentioned over the years in literature and discussed what was known about them. The IATTC said that in some cases an estimate of mortality (*i.e.,* reported mortality) and in other cases a correction factor could be produced based on some data (*i.e.,* injuries, particularly non-serious injuries). Data are not currently available to determine if, for example, facilitated predation, mortality due to stress, or mortality due to cow-calf separation are potential mortality causes. The IATTC staff expressed skepticism that any or all these factors could account for even a small fraction of the number of animals expected but not observed in the NMFS model. A NMFS scientist added that even if the sources of mortality may be small in magnitude they cannot be assumed away and that an attempt to estimate them should be made and if they prove to be insignificant sources of mortality they will be excluded. The IATTC staff mentioned at the consultation that some data analyses and comparisons were underway to address some problems and the results of those will be reported when they are finalized. The IATTC also mentioned that observer performance checks are done regularly and observers are eliminated from the pool when their data are suspect. An NMFS scientist suggested that such a review relates to the process that generates the numbers used in mortality estimation rather than the verification of the actual numbers being used and inquired what was being done to confirm the numbers used in the estimation process. There were some discussion about comparing the national program data with IATTC data. The IATTC commented that such a comparison was to be discussed at an IATTC meeting but that there was no further information on whether this comparison is being pursued.

5. Attribution of cause

Because the IDCPA requires a determination of whether a significant adverse impact caused by the practice of encircling schools of dolphins with purse seine nets is occurring, other potential causes for any observed lack of recovery of dolphin stocks must be identified and evaluated to avoid incorrect attribution of cause. Consequently, the SWFSC included in its IDCPA research program several studies to address possible alternate explanations for the observed status of dolphin stocks. Environmental effects can directly and indirectly affect assessments of cetacean populations. Indirectly, environmental conditions can affect the ability to detect animals during research vessel surveys. However, the line-transect methodology used in these surveys is designed to account for such effects. The size of the dolphins favorable habitat may also change as the environment changes and may affect the

coverage of dolphin stock ranges during a research vessel survey. The NMFS is confident that its ETP study area suitably covers these ranges of the depleted stocks being studied.

5.1 Environmental Effects

5.1.1 Oceanography

Oceanographic data are collected continuously and at selected stations on the NMFS research vessel surveys in the ETP. A long time series of several oceanographic indices is also available to assess the potential effects of seasonal and interannual variability in the environment. These indices show that during the most recent NMFS research vessel surveys (1998 and 1999) there was less environmental variability than during the MOPS surveys (1986-1990) and that the indices during the recent surveys were well within the range of the MOPS surveys. Environmental variability has been shown to occur on interdecadal (~20-year) as well as ENSO (3-to 7-year) scales. Current studies show that, in the eastern tropical Pacific, ENSO variability is considerably greater, although it can be modulated by interdecadal variability. Nevertheless, interdecadal variability will be investigated for the final research report.

5.1.2 Zooplankton

Ecosystem variability stemming from faunal changes is also being investigated. Plankton tows are conducted during the research vessel surveys and will be compared to the surveys done in 1986-1990. A comparison will also be attempted with data collected during the EASTROPAC sampling in the late 1970s, but this comparison may be constrained by sample sizes and methods from that program. Results of these plankton studies alone may not indicate an ecosystem change. However, when combined with results from concurrent studies on birds, turtles and fish, more meaningful conclusions can be drawn.

5.1.3 Predators

In order to better understand whether major physical or biological changes (*e.g.*, regime shifts) are occurring, or if human intervention (*e.g.*, the effect of the fishery removing biomass, which may change the structure and interaction of predator communities) could be factors affecting the recovery of dolphin populations, a large set of data will be examined and incorporated into the final research report. This includes data on abundance and distribution of ETP cetaceans, seabirds, zooplankton, flyingfish (an common prey item in the ETP) and large fish (via other published studies). Some concerns were expressed by the IATTC regarding the ability to determine if the overall carrying capacity of the ETP has changed over the time period of interest (1950s through 1990s). They felt it was inappropriate to attempt to back calculate dolphin abundance to reach a historical carrying capacity, especially because changes in the ecosystem may have indirectly affected the carrying capacity of dolphins without changing the overall capacity of the ETP ecosystem (*i.e.*, it is possible the ecosystem has reached a new equilibrium that would not be taken into account in the NMFS's population assessments). Some suggested, however, that changes

of that nature would constitute a regime shift in which productivity remains constant but species composition changes. If a major shift in the ecosystem has occurred such that recovery of dolphin populations were affected, it should be possible to detect a shift given the long term data available on a number of major elements of the system.

5.2 Fishery Effects

A brief review of research addressing the potential effects of the fishery on dolphins was provided.

5.2.1 Stress

5.2.1.1 Molecular indicators

The NMFS has developed a test for chronic stress in dolphins using skin samples. This test is currently being applied to the tissue archives at the SWFSC, which include samples previously collected from the fishery and taken up to the present during research vessel surveys. An analysis relating chronic stress levels to the number and geographic distribution of sets and reproductive indices will be conducted for the final research report to be submitted to Congress in March 2002.

5.2.1.2 Necropsy program

The necropsy program was designed to collect tissue samples from dolphins killed in the fishery and to perform a variety of pathophysiological analyses on the samples to look for morphological indications of physiological stress. Placement of necropsy technicians on purse seiners has been slow despite reassurances from Mexico, the only country that has agreed to cooperate with the U.S. on this program. To date, samples from eleven dolphins have been collected during three trips and are awaiting transfer to designated laboratories. The samples collected so far are part of a pilot program that was initiated to determine if the samples collected are of the necessary quality and if it is feasible to collect a sufficient number of samples for the laboratory results to be meaningful. NMFS has determined that ten trips are required to complete the pilot program; three trips have been completed at the time of this meeting.

5.2.1.3 Chase-recapture or related experiment

Under the research requirements of the IDCPA, the NMFS is required to conduct an experiment "involving the repeated chasing and capturing of dolphins by means of intentional encirclement." Although a planning workshop and two meetings regarding this experiment have occurred since 1997, much of the planning depends on the preliminary results of the necropsy program. Thus, the planning and execution of this experiment has been affected by the delays in the necropsy program. Nevertheless, in an attempt to move ahead with the plans for this experiment, the NMFS recently hosted a meeting in which the experimental design of the study originally suggested was thoroughly examined. A group

of scientific experts and representatives from the MMC and IATTC met with the NMFS to review the original conception of the experiment, to identify its weaknesses, and to recommend modifications necessary to make the suggested chase/recapture experiment more effective at contributing to the question of whether stress from chase and encirclement is having a detrimental population level effect on dolphins in the ETP.

