SOUTHWEST FISHERIES SCIENCE CENTER

NATIONAL MARINE FISHERIES SERVICE SOUTHWEST FISHERIES SCIENCE CENTER P.O. BOX 271 LA JOLLA, CA 92038

JUNE 1992

# MINUTES FROM A WORKSHOP ON STATUS OF PORPOISE STOCKS IN THE EASTERN TROPICAL PACIFIC, WITH SPECIAL EMPHASIS ON THE PERIOD, 1985-1990

By

D.P. DeMaster and J.E. Sisson

ADMINISTRATIVE REPORT LJ-92-21

This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports and special studies. We recommend that it not be abstracted or cited.

SH
11
.A2
S662
no.
92-21
c.2

LJ-92-21

# MINUTES FROM A WORKSHOP ON STATUS OF PORPOISE STOCKS IN THE EASTERN TROPICAL PACIFIC, WITH SPECIAL EMPHASIS ON THE PERIOD 1985-1990.

June 15, 1992

D. P. DeMaster and J. E. Sisson

National Marine Fisheries Service
Southwest Fisheries Science Center
P.O. Box 271
La Jolla, CA 92038

**CONTENTS**

SH
11
.A2
5662
no. 92-21
c.2

LIBRARY
AUG 19 2004
National Oceanic &
Atmospheric Administration
U.S. Dept. of Commerce

# MINUTES FROM A WORKSHOP ON STATUS OF PORPOISE STOCKS IN THE EASTERN TROPICAL PACIFIC, WITH SPECIAL EMPHASIS ON THE PERIOD 1985-1990.

## INTRODUCTION

A workshop to review the status of dolphin stocks in the eastern tropical Pacific (ETP) was held at the Southwest Fisheries Science Center (SWFSC), La Jolla, CA from 18-22 November 1991. The agenda, list of participants, list of papers to review, background documents, and abstracts for each of the working documents are provided in Appendices 1, 2, 3, 4, and 5, respectively. The meeting was chaired by Douglas DeMaster, SWFSC.

The first workshop on stock assessment of ETP dolphins was held in July 1976 (SWFC Staff 1976). A second workshop was held in August 1979 (Smith 1979). These workshops were scheduled so that findings would be available to Congress during the hearings that preceded the re-authorization of the Marine Mammal Protection Act (MMPA). A series of preliminary workshops were held prior to the re-authorization of the MMPA in 1984. However, a final workshop assessing the status of ETP dolphins was never held, because the Congress extended the general permit to the American Tunaboat Association indefinitely. The amendments to the MMPA in 1984, among other things, required the National Marine Fisheries Service (hereafter referred to as the Service) to undertake a 5-year research program to monitor trends in the abundance of dolphin stocks that are used by the purse seine tuna fleet to locate tunas in the ETP. The results of this research program plus a number of recommendations obtained during a series of international meetings to review progress in reducing dolphin mortality are to be presented to Congress in early 1992 as part of the next cycle of reauthorization activities for the MMPA.

## REVIEW OF WORKING PAPERS

### SOPS 19. Gerrodette, T. <u>Calibration of shipboard estimates of dolphin school size from aerial photographs</u>.

Gerrodette summarized the paper for the panel. The purpose of the paper was to evaluate the utility of calibrating school size estimates obtained from observers on research vessels with school size estimates determined from aerial photography. Accurate counts of 171 dolphin schools based on high-quality aerial photographs were compared with shipboard observer estimates. The performance of various calibration schemes was assessed using a cross-validation approach. Thirteen of the 23 observers had school size estimates that were not significantly improved by calibration, while estimates of school size for 10 observers were improved by calibration against schools of known size. Overall, dolphin school size estimates made by observers on research vessels were unbiased, although there was considerable variability in the estimates. On average, observers underestimated school size in the calibrated sample by approximately 10%.

Chapman inquired whether observers were better at estimating small or large schools. Gerrodette responded that in log-log space, the relationship of school size estimated by observers against school size from aerial photographs over all observers and all stocks was approximately linear. Hall asked whether the photographed schools covered a representative sample of school sizes from all stocks. Gerrodette responded that only those schools where the entire school was photographed and where the clarity of the image was high were used in the calibration study. Therefore, very large schools were likely under-represented. Perryman added that spinner and spotted dolphins travel in schools that are consolidated relative to schools of striped dolphin, which makes it easier to photograph whole schools. Salomons asked if good photographs were available for all sea states. Gerrodette noted that most of the photographs were taken in Beaufort states 1 through 3. Gilpatrick added that some photographs used in the calibration study were from Beaufort state 4.

Scott noted that aerial photographs were not necessarily a valid "ground truth" and recommended that additional studies be undertaken using schools photographed and subsequently captured in purse-seine nets. Hobbs asked whether round off-error was a problem in school size estimation. Gerrodette responded that the level of error introduced by such an effect would be negligible relative to other sources of error. Hall asked if the performance of ex-tuna vessel observers was different from that of other observers, and if it could be provided to the IATTC. Gerrodette agreed to provide these data to Hall. In general, the panel concluded that a calibration factor that could be applied to school size estimates made by a "naive" observer would be useful. Such an analysis might use regression techniques, using independent variables, such as past experience, estimation methods, and school size.

Buckland raised the issue of whether it would be useful to train observers on how to estimate school size based on the results of the calibration analysis. He noted that it should be possible to identify "good" observers and, using them as models, teach other observers to estimate abundance. Such an approach could reduce the variance of school size estimates. Burnham commented that he recommended continuing with independent observer estimates of school size, but that training programs for observers on how to improve the quality of school size estimates, should be developed. Such a program might involve field trials prior to the initiation of field studies in a particular year. It was noted that calibration of observer's estimates of school size was useful in that it would reduce bias, but that calibration alone would not reduce the variance of school size estimates.

In general, the panel thought the calibration approach proposed by Gerrodette (i.e., using individual calibrations as opposed to calibrations averaged over all observers) was a good one and should be applied to the research vessel sightings. Questions were raised as how to calibrate observers in 1986, when aerial photographs were not available. The panel recommended using the average observer calibration for uncalibrated observers and observer-specific calibrations for observers who returned in subsequent years. Anganuzzi recommended incorporating the additional variability introduced by the school size calibration into the analysis of research vessel sighting data. Hall recommended that the consistency in observer-specific biases should be mentioned and the evaluation of individual observer estimates over time should be studied. Scott noted that he had heard reports that some of the observers may have intentionally overestimated school size in 1987 because of the initiation of the calibration procedures. Gerrodette responded that this may have been true for a small number of observers, but was not a general problem. Alverson asked if a vessel-calibration experiment had been undertaken. Gerrodette responded that such an experiment had not been performed and would be difficult, unless additional vessel time were made available.

**SOPS 7. Palka, D. <u>Accounting for school size bias using a bivariate hazard rate detection function in line transect surveys of dolphins from the ETP</u>.**

Palka reviewed this paper for the panel. The purpose of the paper was to evaluate various methods for incorporating the influence of school size on school detectability into the line-transect analysis methods used to analyze marine mammal sightings data from research vessels. A bivariate hazard rate model was applied to the 1986 to 1990 survey data for northern offshore spotted dolphin and southern striped dolphin. The results indicated that school size does influence detectability of northern offshore spotted dolphins, but not of southern striped dolphins. For the northern offshore spotted dolphin, incorporating the bivariate method reduced the abundance estimates by 10-30% due mostly to reductions in estimated school size.