5.2.2 Cow/calf separation

A study using historical data from the purse seine fishery was conducted by the SWFSC to determine if the dolphin kill in the fishery may have been seriously underestimated because of separation of nursing calves from their mothers during fishing. The study provides quantitative and qualitative results showing that some aspect of the fishing procedure separates calves from their mothers. A detailed examination of a large sample of dolphins killed in the purse seine fishery showed that more lactating females than calves were killed on about one quarter of sets on which dolphins were killed. It could not be determined if the missing calves were killed in the net but not seen by observers, escaped the net alive either before or after the deaths of their mothers, or were separated from their mothers during the chase but before encirclement. It was noted that the enumeration of this calf deficit is described in more detail in a manuscript of the study that has been submitted for publication and is currently undergoing peer review.

5.2.3 Under-reporting of fishery mortality

This topic was discussed under agenda item 4.2.3 (TVOD mortality estimates).

6. Proposed decision rules

The following outline for discussion of this agenda item was proposed. Because of time constraints, item 3 on the outline (attribution of cause) was not thoroughly discussed and the group agreed to hold another consultation in the near future to fully address this important item.

1. *Abundance and Trend issues. Revisit decision rules related to abundance and trends in light of any new data and new calculations available.*
   - a. *Existing criteria*
   - b. *Additional criteria*
   - c. *Data Issues*
     - i. *Index of relative abundance (TVOD)*
     - ii. *Mortality estimates (TVOD)*
2. *Effects on individual animals.*
3. *Attribution of cause.*
   - a. *Fishery-related causes*
     - i. *consideration of under- and mis-reporting*
     - ii. *chase and recapture stress (chronic and acute)*
     - iii. *cow/calf separation*
     - iv. *ecological disruption (secondary effects stemming from major perturbations caused by fishery)*
     - v. *reproduction effects*
   - b. *Causes not related to fishery*
     - i. *oceanographic changes*
     - ii. *ecosystem changes*
   - c. *Determining combining rules for quantities from various studies under the IDCPA research program.*

Item 1. The group revisited the existing decision rules related to abundance and trends to decide if any criteria should be added or changed.

Item 1a: Existing criteria. μ/r_{max}: The group proposed no change to this criterion defined at earlier consultations and used in the 1999 Report to Congress (*i.e.*, there must be less than a 50% probability that the sum of the reported post-1991 kill rate and the estimate of post-1991 growth rate depression exceeds one quarter the r_{max} from the period up to and including 1991).

Item 1b: Additional criteria. $\hat{R}_{max}$: Inclusion of this additional parameter in the analysis was recommended in order to consider effects operating during the entire fishery (as opposed to μ , which relates to effects that have been increasing since 1991). It was noted that it is not entirely clear what standard should be used for such a measure but that an appropriate range could be arrived at by the group.

In discussing the plausible lower limit for $\hat{R}_{max}$, many suggested that 2.75% could be reasonably expected. This expected rate stems from a published estimate for killer whales (a delphinid) that is known quite precisely. Many participants added that this was likely a conservative estimate because ETP dolphins have a shorter inter-birth interval than killer whales; thus, it was reasonable to believe that ETP dolphins could meet if not exceed

this level. The group decided that the probability associated with this criterion would be the most tolerant requiring only a preponderance of evidence (*i.e.*, 50%). Two additional thresholds and associated certainty levels were set that reflect higher desired certainty that the population is at least growing at some lower rate. Thus, the decision rules (and associated certainty levels) agreed upon for this parameter were as follows.

$$\hat{R}_{\max} > 1.0275, 50\%$$
$$\hat{R}_{\max} > 1.015, 75\%$$
$$\hat{R}_{\max} > 1.005, 99\%$$

It was suggested that one more criterion be introduced to the decision rules associated with abundance and trend information, namely, that in a recent year (1999 was proposed) the population was increasing, that is the underlying growth rate in conjunction with the fishery mortality allowing for positive growth. This was formalized as $R_{Nt} - F_t > 1.0$, where the first term is the growth rate of the present population (adjusted for density dependence) and the second term is the current fishery mortality. A certainty level of 95% was suggested by some participants noting that this was a level used in the Endangered Species Act (ESA) framework and is similar to the levels used in the Potential Biological Removal (PBR) scheme under the MMPA. Wide support was expressed for setting a high probability level (95%) for this criterion that net growth is occurring with the condition that information from simulation studies are provided that indicate what the probability level is for achieving that level of certainty based on the data used. The concern behind this condition is that the abundance estimates are too variable to allow such a high probability to result. This is similar to saying we may not have the statistical power to achieve the desired probability level. The solution to this problem will be to compute growth over a larger window of time (more than one year).

Item 1c: Data issues. Because of the probability that the re-analysis of TVOD being conducted by the IATTC will not appear in peer-reviewed, published format in time for consideration in the final research report, the group agreed that an external peer review panel could assess the scientific issues related to inclusion or exclusion of TVOD abundance indices in the population assessment modeling to be covered by decision rules developed during this consultation. Establishment of a steering committee was recommended to organize the review. Representatives from the MMC, IATTC and SWFSC will comprise the steering committee (identification of specific participants was not discussed though Reilly was asked to designate someone from his staff who could organize the committee and serve as its chair).

The discussion of whether to include or exclude TVOD centered around whether it was suitable for the application at hand; the group did not attempt at this meeting to decide if the TVOD were unsound or not. The IATTC made available a letter it wrote to Dr. Tillman of the NMFS stating their concern about using TVOD (see Appendix 2) stating that TVOD should not be used to make comparisons among years (particularly between early and

late years in the series) because the biases associated with these data appear to have been changing over time.

Item 1.c.i: Estimates of relative abundance (TVOD). Five items were discussed regarding the use of estimates of relative abundance from TVOD: 1) criteria for including TVOD, 2) criteria for excluding TVOD, 3) criteria for using 'revised' TVOD, 4) criteria for selective inclusion of subsets of TVOD, and 5) Criteria for weighting TVOD.

1) Given the large body of published work arguing that TVOD are suitable for estimating relative abundance and trends, and currently lacking any peer-reviewed work that indicates the opposite, it was recommended by NMFS that the default position regarding the use of TVOD in the assessment should be to include these data. Under the assumption that this default position would continue to be supported by NMFS, the group defined circumstances under which the exclusion of the TVOD would be justified. The IATTC reiterated its opinion against the inclusion of the recent TVOD in evaluating the impact of "dolphin fishing" on the recovery of the three stocks of depleted ETP dolphins (see also Appendix 2).

2) Criteria for deciding to exclude TVOD. In order to exclude TVOD, the group suggested that there be (a) diagnosable evidence or (b) theoretical considerations regarding undiagnosable sources of error that include plausibility and magnitude levels. Some work relevant to the first condition (a) is currently being explored (*e.g.* the IATTC's investigation of internal correlations in the data). Also, an inquiry into the second condition (b) is underway (*e.g.* the SWFSC's report on the potentially undiagnosable problems associated with the TVOD). The group concluded that if either condition was met, it would be sufficient to exclude TVOD from the analyses.