Burnham commented that the bivariate approach was generally accepted in the line transect literature, but he recommended that Palka take a more theoretical approach in applying bivariate methods to these data. Burnham agreed to discuss the specifics of this recommendation directly with Palka. Alverson asked if the issue of whether bird cues were used to detect schools at a distance was incorporated into the analysis. The panel concluded that in general, the presence or absence of bird cues should not bias the bivariate analysis. Hall noted that if a correlation exists between the size of dolphin schools and the size of bird flocks that are associated, and if larger bird flocks are more detectable than smaller bird flocks, then not stratifying the analysis by flock size could bias the estimate of dolphin school size. Anganuzzi asked whether the sightings data had been truncated by distance. Palka responded that the same truncation rules employed by Wade and Gerrodette (see SOPS 1) were used.

Burnham noted that various weighting or stratification methods could also be used to adjust for bias in estimating school size due to the increased detectability of large schools, but that he was not sure which method would perform best. Palka commented that she had performed a series of simulations comparing univariate, bivariate, and stratified methods to correct for bias in school size and found that stratification methods performed the worst. Burnham noted that it would be a better test if the univariate approach, incorporating independent methods to account for bias in school size, were compared to the bivariate method. Buckland recommended considering a regression approach that used the log of school size versus detectability at distance.

Scott raised the issue that school size changes as a function of time of day. The panel came to no consensus as to how this would affect estimates of abundance based on research vessel surveys. Hall noted that research is needed, perhaps using simulation techniques, to assess if diel cycles in herd size, (and/or seasonal changes) can affect the estimates (e.g., in view of Palka's results). The studies by Scott show that herd size increases during the morning, presumably as a result of groups merging. This creates a situation where in one part of the day (i.e., morning) there are many small herds of dolphins, and relatively fewer, larger herds at other times (i.e., noon and afternoon). Buckland commented that regression approaches to this problem should be considered, but that these methods were currently under development.

Buckland noted that one solution to the bias problem in estimating school size was to eliminate schools from the estimation of school size that were beyond a distance where the detection probability was near unity. This distance would be selected such that there would be no correlation between school size and distance from the trackline. Wade commented that he had considered this approach, but found that, at least for northern offshore spotted dolphins, there was a gradual increase in school size with distance from the track line.

**SOPS 1. Wade, P.R. and T. Gerrodette. <u>Monitoring trends in dolphin abundance in the ETP: Analysis of five years of data</u>.**

Wade reviewed the paper for the panel. This paper presents a major departure from prior analyses in the manner in which the sightings data were analyzed (see Sexton et al. 1992; and Wade and Gerrodette 1991a). Many of the changes incorporated into this report were in direct response to a series of reviews by the sub-committee on small cetaceans of the International Whaling Commission. In particular: 1) estimates of the effective strip width (i.e., 2/f(0)) were stock-specific, where sample sizes were adequate, (previous estimates of the effective strip width were pooled over all stocks); 2) stock-specific abundance estimates were based, where possible, on stock-specific estimates of density, and the area occupied by that stock (previous estimates were based on species specific density, prorated by area occupied by the stock); 3) dolphin schools of any size were included (previous estimates did not include sightings of schools including fewer than 15 dolphins), and school size estimates were not weighted (previous estimates of school size were based on weighted estimates); 4) unidentified dolphin schools were not included in the analysis; 5) schools sighted more than 7.4 km from the trackline were excluded from the analysis (previous estimates were based on a truncation point of 3.4 km); and 6) bootstrap variance estimates were based on the survey effort per year, and the number of iterations was increased from 100 to 200. The results of these changes were to reduce the susceptibility of estimates to bias and to increase the coefficient of variation.

Burnham commented that he considered the approach an improvement over previous analysis methods but noted that a specified strategy was needed to determine when pooling across stocks or years would improve precision with no measurable loss of accuracy. He recommended using an analysis of variance (ANOVA) approach to look for data elements that could be pooled, followed by an Akaike Information Criteria (AIC) approach to perform the trade-off analysis. The panel concluded that some pooling across species and stocks may be warranted, but that such pooling should be done only where species/stocks have similar sighting characteristics. Barlow commented that in comparing sighting by frequency histograms, a Kolmogorov-Smirnov goodness of fit test (KS) was likely to be more meaningful than a test that simply compares the effective width strip estimates. Buckland recommended using likelihood ratio tests for this application. He noted that the variance associated with encounter rates and school size could be estimated with relatively small samples but that the variance associated with the effective width strip estimates required a relatively large sample (e.g., greater than 80 sightings). Wade commented that he had plotted for each of the five years and nine stocks the CV versus the number of sightings. In general, the CV reached a minimum at approximately 80 sightings per year, but surprisingly did not diminish further with more sightings. A number of panel members recommended pooling several of the data elements over years. After discussion, the panel concluded that, while this might improve the accuracy of the abundance estimate, it might compromise the use of the data to detect trends in abundance over time. The panel agreed that pooling data elements over years was recommended where the estimate would be used as the average index of abundance between 1986 and 1990.

Burnham added that he thought the truncation point of 7.4km was too large. On that point, Buckland noted that the 3.4km truncation used originally by Holt and Sexton (see Holt and Sexton 1990) was too severe. Burnham suggested that a more objective procedure for truncation would be to truncate sightings at the distance where the estimated detection probability was 0.1 or 0.15.

Hall noted that after inspecting Table 4 he noticed an unusual degree of correspondence in the change in abundance from year-to-year among stocks. The table presents estimates for 5 years, and there are therefore, four interannual periods. In two of these four periods, the abundance of eight of the nine stocks changed in the same direction. In the 1986-1987 period, they increased in size; in the 1989-1990 period, they decreased in size. Some of these stocks are never targets of the fishery, while others are the target of a very small number of sets per year, so it is not clear why these estimates change together. The explanation probably lies in the methodology used rather than in real population changes. These correlations should be explained, because they may indicate problems with the estimation methods, designs, etc. Perrin noted that in general the stock-specific abundance estimates in 1990 were lower than those from other years. Possible reasons for this pattern were discussed, but no specific factor could be identified by the panel. Wade pointed out that the average sea state during the survey period increased from year 1 to year 5, as did the percent of survey effort accomplished in Beaufort 4 or greater. He added, however, that he had not investigated the possibility of there being any trends or patterns in the stock-specific the effective width strip estimates. Others noted that given the relative high mortality levels in 1986 and the moderate El Niño in 1987, some of the observed pattern could be explained by incorporating a lag in the time it would take for a population to respond to an adverse environmental influence.

Alverson commented that the differences in abundance estimates and the pattern of abundance estimates based on the previous approach (see Sexton et al. 1991; and Wade and Gerrodette 1992a) and the approach proposed by Wade and Gerrodette were considerable. Buckland noted that the previous approach was not designed to estimate absolute abundance, while the approach of Wade and Gerrodette reduced the bias in estimating absolute abundance. He added that the approach used by Sexton et al. (1992) to estimate stock abundance was very sensitive to interannual differences in the distribution of animals, while the approach used by Wade and

Gerrodette was not.

Anganuzzi asked whether the percentage of sightings where no best estimate of school size was made was significant. Wade responded that there were only a few such schools in the data base. Hall asked whether there had been a change in the proportion of unidentified schools. Wade responded that there did not seem to be a temporal trend in this percentage. He added that the average percentage of unidentified schools per year was approximately 3%.

The panel concluded that the abundance estimates should be corrected for bias caused by the way school size may interact with school detectability and school size estimation, as discussed in the review of SOPS 7. This would include separate corrections for individual observer differences, calibration with school size estimates made using aerial photographs, and for the non-constant probability of sighting a school as school size increases. It was further agreed that these abundance estimates could only be applied to the actual study area. Finally, Hall recommended that an analysis be performed to compare the year-to-year pattern in encounter rates, school size and the effective strip width estimate for each stock from sightings data made from tuna vessels and research vessels. One objective of this study would be to explain the covariation of the stock-specific elements in different years.