3) Criteria for using a revised TVOD index. If revised or "corrected" TVOD are produced, it was agreed that it must not meet either condition above to be used in the population assessment analyses.

4) Criteria for selective inclusion of subsets of TVOD. The group decided that selective inclusion of segments of the TVOD series needed to meet the same conditions for revised TVOD with the understanding that it is unlikely a subset of the data will pass these filters if the entire time series of data does not.

5) Criteria for weighting included TVOD. Although the IATTC stated that the current weight the TVOD have in the analyses was inappropriate given their recent concerns about the soundness of the TVOD, most participants argued that more complicated weighting schemes were unavailable for practical application and that an arbitrary weighting scheme for variances should not be introduced to the analyses at this point.

Item 1.c.ii: TVOD mortality estimates (criteria for accepting revision). The IATTC was unable to comment on whether changes in the mortality estimates from TVOD were expected. Consequently, the group agreed that revisions of the TVOD mortality estimates were unlikely absent a final report or peer-reviewed publication from the IATTC

summarizing the results of their reevaluation of the mortality data..

Item 2: Effects on individual animals. There is a possibility that statements can be made regarding the effects of chase and capture on individuals. In that case, criteria such as what the definition of stress is will have to be determined even if this element is not folded quantitatively into the decision analysis.

Item 3: Attribution of cause. It was agreed that for the items under 3.a. (fishery-related causes) the mechanisms should be distinguished that are specific to μ (1992-1998) versus those that more generally depress the growth rate. Regarding items under 3.b. (causes not related to the fishery), the group agreed that if they cannot be dismissed as having an effect, they should be quantified.

7. Closing comments

The MMC found the consultation useful and was encouraged by the careful thought addressing the best methods for addressing the finding required by the IDCPA. The IATTC appreciated the opportunity to participate in the process and hoped it could contribute to providing the best solution to this long-standing issue. The NMFS concurred that this consultation was useful and thanked those present for their participation.

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Appendix 1. Agenda.

IDCPA Research Program
Analysis Decision Framework Consultation
April 27-28, 2000
Southwest Fisheries Science Center

Objective: Continue development of the decision framework in consultation with the Marine Mammal Commission and Inter-American Tropical Tuna Commission.

Location: Large Conference Room, SWFSC, 8604 La Jolla Shores Dr, La Jolla, CA

Schedule:

Thursday April 27
- 9:00 begin
- 10:30 - 10:45 coffee break
- 12:15 - 1:30 lunch
- 3:30 - 3:45 coffee break
- 5:00 adjourn for day

Friday April 28
- 0:900 begin
- 10:30 - 11:00 break
- 1:30 (earlier if possible) close of meeting.

Facilitator: Dr Norman Bartoo, Planning Officer, SWC

Background documents:

1. Goodman, D. January 24, 1999. *Decision framework for assessing the status of the eastern tropical Pacific dolphin stocks*. Attachment to: Southwest Fisheries Science Center, NMFS. Report to Congress on the initial finding...March 25, 1999.

2. Southwest Fisheries Science Center, NMFS. *Report to Congress* on the initial finding, required under the Marine Mammal Protection Act of 1972 as amended by the International Dolphin Program Conservation Act of 1997, regarding whether the intentional deployment on or encirclement of dolphins with purse seine nets is having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean. March 25, 1999.

Agenda:

1. Welcome and Introductions (Bartoo).
    - 1.1 Opening Comments
        - 1.1.1 NMFS
        - 1.1.2 MMC
        - 1.1.3 IATTC
2. Review present state of Framework development, as documented in Goodman (24 January 1999). (Goodman).
3. Interpretation of "Significant Adverse Impact"
4. Trend and Abundance Component of the determination
    - 4.1 Structure of assessment model (Wade)
        - 4.1.1 Definition of "mu"
        - 4.1.2 r-max estimation
        - 4.1.3 other model issues
    - 4.2 Data issues
        - 4.2.1 RV abundance estimates (Gerrodette)
        - 4.2.2 TVOD trend estimates (Reilly)
        - 4.2.3 TVOD mortality estimates (Hall?)
5. Attribution of Causality
    - 5.1 Environmental Effects
        - 5.1.1 Oceanography (Fiedler)
        - 5.1.2 Zooplankton (Fiedler, Moser)
        - 5.1.3 Predators: cetaceans, birds, fishes (Reilly and others)
    - 5.2 Fishery Effects
        - 5.2.1 Stress
            - 5.2.1.1 Molecular indicators (Dizon)
            - 5.2.1.2 Necropsy program (Edwards)
            - 5.2.1.3 Chase-Recapture or related experiment (Reilly)
        - 5.2.2 Cow-calf separation (Archer)
        - 5.2.3 Under reporting of fishery mortality
6. Proposed Decision Rules (Goodman)
    - 6.1 Trend and abundance rules
    - 6.2 Environmental effects
    - 6.3 Fishery effects
    - 6.4 Other effects
7. Closing Discussion
    - 7.1 General discussion
    - 7.2 IATTC closing comments
    - 7.3 MMC closing comments
    - 7.4 NMFS closing comments

Appendix 2. Letter to M. Tillman from IATTC, 27 April 2000.

COMISION INTERAMERICANA DEL ATUN TROPICAL
INTER-AMERICAN TROPICAL TUNA COMMISSION

Scripps Institution of Oceanography, 8604 La Jolla Shores Drive, La Jolla CA 92037-1508, USA
Tel: (858) 546-7100 – Fax: (858) 546-7133 - Director: Robin L. Allen, Ph.D.

April 27, 2000
Ref.: 0260-812

Dr. Michael Tillman
Director, Southwest Fisheries Science Center
8604 La Jolla Shores Dr.
La Jolla, CA 92038

Dear Dr. Tillman:

IATTC Staff Comments for Meeting April 27-28,2000

The IATTC staff welcomes this opportunity to continue the consultation on research required by the Act. However, we do need to clarify that while the staff will report any proposals to the Commission we cannot, without time to give it an opportunity to consider the issues raised at the meeting, give the Commission's views on any matter.

At the outset of this meeting we want to repeat two points which we made previously but which were not given any prominence in the advice from the Southwest Fisheries Center to the Secretary of Commerce for the initial decision. The first concerns the nature of the Decision Framework itself, and the second the treatment of the TVOD estimates of relative abundance and the survey abundance estimates.

Our concern about the Decision Framework is that it includes a Decision Rule that makes policy decisions, which should be made by the Secretary of Commerce (or the person to whom he has delegated authority), within what could be taken to be a scientific analysis. There are two critical elements of judgment to be exercised by the Secretary. One is what constitutes a significant adverse impact, and the other the level of certainty he should have in deciding whether the evidence presented to him is sufficiently compelling to decide that there has or has not been an significant adverse impact. Neither what should be considered a "significant adverse impact" nor what probability level the Secretary ought to use in weighing the evidence can be determined by the research mandated by Congress. The decision framework reported in the paper attached to the invitation gives the impression that a scientific process has resolved these questions and invites the Secretary to relinquish his discretion in those issues. In particular, the three criteria both interpret "significant adverse impact" and assign probability levels for evaluation.

We believe the appropriate way to present the scientific results would be by reporting them with confidence intervals or in a probability statement which would then allow the Secretary to decide whether there was a significant adverse impact.

During the earlier consultations we repeatedly warned that the TVOD data should not be used to make comparisons among years and particularly between early and late years in the series. That

is because the biases, that are always present when opportunistically collected data are used, appear to have been changing over time. That alone makes those estimates unsuited to the purpose they were used for by NMFS.

Further, it is clear that the TVOD estimates suffer from a process error in addition to sample variation, as demonstrated by large inter-annual variations among the estimates, which was not accounted for when NMFS analyses used them alongside the research surveys. The analysis carried out by NMFS which used both the TVOD indices and the Survey estimates weighted each by the inverse of the estimated sample variances. The sample variances of the TVOD indices are very small because of the large number of observer sightings, and this caused them to have much more effect on the population growth estimates than the survey estimates. That weighting does not take account of other errors in both series and is clearly inappropriate.

We are engaged in a project to investigate these matters further and may have additional results early next year.

While those points have been made in letters during the last consultation, we believe we need to reiterate them because they were not given much weight in the consideration of a Decision Framework. We find it hard to see the previous process as an effective consultation when our views on indices which we developed, and for which we have the greatest expertise in, have apparently been given no effective weight.

We also submit for consideration the analysis of all the survey results from 1979-1998. Fitting an exponential model to those indicates that there has been a significant increase in the population of both eastern spinner and northeast offshore spotted stocks dolphins during that period, and than no conclusion could be drawn about differences in growth rates before and after 1991.

During the course of the meeting the staff may wish to comment on other points, and as noted at the outset, we will report the results of the meeting to the Commission so we can provide to NMFS, at a later time, any comments the Commission may have.

Sincerely,

M.A. HALL

for Robin Allen
Director

Enclosure
As above

CC: Commissioners

Inter-American Tropical Tuna Commission

ESTIMATES OF GROWTH RATES OF EASTERN SPINNER AND NORTH-EASTERN SPOTTED DOLPHIN POPULATIONS OF THE EASTERN TROPICAL PACIFIC

26 March 1999

Population growth rates for eastern spinner and northeastern spotted dolphins were estimated by fitting a simple exponential population model to the U.S. National Marine Fisheries Service (NMFS) marine mammal survey data provided on the web site of the NMFS Southwest Fisheries Science Center.

The population model is given as

$$N(t+1) = exp(r(t))\,[N(t)-C(t)]$$

in which $N(t)$ is the population abundance in year t, $r(t)$ is the population growth rate in year t, and $C(t)$ is the total dolphin mortality in the purse-seine fishery in year t, as estimated by the IATTC. The relationship between dolphin abundance as measured by the NMFS survey and true abundance is assumed to be:

$$x(t) = ln[N(t)] + e(t) + d(t)$$

in which $x(t)$ is the logarithmic transformation of the survey estimate of abundance in year t, $e(t)$ is the survey measurement error as characterized by the sample variance reported by NMFS, and $d(t)$ is an additional unreported survey error due to sources other than sample variance (referred to as "process error" in the letter from R. Allen to M. Tillman dated 5 March 1999). The first error term, $e(t)$, is assumed to be normally distributed, with standard deviation equal to the survey sample coefficient of variation reported by NMFS; the second error term, $d(t)$, is assumed to be normally distributed with unknown variance V, which is an additional parameter to be estimated. A Bayesian statistical estimation procedure, the MCMC algorithm, was applied to calculate posterior probability intervals for net growth rate of the population and annual abundance. Prior distributions were chosen as uniform distributions on $r(t)$, $ln[N(1979)]$, $ln(V)$ because of the nearly linear structure of the problem under a logarithm transformation. Bounds of the uniform priors were chosen well beyond appreciable density of the likelihood function.

NMFS has proposed testing the hypothesis that after 1991 the population failed to grow at the rate expected from the dynamics in the 1975-1991 period. To examine this hypothesis, the population model was fitted on the assumption that $r(t) = r1$ prior to 1992 and $r(t) = r2$ after 1991. The results (Figures 1-4) indicate that the abundance of the populations of both eastern spinner and northeastern spotted dolphins increased during the period covered by NMFS surveys (1979-1998), but that the large amount of variance

in the survey indices precludes drawing definitive conclusions about population growth rates in the pre-1992 *versus* post-1991 periods.

This hypothesis proposed by NMFS does not square with the Dolphin Protection Consumer Information Act as amended in 1997. That Act addresses the issue of whether intentional deployment of purse-seine nets on dolphins, or encircling them in such nets, is having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific. As discussed in the above-mentioned letter, the number of dolphin-associated purse-seine sets in the geographical range of the northeastern spotted dolphin during 1993-1997 was substantially lower than in the previous eight years. It is illogical to hypothesize additional mortality after 1991 as a result of setting on dolphins because the number of dolphin-associated sets, at least on northeastern spotted dolphins, was lower in that period than previously. We have not yet calculated the annual numbers of sets in the range of the eastern spinner dolphin.

A more reasonable question would be "Have the depleted dolphin populations shown growth during the period covered by the NMFS surveys?" Fishing effort on dolphin-associated tunas has been substantial during that period, and the depleted populations are thought to have been at a low level of abundance. To address that question, the above population model was fitted on the assumption that $r(t) = r$, a constant rate, during 1979-1998. The results show that median population growth has more than tripled the abundance of the eastern spinner dolphin population and increased by more than 50% the abundance of the northeastern spotted dolphin (Figures 5 and 7). The net cumulative growth rate during 1979-1998 is given by $ln[N(1998)/N(1979)]$. The results indicate that the probability that the population has grown during those years is greater than 95% for the eastern spinner dolphin and about 80% for the northeastern spotted dolphin (Figures 6 and 8).

Figure 1.