Burnham supported Hall's recommendation and noted that the product of the encounter rate and the effective strip width estimate were especially important, and it is this product that should be analyzed for patterns between years and stocks. Further, he added that an overall strategy to analyze line transect data should be the subject of an entire workshop. Recommendations from such a workshop concerning the best analysis methods of these data should be clearly articulated.

**SOPS 3. Reilly, S.B. and P.C. Fiedler.** **<u>Interannual variability in dolphin habitats in the ETP, 1986-1990</u>.**

Reilly summarized the paper for the panel. The objective of the analysis was to investigate habitat use by spotted, spinner, striped and common dolphins in the ETP during 1986-1990 using an eigenvector ordination technique called canonical correspondence analysis (CCA). CCA represents an improvement over principal components analysis because it allows for a high frequency of cells where no marine mammals were sighted (i.e., "zeros") and a unimodal non-linear relationship between marine mammal sightings and environmental data. Data were collected during annual research vessel cruises conducted from late July to early December. Environmental variables included in the analysis were surface temperature, salinity, sigma-t, chlorophyll, thermocline depth and thermocline thickness. The dominant axis in the species-environment relationship separated common dolphins from spotted and spinner dolphins, based on the common dolphin's association with cool upwelling modified water and the spotted/spinner dolphin's association with warm tropical water. The second axis separated whitebelly spinner dolphins from eastern spinner dolphins. Overall, the environmental data explained 15% of the variance in observed daily encounter rate. For individual school types this ranged from 36% for common dolphins to 6% for striped dolphins. Interannual variability was small but judged significant by a Monte Carlo randomization test. Fixed geographic effects were determined to be most important in explaining the distribution pattern of whitebelly spinner dolphins.

Wade noted that encounter rates tended to be less variable than the other parameters used in the line transect estimate of abundance. After some discussion, the panel recommended that the analysis should include information on school size. Hall asked why the Costa Rica Dome was not clearly differentiated from the surrounding environment, and why the area in which it occurs was included in different habitat types in different years. Reilly responded that this was in part due to the smoothing algorithm but in part represented real variability. Hobbs asked if Reilly had tested for the effects of transition zone (fronts) placement on distribution patterns. Reilly noted that the scale of transition zones was considerably smaller than the scale he could address, given the pattern of sightings and survey effort in the entire study area. Buckland asked whether remote imagery from satellites would contribute to the analysis. Reilly commented that this had been attempted, but problems with persistent cloud cover over the study area limited the use of this approach.

The panel concluded that the approach used by Reilly and Fiedler represented a significant improvement over previous attempts to correlate environmental patterns with the distribution of marine organisms. There was general agreement that the conclusions would be strengthened if the authors could incorporate school size information and the distinctiveness of northern and central common dolphin into the analysis.

**SOPS 4. Gerrodette, T., P.C. Fiedler, and S.B. Reilly. <u>Including habitat variability in line transect estimation of abundance and trends</u>.**

Gerrodette summarized the paper for the panel. The objective of the study was to evaluate several different approaches for standardizing indices of habitat quality for the purpose of adjusting the annual index of dolphin abundance, as determined by research vessel surveys. The habitat index best correlated with the abundance index was used in the adjustment process, weighted by the amount of variance explained in the canonical correspondence analysis. However, it was noted that an increase in habitat quality does not necessarily correspond to an increase in estimated abundance because of the variable degree to which the MOPS study area encompassed the entire distribution of a stock. Further, because of the relatively low amount of variability explained by the CCA (i.e., 6 to 36%, depending on the species), the adjusted index of abundance was similar, although less variable, than the unadjusted index of abundance.

Hall noted that one explanation for the lack of correlation between abundance and habitat quality could be related to the time it would take for a population to respond to environmental changes (i.e., changes in emigration, birth or death rates). He recommended that this approach be used on a much smaller scale and that environmental data be correlated separately with encounter rate, school size, and f(0). Gerrodette noted that he thought the small number of sightings might preclude this level of stratification. Fiedler re-iterated that this study intended to use changes in habitat quality to account for the interannual variability in dolphin population estimates.

Perrin asked how adjusting the abundance index for a stock like the eastern spinner dolphin would be interpreted, given the entire distribution of the stock was in the MOPS study area. Gerrodette responded that he would not expect adjustments for interannual variability in the environment to be necessary for such stocks. Hall disagreed and noted that as the pattern of distribution changed, so would the distribution of school size and encounter rates. These could cause changes in bias from year to year, even for stocks entirely distributed within the study area. Buckland noted that the environmental data could be used to integrate density contours between the track lines. Further, he noted that it would be useful if the collection of environmental data were extended beyond the study area. Gerrodette commented that because environmental data were collected from the vessel, they were generally limited to the study area, except where the vessels returned to port at the end of a leg of survey effort.

Pitman stated that a part of the variability in the distribution of common dolphins may be related to their association with fronts. These features would not be closely associated with any of the environmental parameters used in the analysis and further, would be of very small geographical scale.

The panel concluded that linear models should be developed that could be used to describe the surface of the relationship between several environmental parameters and data on encounter rates and school size. The panel recognized that the results of such an analysis might not significantly reduce the variability in the abundance index because of the problems associated with small scale features and the extent to which stocks are distributed outside the study area. Chapman commented that a much simpler analysis would be to post-stratify dolphin abundance estimates, based on environmental data. Perrin recommended that common dolphin abundance estimates be stratified by stock type.

**SOPS 8. Edwards, E. and P. Perkins. <u>Power to detect trends in dolphin abundance: estimates from tuna vessel observer data 1975-1989</u>.**

Edwards summarized the paper for the panel. The objective of the paper was to evaluate the utility of using weighted linear regression techniques to detect trends in abundance of dolphin stocks in the ETP. Abundance indices were derived from tuna vessel observer data (TVOD) collected between 1975 and 1989. The statistical power to detect trends over 5, 8 and 10 years for the eight stocks of ETP dolphins was generally low (i.e., 10-50%). Detectability of trends increased dramatically with the survey length. However, only for northern spotted dolphins and only for periods of 8-10 years were the results adequate for the purpose of management. For example, changes in abundance on the order of 5% per year over a 10 year period should be detectable, given the observed variability in TVOD. Whereas, linear trends on the order of 20% per year are required in order to be statistically detectable over a 5 year period.

Anganuzzi concurred with the assessment of Edwards and Perkins but suggested that the variance structure of TVOD does not in general fit the assumptions of a weighted linear regression. The panel concurred that this particular approach was not recommended for the purposes of detecting trends in dolphin abundance using TVOD. Burnham questioned whether a one-sided test would not have been more appropriate. Buckland commented that applied statisticians tended to recommend against one-sided tests, while Burnham noted that theoretical statisticians recommended against two-sided tests.

**SOPS 6. Anganuzzi, A.A., K.L. Cattanach, and S. Buckland. <u>Relative abundance of dolphins associated with tuna in the eastern tropical Pacific, estimated from preliminary tuna vessels sightings data for 1990.</u>**

Anganuzzi summarized the paper was summarized for the panel. Relative abundance estimates of three dolphin species in the ETP were estimated annually between 1976 and 1990 using TVOD. The abundance index was smoothed using a procedure based on running medians. Confidence intervals were obtained through a combination of resampling methodology and smoothing procedures. This approach is robust to the presence of outliers and non-linear trends in abundance, and incorporates appropriately the precision of each individual estimate of abundance.