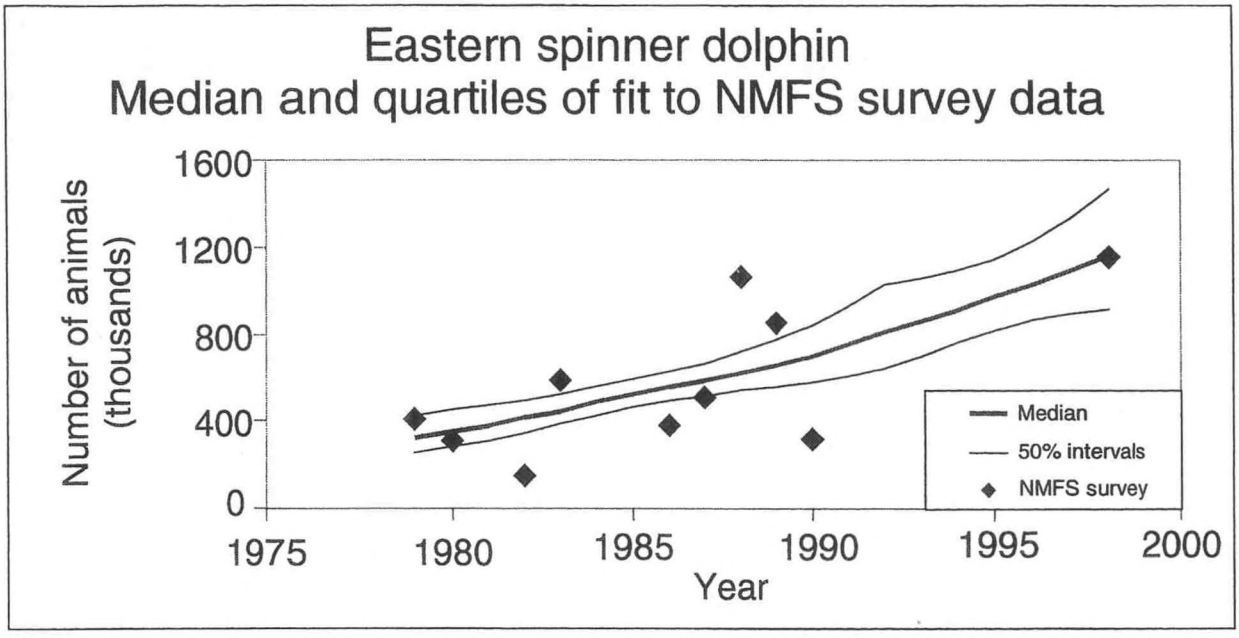


Figure 2.

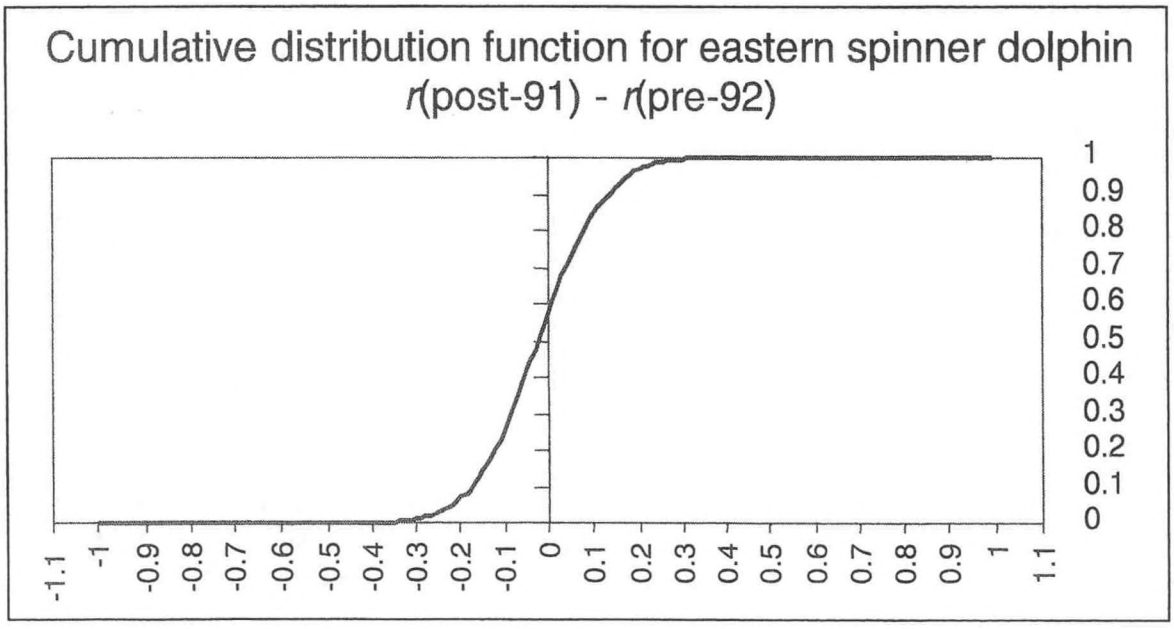


Figure 3.

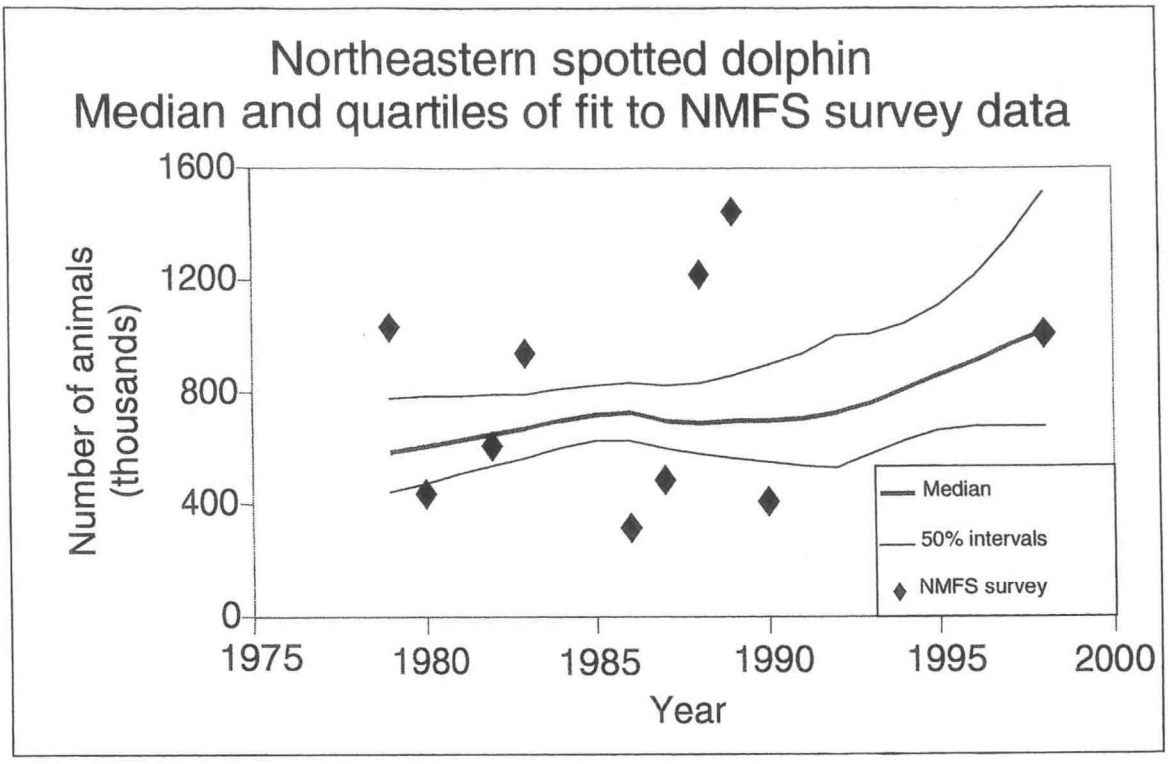


Figure 4.