Gerrodette commented that adjacent smoothed estimates could not be considered statistically independent and that such comparisons would be conservative. Buckland noted that the independence assumption would improve as separation between the years to be compared increased and that for periods over which there is adequate power to detect trends, the assumption of independence was reasonable.

Several panel members commented on the apparent increase in southern spotted dolphins in recent years. Buckland responded that he thought this pattern was the result of movements of animals from the northern area to the south. Edwards asked if all of the observed rates of increase that were statistically significant were biologically reasonable. Buckland responded that apart from souther offshore spotted dolphins, the few increases that were statistically significant were only marginally significant. Therefore, the confidence interval around these rates of change would include biologically acceptable rates of increase. Buckland added that they chose not to estimate rates of change over set time periods because of the arbitrary nature of this approach.

The panel concluded that there evidence exists for significant changes in the abundance level for the following stocks:

For the northern offshore spotted dolphin, there is evidence of a significant decline during the late 1970's with stability since the early 1980's;

For the southern offshore spotted dolphin, there is evidence of an apparent decline occurred during the mid 1980's followed by an increase during the last years, although the recent high estimates suggest that there is movement of the animals across the stock boundaries;

For the eastern spinner dolphin, the population appears stable, with the exception of a decline during the late 1970's;

The whitebelly spinner dolphin also exhibits a stable trend except for a possible increase during the late 1980's;

For the northern common dolphin, there is no evidence of any significant trend, but the precision of the estimates is low;

Central common dolphin seem to have been stable since the early 1980's after a significant decline in the late 1970's;

Information on the southern common dolphin stocks is limited, but suggests a decline in the late 1970's, and stability since.

DeMaster asked about the status of an analysis of the statistical power of this approach. Anganuzzi noted that a report summarizing the findings of such an analysis would be presented at the 1992 IWC Scientific Committee meeting. Hall noted that the degree to which stock-specific indices of abundance changed from year to year in the same direction was much less than observed for the research vessel data. The reasons for this difference were not apparent to the panel, but this was recognized as an important area of future research.

**SOPS 5. Fiedler, P.C. and S.B. Reilly. <u>Interannual variability in dolphin habitats and abundances estimated from tuna vessel sightings in the eastern tropical Pacific, 1975-1989</u>.**

Fiedler summarized the paper for the panel. The objective of the paper was to evaluate methods for using environmental data to reduce the bias in dolphin abundance estimates from TVOD. The analysis was based on results presented in SOPS 3. However, in this case only three environmental parameters were used because of the need to expand the environmental data base from the MOPS surveys to include the years 1975 through 1985. For spotted and eastern spinner dolphins, annual abundance estimates were significantly correlated with habitat quality, indicating that dolphins would migrate to high quality habitat beyond the MOPS study area.

Fiedler recommended that the approach proposed by Chapman for analyzing research vessel data, where sightings data would be post-stratified based on environmental data, be adopted for TVOD. Hall recommended that the environmental data should be used in a linear model to reduce the variability in school size and encounter rate from TVOD. The panel concurred with these recommendations.

**SOPS 2. Wade, P.R. <u>Estimation of historical population size of eastern spinner dolphins</u>.**

Wade summarized the paper for the panel. He noted that the primary objective of the analysis was to incorporate what was considered a better estimate of absolute abundance in the back-calculated estimate of historic abundance for the eastern spinner dolphin, holding all other parameters in the back-calculation model equal to those used by Smith (1983) and using the same back-calculation model as Smith. Wade noted that Smith used an abundance level of 293,000 animals in 1979, while recent survey results indicate the abundance level of eastern spinners between 1986 and 1990 was between 391,000 and 754,000. He added that the available information on trends in abundance for eastern spinner dolphins (see SOPS 6) indicates that this population has been relatively stable over the last 15 years. Therefore, it was unlikely that the population increased from 293,000 in 1979 to approximately 600,000 in 1988. Further, based on the more recent estimates of abundance it was likely that Smith underestimated the status of eastern spinner dolphins in 1979. That is, the ratio of N(current)/N(maximum) based on Smith's analysis was between 0.17

and 0.23, while in Wade's analysis it was between 0.18 and 0.73.

Hall questioned the merit of applying back-calculation models to this data set because of the 1) non-random manner in which information was collected in the 1960s and early 1970s, 2) uncertainty in kill-per-set (KPS) by year and the number of sets using backdown by year, 3) extremely low level of observer coverage during the 1960s, 4) changes in the size composition of the tuna fleet between 1959 and 1970, 5) changes in the spatial distribution of sets between 1959 and 1972, and 6) uncertainty in the species/stock composition of the kill. Finally, Hall questioned the validity of this approach because of its inability to incorporate information on the effects of other species (i.e., changes in the abundance level of other dolphin species, and complex ecological interactions resulting from changes in the abundance of other predators, such as non-target dolphin species, tunas and sharks). Hall recommended that the Service respond to questions that require back-calculated estimates of historical abundance by saying that they are of such a nature that sound scientific methods cannot be applied to these data. Many of the panel members considered it ill-advised to manage marine mammal populations relative to an estimate of historic abundance based solely on back-calculation techniques.

Anganuzzi noted that models that incorporated age structure effects were needed to account for lag times in the population response to changing removal levels. Buckland recommended that the parameter space of abundance estimates be changed to include the upper and lower 90 or 95% confidence interval for the research vessel survey data pooled over the 5-year period, rather than the high and low abundance estimates for the 5-year period.

Chapman questioned how the uncertainty in the mortality data between 1959 and 1972 were handled. Hall noted that there were only 4 trips between 1959 and 1970 where data on KPS were available, and that sampling coverage was certainly less than 0.1%, even if the non-representative data are included. Statistical simulations show that some ratio estimates produce a positive bias with 5% coverage (the lowest level studied), and that this bias almost disappears at about the 30% coverage level. There are strong indications that the bias increases non-linearly with lower coverage, but even after applying a bootstrap procedure and some corrected-for-bias formula, a sampling coverage rates 50 times higher than the one used in the back-calculations produce bias of up to 10%. Perrin commented, with regard to the representativeness of the sample, that most trips sampled in 1971 and 1972 were also on a voluntary basis, and so were not selected at random.

Wade responded that he used the kill rates reported in Smith (1983), which were similar to those reported in Lo and Smith (1986). He added that the kill rates reported in Lo and Smith were based on data collected during observed trips in 1971 and 1972 and likely underestimated the actual kill rate between 1959 and 1970. He concluded that he considered his analysis as nothing more than a first order approximation, and that status was very likely overestimated. That is, the ratio of current to historic abundance, based on this approach, likely produced estimates of status that were closer to unity than they actually were. He asked whether the Punsly report on the number of dolphin sets made between 1959 and 1970 (Punsly 1983) was generally accepted as being accurate. Hall recommended that Wade discuss that particular issue directly with Punsly. Anganuzzi noted that the mortality levels in Wahlen (1986) were considerably less than those reported by Smith (1983) for some years (e.g., 1973), and that these lower numbers better represented the actual number of removals. Hall commented that the underestimation inferred by Wade cannot be verified or quantified. For instance, fishing outside the CYRA did not start in earnest until 1970, therefore, the kill rates obtained in 1971-1972 may reflect fishing in an area that has traditionally shown higher kill rates than the inshore areas. On the other hand, the statistical bias towards overestimation is likely present for the whole period. Hall concluded that it is not possible to assess the relative weight of all the biases mentioned and that without these, the historical population level cannot be reliably determined. The panel concluded that, if this approach was pursued, Wade should use the kill levels reported in the more recent publications of Lo and Smith (1986) and Wahlen (1986).

Reilly recommended using a Bayesian approach in reporting the results of Wade's back-calculation analysis. In this way, the likelihood of a particular status value being "true," given the available data, is presented relative to the likelihood of all other possible values of population status. DeMaster noted that with this approach, if the level of uncertainty used in the analysis were as high as many of the panel members suspected, the resulting posterior distribution would be "uninformative" (i.e., all status values between 0.1 and 1.0 would be equally likely). However, he noted that this conclusion from a management perspective would be informative because a Bayesian approach would evaluate the robustness of Wade's analysis.

DeMaster commented that for the purposes of responding to a petition to list eastern spinner dolphins as depleted under the MMPA, alternative approaches to the back-calculation methods reported in Wade's report could be used. For example, if the population trend for eastern spinner dolphins reported in SOPS 6 showed a 40% decline or greater over the 15-year time period, the population could be considered depleted. Also, the status determination based on an Administrative Law Judge's findings (Appendix 6) could be used as the starting point for the status of the eastern spinner dolphin population and the TVOD trends reported in SOPS 6 could be applied.

Deriso and Anganuzzi tabled a paper (Appendix 7) that provided an independent back-calculation model which they concluded was very sensitive to assumptions concerning birth and death rates as well as the structure of the model. Their analysis relies on the assumption that the population was in equilibrium with the average kill rate between 1986 and 1990. The results are sensitive to the assumptions concerning the maximum rate of increase of the population. In their analysis, if a population harvested at the 0.025 level is stable and if the MNPL of this population occurs at 65% of carrying capacity, the population must be depleted whenever the maximum rate of increase is less than 3% per year. The panel concluded that this approach had merit because it does not require information on historical levels of kill to assess status. The panel noted that the conclusions were very sensitive to the ratio of kill to population size and that the range of maximum rates of increase for most delphinid stocks was thought to be between 2% and 6% per year. Buckland noted that he would be unwilling to use a window as small as 5 years (or smaller) to assess the stability of the eastern spinner dolphin population, based on the approach reported on in SOPS 6. He added that concluding this population was stable over a 15-year period might be more secure.

Salomons recommended another approach, where the back-calculation model would only be run back to 1972 or so (a time period where kill levels are relatively well known). Again, in such an analysis, if the status of a population relative to 1972 was less than 0.6, it should be considered depleted.

Palka recommended that several of the IWC assessment models (e.g., Hitter-Fitter) be applied to this data set. Reilly noted that one could use the TVOD series to "fit" the model and the most recent population estimates as targets for the model to "hit," but that this approach would not rectify the problem of inadequate mortality data between 1959 and 1972. Anganuzzi commented that he and Deriso had explored this approach and the results were not encouraging.

The panel concluded that the reliability of estimates of historical abundance based on back-calculated historical abundance are unreliable and recommended that, where possible, other methods be used to make status determinations. If other methods can not be developed, the following analyses were recommended: 1) the Lo and Smith (1986) and Wahlen (1986) mortality figures should be used preferentially to those in Smith (1979 and 1983), 2) separate simulations using the Administrative Law Judge findings for 1979 (Appendix 6) and the more recent kill and population data should be conducted, 3) the range of population estimates for 1988 should be based on average abundance from research vessel data (1986-1990) and 90% confidence intervals around this average, 4) age-structured models should be used to evaluate the potential effects of age and sex selectivity in the kill, and 5) Bayesian-like models should be explored for potential use to allow researchers and managers the opportunity to evaluate the robustness of any conclusions.

**SOPS 10. Chivers, S.J. and A.C. Myrick, Jr. Comparison of age at sexual maturity for two stocks of offshore spotted dolphins subjected to different rates of exploitation.**

Chivers introduced the paper for the panel. The objective of the analysis was to determine whether the age of sexual maturity (ASM) and associated reproductive parameters had changed in a manner consistent with our current understanding of the status of northern and southern offshore spotted dolphin populations. Decreasing trends in ASM and increasing trends in pregnancy rates were predicted for both stocks. Additionally, the ASM for the northern stock was predicted to be less than the ASM for the southern stock, because the northern stock is thought to be depleted. To reduce bias caused by the spatial progression of the fleet to the west and south, the sample of specimen material from the north included only those animals collected north of 1°S and west of 120°W. No significant trends over time were detected for any of the reproductive parameters. The relative mean parameter estimates were contrary to our expectation. For example, the ASM of the northern stock was 11.12 yr (SE=0.23), while for the southern stock it was 9.78 yr (SE=0.26). The observed results indicate that the populations are not responding as predicted to increases in the per-capita availability of resources. This may be because of 1) intrinsic stock differences in vital rates, 2) non-linear relationships between density and net production (i.e., level of maximum net productivity already passed in both stocks), 3) increased stress caused by the fishery, or 4) changes in carrying capacity.

Hall suggested that one explanation for the observed differences in life history parameters may be related to the movement patterns of transient and resident schools. In particular, if younger animals tended to be more transient and if transients tended to move from the southern area to the western area, patterns in reproductive performance would be difficult to detect. Hall commented that the information on the movement patterns and social structure of these animals was necessary to interpret these results. Dizon commented that another confounding factor was the possible increase in stress to the dolphin stocks caused by repeated captures throughout the year. Myrick added that he expected to complete a study on stress by next spring. Edwards commented that the number of times a dolphin is set on depends on the degree to which animals remain with a particular school. She noted that because the tuna fleet tends to set on large schools, if these large schools represent a coherent and permanent social group, the animals in these schools would be set on at a much higher rate than animals typically associated with smaller schools. Alverson pointed out that tagging studies had shown that some animals tagged together in the same school were found in different schools the next day. Again, the lack of information on movement patterns and social structure was noted as a problem.

Hall recommended that the most recent stock structure recommendations (see SOPS 9) be followed in stratifying the analysis. Reilly commented that the habitat quality data from the MOPS cruises could be used to examine annual changes in possible movement patterns of animals. Alverson added that the cool water currents that likely serve as barriers to movements between the northern and southern regions are not constant over time and that perhaps movements of animals between regions could be predicted based on environmental data.

Scott questioned whether some of the observed differences in ASM could be due to between-reader variability. Chivers responded that Myrick had read all of the teeth used in this study. In addition, because specimens were aged by a "blind," procedure over a relatively short period of time, within-reader variability should not be a problem. Finally, Chivers noted that she had compared the age distribution from this study with those from Myrick's earlier work (see Hohn and Myrick, 1986) and found no differences.

Most of the panel concluded that the lack of trend in reproductive parameters for the northern animals was consistent with the population being depleted to a level where density dependent responses would not occur. However, the difference in ASM between the two stocks (with the ASM of the northern stock being greater than the ASM of the southern stock) and the lack of trend for the southern stock are unexplainable at this time.

**SOPS 13. Bright, A.M. and S.J. Chivers. <u>Post-natal growth rates: a comparison of northern and southern stocks of the offshore spotted dolphin</u>.**

Chivers introduced this paper to the panel. The objective of the study was to determine whether the growth rates of northern and southern offshore spotted dolphins had responded in a manner consistent with the prediction that per-capita availability of resources had increased for these two stocks over the last 20 years. To reduce bias caused by the spatial progression of the fleet to the west and south, the sample of specimen material from the north included only those animals collected north of 1°S and west of 120°W. Two measures were tested: the average growth rate from birth to age one, and the average size at ages one and two. No statistically significant differences were found in either measure between the two stocks or, for the northern stock, between time periods. However, the length at birth of the northern animals was significantly less than it was for southern animals, while the length at sexual maturity was significantly greater for northern animals than for southern animals. This statistical discrepancy is biologically anomalous.

Anganuzzi noted that there was a pattern to the residuals from fitting the growth model to the observed lengths. He recommended that perhaps a logistic model would produce a better fit.