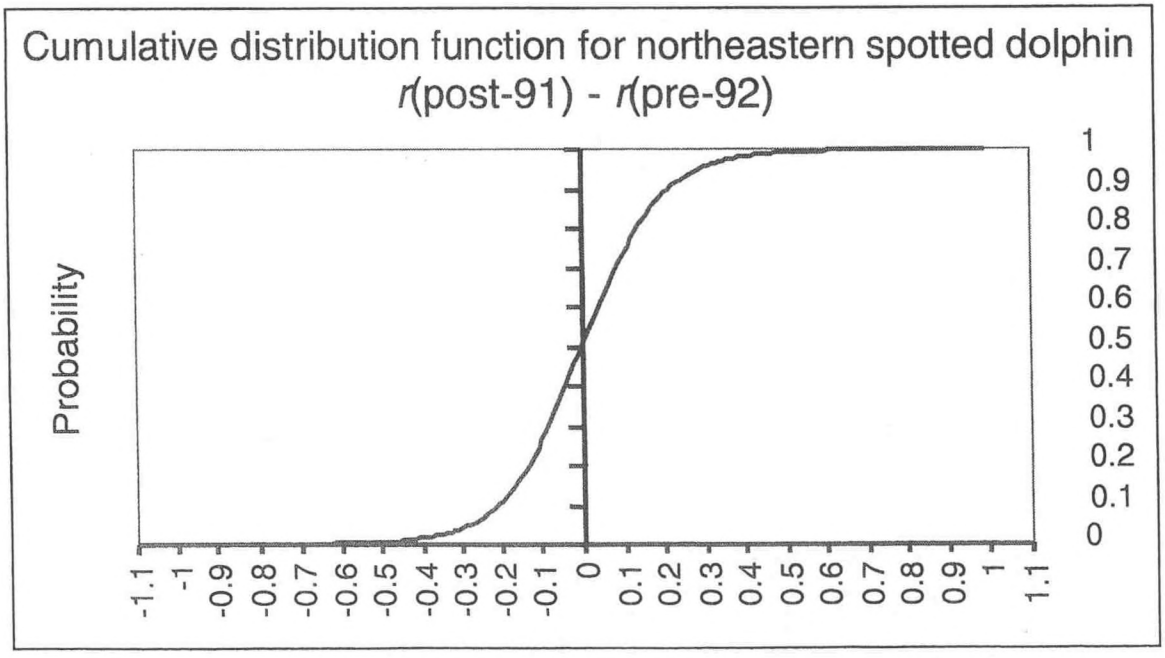


Figure 5.

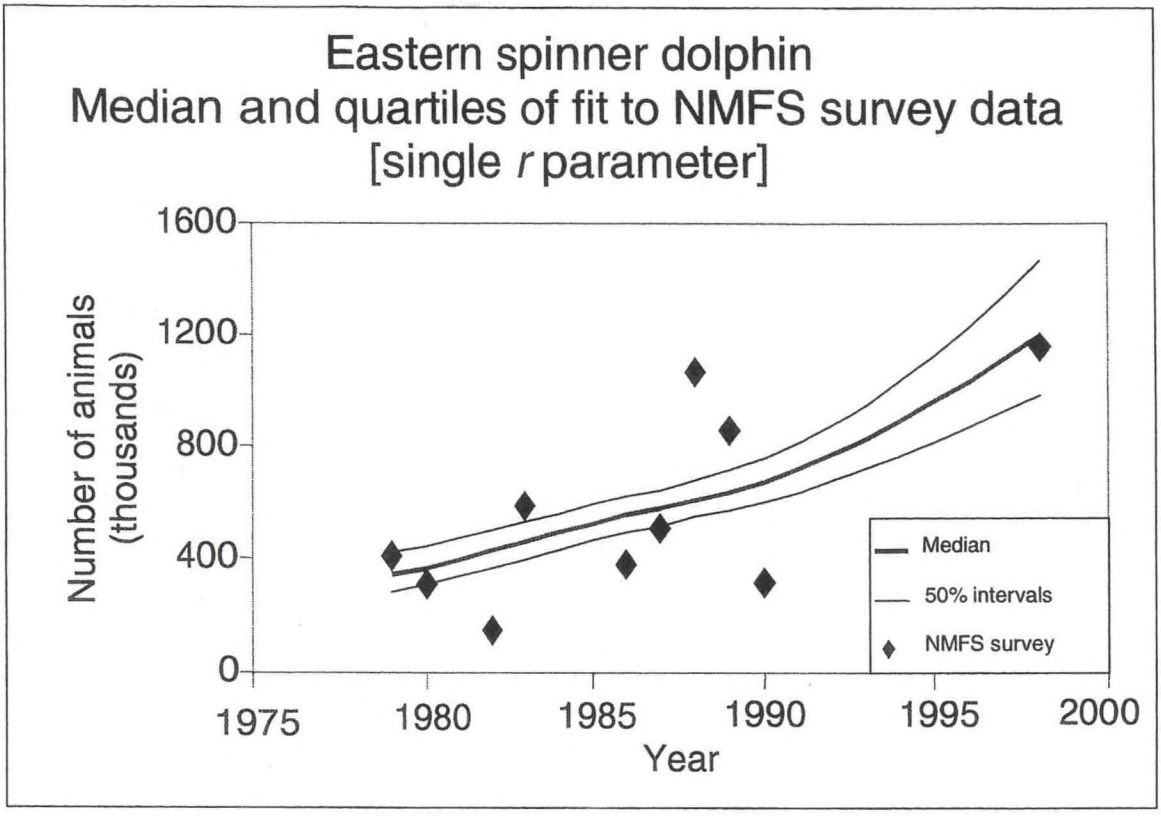


Figure 6.