Scott asked about the significance of the 150cm cut off in length for including animals in the analysis. Chivers stated that because of the secondary increase in growth rates for animals over 150cm, it was necessary to truncate at 150cm. Buckland noted that this procedure could introduce bias unless the truncation point was incorporated into the way the model was fit to the data. Buckland added that one solution would be to truncate at a certain age (in this case, age 2), because this would include animals of all lengths in age class 2. The panel concurred with this recommendation.

Hobbs asked if there was an adequate sample of weights to use in this analysis. Chivers responded that, currently the sample size of weight data was inadequate.

Hall questioned whether the movement of animals from the south to the west or vice versa could have biased the analysis, if these transients were selectively taken at a higher (or lower) rate. Chivers responded that there were no data to address this issue. Perrin commented that the pattern of reduced length at birth, but increased length at maturity, for the northern stock relative to the southern stock was very unusual. DeMaster questioned if information on length, maturity, etc. were being collected by observers on foreign vessels. Scott responded that at present only stomachs were being collected. The panel recommended that, if possible, additional information and specimen material be collected by the foreign observers.

Reilly asked why ages were read to 0.25 yr. Chivers responded that Bright believed that readings to 0.25 yr were consistent, but that a finer scale of aging would not produce reliable results. She added that based on a series of "independent" readings, 90% of Bright's estimated ages were within 0.25 yr of each other. Scott recommended that a marked photograph of an "aged" tooth be added to the paper. Chivers responded that given the comparative nature of the analysis and the high degree of consistency with which the teeth were read, including photographs in the report seemed unnecessary.

Buckland noted that the sample unit for the bootstrapped estimates of variance should be individual schools (or sets) and not individual animals. The panel agreed with this recommended change in estimating the variance of the life history parameters.

Most of the panel concurred with the conclusions of the authors that the lack of a temporal difference in growth rates for the northern stock was likely caused by the lack of available specimen material from the early 1960's. The lack of differences in growth rates between animals from the western and southern portion of their range is consistent with the proposed changes in stock structure (see SOPS 9), although the significant difference in length at birth is not.

**SOPS 11. Chivers, S.J. and D.P. DeMaster.** **Potential biological indices evaluated for four species of eastern tropical Pacific dolphin.**

The paper was summarized by Chivers. The purpose of the paper was to evaluate the potential of using changes in life history parameters to infer changes in abundance of ETP dolphins, and to infer whether any observed declines in abundance were related to either the incidental take associated with the tuna fishery or to changes in the environment. The parameters investigated consisted of the proportion of mature females in the sample and the proportion of mature females in each of the following reproductive conditions: pregnant, lactating, resting, and simultaneously pregnant and lactating. Where populations were thought to have declined from near carrying capacity during the period of specimen collection, the following density dependent responses were predicted and tested for: 1) the proportion of mature females pregnant and simultaneously pregnant and lactating would be negatively correlated with abundance, and 2) the proportion of mature females lactating and resting would be positively correlated with abundance. Estimates of population size for only the southern offshore spotted dolphin and central stock of the common dolphin indicate a decline from near carrying capacity since 1974 to the present, and therefore, changes in life history parameters were predicted to occur on these stocks. Density dependent responses for the central stock of common dolphin were found as predicted. For the southern offshore stock of spotted dolphin, preliminary analysis of the life history data indicates that either this stock has increased towards carrying capacity between 1974 and 1990, the carrying capacity of the environment has decreased during this same time period, or the analysis is confounded by our inability to assess the precise stock structure (or all of the above).

Perrin commented that he thought this was a very important paper because the inferences concerning status were based on within-population differences in life history parameters over time and not between-population differences. Hall commented that the interpretation of the results would be confounded by the geographical progression of dolphin mortality in the ETP. Dizon noted that where Chivers tested for spatial patterns in life history parameters for northern spotted dolphins none were found.

Hall questioned how the negative trend in percent mature for northern spotted dolphins was to be interpreted. DeMaster responded that one possible explanation was that the selectivity of the kill could be causing the mature segment of the female population to decline faster than the immature segment of the population. He noted that the rate of change in percent mature over time was relatively small. Other explanations included 1) a lagged response to the reduction in mortality levels throughout the late 1970s and early 1980s and 2) an unexpected density dependent response. Hall proposed that an analysis of changes in the proportion of various color morphs for spotted dolphin in the kill sample would be informative in terms of understanding whether the change in the proportion of mature animals was caused by the selective removal of mature females. Perrin noted that an analysis of changes in color patterns would be confounded by possible density dependent changes in the growth rate of individuals. Perrin added that color patterns were likely determined by the size, not age, of the animal. The panel concluded that the final report should consider all of the above as possible explanations for changes in the proportion of mature females. Additional studies were recognized as being needed to resolve this issue.

Hall commented that many of the apparent trends in life history parameters were not significant. He recommended that the authors add a section in the discussion that reviews the implications of possible trends for each stock independent of other information on stock status.

Buckland noted that, while the test for trends was appropriate, some of the plotted trend lines in the figures seemed in error. Chivers responded that she would check all of the plots prior to finalizing the report. Burnham noted that because the regressions were weighted, some of the "best-fit" plots may appear in error but would actually be correct. Hall commented that in evaluating trends in life history parameters a weighted regression might not be appropriate, because "El Niño-type" years resulted in fewer samples being collected. Therefore, the life history data from these years would be weighted less than other years. Rather, a simple linear regression would weight the individual years equally. Buckland commented that if the underlying relationship was linear, the weighted regression was appropriate.

Hobbs asked whether all of the reproductive classes were taken with equal likelihood by the fishery. Chivers responded that previous work by Barlow indicated that the parameters used in this analysis were relatively insensitive to the number of animals killed in a particular set but that there appeared to be reproductive synchrony within a school. Perrin noted that other factors could bias the results like the length of the chase and the degree to which different stocks segregate by age and sex.

The panel concurred with the authors that the lack of trends in the life history parameters for the most part was due to the lack of life history data at the inception of the fishery. Only for the central stock of common dolphins were adequate samples collected and collections initiated when the population was near maximum levels. The fact that significant temporal trends in certain life history parameters were detected suggests that life history parameters can be used as an index of population change. However, the index will only be useful where the population has been reduced from near the carrying capacity or where the population has recovered to levels near the carrying capacity.

SOPS 12. DeMaster, D.P., E.F. Edwards, P.R. Wade, and J.E. Sisson. <u>Status of dolphin stocks in the ETP</u>.

The paper was summarized for the panel by DeMaster. The purpose of the paper was to provide a summary document of preliminary results concerning the status of dolphins in the ETP. A similar format to this paper will be used in the final report to Congress on the status of ETP dolphins incorporating comments and suggestions obtained from this panel. It was noted that in this report only three dolphin species were reviewed (spotted, spinner, and common dolphin). To date, there is no evidence of any significant trends (increases or decreases) in abundance for any of these three species over the last 5 years. However, declines in abundance have been detected over the last fifteen years.

Buckland commented that the stock concept used in this paper should incorporate the following points: 1) geographically defined management units are not necessarily biologically meaningful; 2) abundance can be estimated for a management unit, but trends in abundance must often be determined by pooling stocks that are thought to mix or overlap in distribution; and 3) where quota management is considered appropriate, quotas should be established for each management unit.

Hall recommended that scientific answers to the issues raised before the Administrative Law Judge (Appendix 6), should be included in the report to Congress. Anganuzzi recommended that the mortality figures from Lo and Smith (1986) and Wahlen (1986) should replace those in Table 1. Hall added that a series of footnotes should be added to Table 1 detailing problems in the mortality estimates. Chapman recommended that where no data on takes are available (i.e., coastal spotted dolphin), the column should be deleted from the table. Hobbs added Table 1 should specify when kill data are included in the "other" category or where the kill was thought to be zero. Perrin recommended that data on individual stocks of common dolphins should replace the pooled data in Table 6.

Hall recommended that the report state clearly that many of the results discussed at this workshop make it obvious that the boundaries of many of the stocks considered are outside the area studied by the MOPS surveys. Therefore, the resulting estimates of abundance are only relative estimates, or perhaps minimum estimates. He also noted that to redefine stocks, where adopted, would require a re-analysis of data on abundance and mortality.

Buckland noted that management of ETP dolphin stocks should be based on both the results of the trend analysis using tuna vessel observer data and the mortality level which is expressed as a percentage of population size using the data obtained during research vessel surveys. The former takes advantage of the long time series of tuna vessel observer data, while the latter can be used to prevent additional declines and to encourage depleted stocks to recover. The panel concurred with this recommendation.

**SOPS 15. Perrin, W.F., G.D. Schnell, D.J. Hough, J.W. Gilpatrick and J.V. Kashiwada.** Re-examination of geographical cranial variation in the pantropical spotted dolphin in the eastern Pacific.

Perrin and Schnell summarized the paper for the panel. Variation in skull morphology was assessed based on 26 morphometric measures and 4 tooth counts from a sample of 611 museum specimens. All characters except two upper tooth counts showed statistically significant geographic variation, while 21 of 30 characters exhibited significant sexual dimorphism. Northern offshore spotted dolphins from the eastern portion of their range were distinctive from animals from the southern offshore spotted dolphin stock. While, animals from the northwestern portion of this range were more similar to southern animals than they were to animals from the northeastern portion of their range. Present management units are inconsistent with the pattern of cranial variation; offshore spotted dolphin from west of 120°W probably should not be pooled with those to the east, as they show closer affinity with southern animals. Further, the boundary between the northern and southern management units should be moved from 1°S to 5°N.

Perrin noted that if the proposed changes were adopted, the resulting pattern of stock structure would be very similar to that of the spinner dolphin. In this case a core area exists in the northeastern portion of the ETP that contains animals with low genetic variability (eastern spinner dolphin) and elsewhere, in a circular band around this core area genetic variability is increased (whitebelly spinner dolphin). Schnell added that the pattern of cranial variability was such that genetic exchange between the two areas is likely restricted. Reilly asked about the importance of the similarities between animals from the areas near the Hawaiian Islands and the Galapagos. Schnell responded that this was most likely an artifact of small samples.

Salomon asked about the statement in the text concerning the designation of three management units (see page 15, par. 1). Perrin responded that life history data (e.g., age of sexual maturity, pregnancy rate, etc.) indicate restricted movements between the southern and western areas. DeMaster asked if any of the cranial data supported managing southern and western animals separately. Schnell responded that two examples in the text, the width of temporal fossa (Fig. 10a) and skull width at the parietals

(Fig. 11a), are consistent with the hypothesis that movements between the west and south are restricted, but emphasized that the main conclusion is that spotted dolphins in the eastern portion of the range should be managed separately from all other spotted dolphins in the ETP. Reilly noted that the northeastern portion of the ETP has long been recognized by biological oceanographers as being unique due to the high degree of endemism reported in this area for other organisms within the pelagic community. The panel agreed with Schnell's recommendation, but agreed to discuss this issue more thoroughly as part of the review of SOPS 9.

Hall raised the issue of whether the analysis was confounded by the sampling regime. Samples are not obtained at random, but in clusters from captured dolphin herds. The number of animals sampled in some areas is small, and they were obtained from an even smaller number of independent sampling units (herds), so any conclusions drawn from these samples should be treated with great caution. Further, Hall added that characterizing a geographic block based on that sample might misrepresent the character of the true population. However, Schnell responded that because of the similarity among adjacent blocks he did not consider this a serious problem. DeMaster recommended that resampling techniques be used to examine how sensitive the conclusions were to differences in variability within and between schools. The panel recommended that additional analyses concerning between and within school variability be performed.

Scott asked whether a disjunction in the distribution of spotted dolphins was still detectable in the sightings data and if this disjunction was reflected in the pattern of cranial variability. Schnell responded that the 5° blocks may be too large to address this question with adequate precision. Perrin added that the pattern of density reported in SOPS 3 was consistent with the pattern of cranial variation.

The panel concurred with the findings in SOPS 15 that spotted dolphins in the northeastern portion of the ETP should be managed separately from other spotted dolphins and that the boundary between these management units be moved to 5°N. In addition, the panel recommended further statistical analyses that examine the sensitivity of the findings to possible low within-school cranial variability, but high between-school variability.

**SOPS 16. Perryman, W.L. and M.S. Lynn.** <u>Identification of common dolphin stocks from aerial photographs</u>.

Perryman summarized the paper for the panel. The purpose of the study was to investigate the stock structure of common dolphins using an index of adult length to discriminate among stocks. These length distributions were generated by measuring the length of animals from aerial photographs taken for the original purpose of calibrating school size estimates of observers on research vessels. In addition, back-projected distributions of birth were examined for stock specific differences in the timing of reproduction. These analyses demonstrated significant differences between geographically adjacent forms in the timing of reproduction and adult length. Further, the pattern of length distributions as determined from aerial photographs was similar to the pattern of length distributions collected by observers on tuna vessels.

Perrin noted that the gestation period of common dolphins was approximately 10 months and asked whether the sampling period of the research vessel surveys (i.e., late July through early December) might bias the results of the back-projection. Perryman responded that he did not consider this a serious problem because of the extensive geographic coverage of the surveys and the ability to back-project date of birth from animals between 1 and 12 months of age.

DeMaster commented that the distribution of measured lengths from aerial photographs should be different from distribution of the measured lengths from observers on tuna vessels because one measurement was made from snout tip to trailing edge of the fluke, while the other measurement was from snout tip to the notch in the fluke. Perrin added that the distance from the notch in the fluke to the trailing edge of the fluke was approximately 2cm. Perryman responded that, while he was surprised by the close correspondence between the published standard lengths (i.e., snout tip to notch in fluke) and length measurements from aerial photographs, his purpose in initiating the study was to examine patterns in relative length and how these patterns related to current information on stock structure. He added that because the attitude (i.e., orientation and flexure) of animals in aerial photographs is difficult to assess, the measured lengths of animals from aerial photographs will be negatively biased. Additional calibration studies would be needed to convert these measures to absolute lengths. Taylor noted that the variance in length measurements of individual animals from photo-pass to photo-pass was a measure of the variance component contributed by the behavior of the animal. Scott added that the relative distance from notch tip to the trailing edge of the fluke was not constant with age and that different calibrations for different length classes would be needed to convert measured lengths from aerial photographs to estimates of "standard" length (i.e., to fluke notch).

Hall commented that the procedure to back-project dates of birth required the assumption that growth rates were constant throughout the first year of life and independent of sex. He recommended that these assumptions be discussed in the report and noted that the accuracy of estimated date of birth was acceptable on a coarse scale (i.e., seasonal), but likely not accurate to within days or weeks. Schnell recommended that the authors include information on the standard deviation of lengths in Table 4. Reilly noted that there were several sources of variability, including within-animal/within-reader, within-animal/between-passes, within-animal/between-readers, between-animals, etc., and suggested that a table presenting how variability was partitioned by source would be informative. The panel concurred with all of these recommendations.