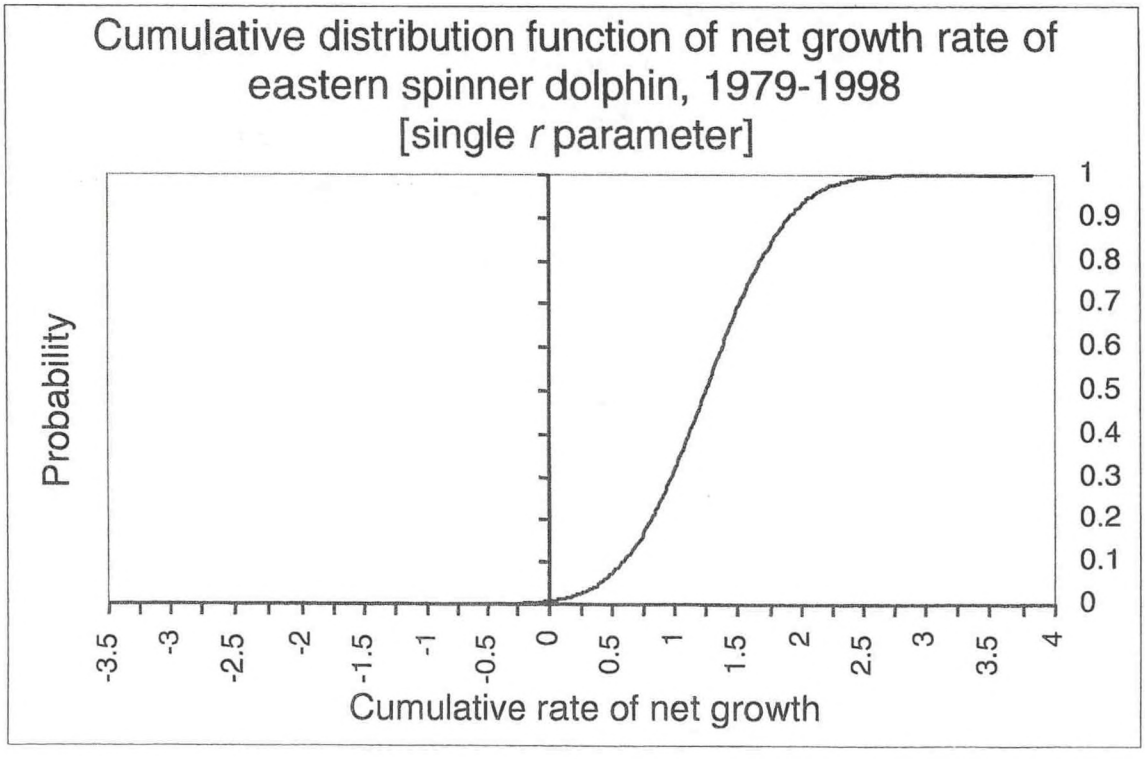


Figure 7.

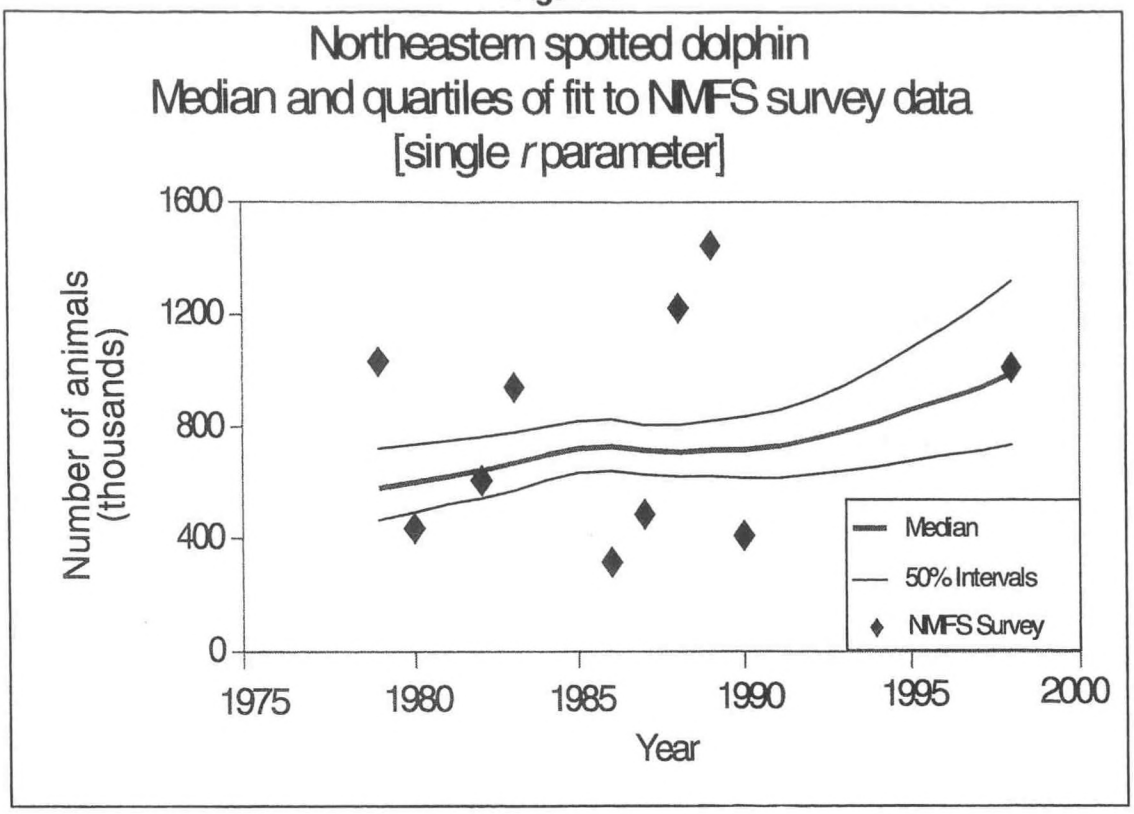
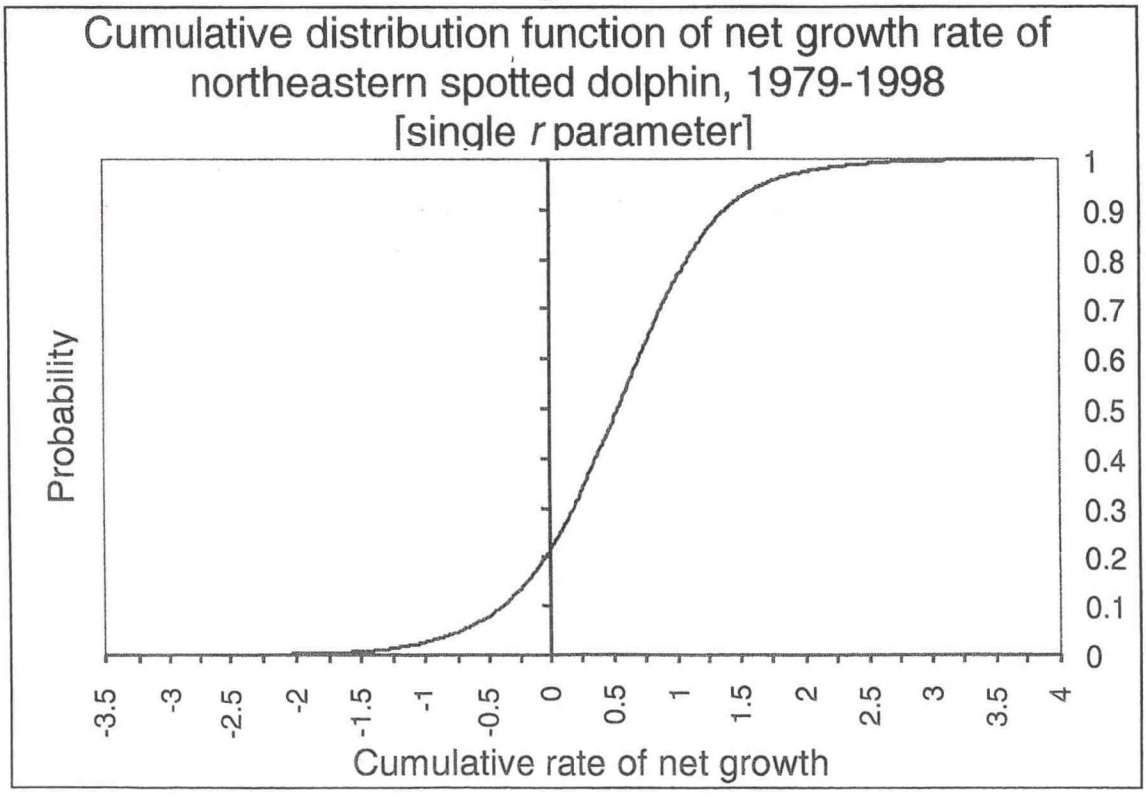


Figure 8.



Appendix 3. Additional comments by IATTC staff, from a letter dated 18 July 2000 from Martin Hall to Meghan Donahue.

On carrying capacity ad related issues:

"The IATTC staff questioned the knowledge of pre-existing carrying capacity of the dolphin populations before the fishery commenced causing its impacts. The paucity and low quality of the mortality data for the first decade of the fishery, the period with the highest mortality values, would have suggested approaches that did not use these data. Even though the mortality levels were probably high, the errors are so large as to render them quite useless. They also questioned the expectation that a long-lived species, with low reproductive rates will recover to its pre-exploitation level in a simple way, ignoring the possibility of other changes taking place in the ecosystem. Given that the biomass of tunas have fluctuated significantly over the period (to the point of requiring different models for yellowfin tunas that imply differences in the carrying capacity of the ecosystem), that in some areas (e.g., California Current) long term changes have been shown by other researchers, and that other fisheries have changed over the period in question, it is hard to expect that the trajectory of the recovery of the dolphin populations, or its rate can be predicted with any accuracy, especially when time lags in response are a distinct possibility. IATTC staff does not assume that, in the absence of fishing, the yellowfin tuna population will recover to the carrying capacity that existed over 40 years ago. They believe that yellowfin tuna dynamics clearly indicate that the environment has changed in recent decades and that there is no reason to believe that the dolphin populations would recover to carrying capacities that existed over 40 years ago.

"The IATTC staff asserted that the removal of the fishing mortality could not guarantee short-term, or a long-term recovery, if other factors had changed (e.g., abundances of competitors, prey species), that the recovery need not be to the "expected pre-exploitation level" because this one is not known, because carrying capacity may have changed, and that time lags may delay the process."

"The IATTC staff replied that the ability of tunas to rebound from a harvest cannot be compared with that of the dolphins. It is this speed of recovery that reduces the danger of major ecosystem changes taking hold during the period of low abundance. Tuna populations are not managed on the basis of their carrying capacities 40 years ago."

On the use of TVOD abundance estimates in the dolphin assessment:

"IATTC staff replied that they doubted that the intention of the U.S. Congress was for NMFS to use TVOD in spite of the advice of those producing those results, and that the lack of peer-reviewed publications was a very poor justification for not accepting the structural problems that have been described by the authors of the methodology and by some of NMFS own staff. A peer-reviewed publication will be produced when the solutions to the problems pointed out are found, or when the attempt to solve them is

abandoned. IATTC staff believes that is the correct scientific handling of the problem."

"IATTC staff showed a series of figures with each year of the TVOD time series of relative abundance of northeastern spotted dolphins, plotted against estimates of the number of dolphin sets in the northeastern spotted area for each year. The variables showed no correlation for the period 1975-1989, when the development of the methodology took place, and these assumptions were checked, but for the period 1990-1997, a significant correlation was detected. The "transition" from one period to the other is not abrupt, and the years 1988 and 1989 could be included on either side of the break point."

Appendix 4. Abstract from "The feasibility of using tuna vessel observer data to estimate trends in dolphin abundance" by Peter Perkins. (Southwest Fisheries Science Center Administrative Report LJ-00-03, May 2000, 19 pp.)

The Feasibility of Using Tuna Vessel Observer Data to Estimate Trends in Dolphin Abundance

"Tests conducted to demonstrate the absence of bias are ofttimes only experimental demonstrations of remarkable ability to repeat the same mistake."

- W.E. Deming

Abstract.

Data recorded by scientific technicians aboard commercial tuna purse-seine vessels in the eastern tropical Pacific Ocean have been used since the early 1980's to estimate trends in abundance for several stocks of dolphins that have been affected by mortality caused by the tuna fishery. These tuna vessel observer data (TVOD) are numerous, however, the conditions under which they have been collected are not well-controlled. Besides the usual random sampling error expected in any animal survey, the TVOD are subject to other complex and poorly-understood factors including: (1) the sample of schools recorded by technicians and the areas searched by vessels are not representative of the stocks and the stock ranges, respectively; (2) the various data recorded by technicians are not measured precisely and are subject to censoring; and (3) complicated dependencies exist between fishing mode, oceanographic conditions, and data collection.

All of these fishery-specific errors could lead to bias or underestimated variance in estimates of abundance. If TVOD are to be used to reliably estimate abundance trends, these additional sources of error must be accounted for, i.e., either removed, demonstrated to be unimportant, or treated as additional components of random error. Because trends, not absolute abundances, are of interest, a factor whose effect was a proportional bias, constant from year to year, in estimated abundance would not be of concern. However, many factors are known or are likely to change over time, and the assumption of a constant proportional bias in all cases is questionable, leading to unreliable estimates of trend due to the different conditions between years. One solution is to treat this interannual variability as a time-varying bias, and to correct for it by incorporating appropriate covariates or stratification into the abundance estimator. Another solution is to treat interannual variability as independent random error, to be included in estimates of precision.

Specialized statistical methods developed to estimate abundance trends from the TVOD primarily address spatial sampling biases. However, other major and problematic sources of error exist. Measurement error and censoring cannot be quantitatively corrected for because no independent "ground-truth" data exist. The effects of environmental variability on data collection may not be correctable because the interactions are so poorly understood. Thus, treating these latter factors as sources of time-varying bias is probably not possible. Treating them as sources of independent random error also may not be possible, because suitable replication in the data does not exist and because some factors are likely to change smoothly over time.

Thus, acceptance of abundance trend estimates based on TVOD would still require largely untestable assumptions about the remaining potential sources of error in the TVOD. The necessary assumptions concern aspects of the data collection process that are poorly understood and cannot be detected or investigated using the TVOD alone. The conclusion of this report is that there is not sufficient information to demonstrate that trend estimates based on TVOD would be valid, or even qualitatively valid.