**SOPS 14. Heyning, J.E. and W.F. Perrin.** **Re-examination of two forms of common dolphins (genus Delphinus) from the eastern North Pacific; evidence for two species.**

Perrin summarized the paper for the panel (Heyning was unable to attend the workshop due to illness). The objective of the study was to re-examine two forms of common dolphins (i.e., short-beaked and long-beaked forms) based on a morphological analysis of 318 specimens. Full adult color patterns were used to separate the two forms completely, as well as measurements of length and rostral length. Additional measures, such as vertebral and tooth counts, showed modal differences between the two forms. The short-beaked form appears synonymous with *Delphinus delphis*. The long-beaked form appears equivalent with the nominal species *Delphinus bairdii* Dall, 1873. The level of differences observed in this geographic region of sympatry are equal to or greater than those for some other full species of small oceanic dolphins. Even if species status is not afforded these two forms, they represent fully separate breeding populations and should be managed separately.

Scott asked how the stock structure of spotted dolphins compared with that of the two forms of common dolphins in the northern ETP. Perrin responded that the two forms of common dolphins were more distinct than the two forms of spotted dolphins reviewed in SOPS 15. He added that there was no intergradation for many of the characters for long-beaked and short-beaked common dolphins.

Perrin raised the point that these two forms of common dolphin were difficult to separate visually, whereas the less distinct split of eastern and whitebelly spinners were relatively easy to distinguish visually.

Dizon noted that it might be possible to develop a "dipstick" type test based on genetic or protein differences between the two forms, but it would require having tissue samples in hand.

Alverson asked if the two forms were ever observed together in the same school. Benson commented that several experienced dolphin observers recorded what they thought was a mixed school of long- and short-beaked common dolphins on the recent California Marine Mammal survey (CAMMS). Perrin noted that the report had not been confirmed, as of yet, and added that he thought such behavior was unlikely, although not impossible. Perryman commented that it would be possible for a research vessel or tuna vessel to push separate schools of the two forms together. Perrin replied that this might be possible as the two forms have been observed where they were separated by only a few miles.

Hall noted that the proportion of the long-beaked form in the northern area was likely to vary with water temperature and the range of this population extends as far north as Oregon in some years. He added that it would be useful if the MOPS study area and the CAMMS study area covered the entire range of this population, and recommended that, as possible, this gap in the area surveyed be eliminated in future surveys.

The panel concluded that the information necessary to manage these two forms as separate stocks should be collected and that the two forms should be managed separately. This would require tuna vessel observers to discriminate between the two forms in reporting kill. Further, survey information on how the proportion of each form changes with distance from shore and under different environmental regimes is needed for estimating the population size of each form. Finally, the panel recommended that additional tissue samples should be collected to allow for additional genetic studies to be performed on these two stocks. It was recognized that several Mexican researchers are interested in conducting research on this topic.

**SOPS 20. Dizon, A.E., P.E. Rosel, and J.E. Heyning. Molecular phylogeny of two forms of common dolphin.**

Dizon summarized the paper for the panel. The objective of the study was to evaluate the genetic distinctiveness of two morphologically distinct types of common dolphin, *Delphinus delphis*. Both forms inhabit coastal waters of California and the eastern tropical Pacific and are killed incidently during fishing operations. Initial results indicate that for the region of mitochondrial DNA (mtDNA) sequenced, the long-beaked form is genetically homogenous and distinct from the short-beaked form. The genetic differences between the two forms included fixed and frequency differences. A phylogeny based on maximum likelihood techniques was presented.

Perrin commented that the genetic findings were consistent with the currently accepted taxonomy of this species.

DeMaster asked if the results of the genetic analysis indicated any genetic differences between animals from the central and northern portion of the range of common dolphins in the ETP. Dizon responded that so far, they had not been able to reliably distinguish between the two groups, but that all of the samples have not yet been analyzed. He added that tissue samples from common dolphins originating from the Black Sea have been analyzed indicating that animals from this population seem to be more closely related to the short-beaked form in the ETP than the short-beaked form is to the long-beaked form. Hall noted that only one member of the panel (Schnell) was qualified to comment on the quality of the studies having to do with molecular biology and genetics.

Perrin noted that the range of the long-beaked form was entirely within the range of the short-beaked form. He recommended that because of the possible species-level differences, these two forms be managed as separate stocks. He also stated that observers should be able to identify adult animals to stock based on measured body length at least off of Baja California, but that schools where only juveniles were killed or where no animals were killed would be very difficult to identify to stock. Scott noted that the IATTC observer training program has instructed observers about the differences between these two stocks, while the NMFS training program has not in the past instructed observers about these differences. The panel recommended that the Service rectify this situation as soon as possible, especially in light of the on-going training program by NMFS of Mexican observers, and recommended that skin samples be collected in order to identify common dolphin schools of uncertain stock.

**SOPS 18. Perrin, W.F., P.A. Akin, and J.V. Kashiwada. Geographic variation in external morphology of the spinner dolphin in the eastern Pacific and implications for conservation.**

Perrin introduced the paper to the panel. This published report represents a summary of findings concerning the stock structure of spinner dolphins in the ETP. The recommended stock divisions have been changed from those originally suggested in Perrin et al. (1985). These changes are based on variation in color pattern, dorsal fin shape, and body length which all exhibit sharp north/south gradients centered at about 5-10°N latitude and east/west gradients at about 120-125°W longitude. A radial pattern of stock distribution has been suggested, where the eastern form occupies the northeastern portion of the ETP, while the whitebelly form occupies the region to the west and south of the habitat of the eastern form. The results of this morphological analysis indicate great variability within the currently defined northern and southern whitebelly management units which suggest that these two stocks should be pooled for management purposes.

Perrin commented that because of the limited overlap of the eastern and whitebelly form in the fishery, a geographic boundary could be established for the purposes of managing the take of the two forms. For example, such a zone, or management unit, bounded by 10°N and 125°W would include 84% of the schools identified in the field as "easterns" and only 5% of those identified as "whitebellies". Hall commented that it would also be possible to plot cumulative observed mortality over a period of years and use this plot to identify an area where 90%, 95%, or 99% of the mortality of eastern spinner dolphins has occurred. This area could be used to define the geographic boundaries for this stock.

The panel recommended that the IATTC prepare a summary of eastern spinner dolphin mortality by block and year. The decision to use a geographic approach in the management of eastern and whitebelly spinner dolphins, if implemented, should be based on a summary of the pattern of mortality over the last 5-10 years. There was general agreement that the sightings data indicate that the movement of eastern spinner dolphins outside of their core area is limited. When shifts do occur, the panel agreed that they were more likely to occur from east to west rather than from north to south. Scott commented that a geographic approach to delineating stocks would certainly make the observers job that much easier.

The panel agreed that the existing division into northern and southern whitebelly stocks should be discontinued.

**SOPS 17. Perryman, W.L. and M.S. Lynn. Length distributions of striped dolphins from aerial photographs: are stocks identifiable?**

Perryman summarized the paper for the panel. The objective of the study was to evaluate the degree to which animals from the northern and southern portion of the striped dolphin range could be separated by asymptotic length, based on vertical aerial photography. This study compared 18 schools of striped dolphins, and detected no significant differences in average length of adult animals. Analyses of back-projected dates of birth revealed a broad pulse in reproduction extending from late October through April, but sample sizes were inadequate to compare the timing of reproduction between the two areas. Finally, based on the observed distribution of lengths, the population seems to segregate into schools of different ages (or lengths). A similar pattern has been reported for striped dolphins in the western Pacific.

Perryman added that the average length of adults as determined from aerial photographs exceeded the average length of adults as determined by measuring animals incidentally killed in the purse seine fishery. He added that although sample sizes were small, the difference was not significant. However, he concluded that juvenile striped dolphins may be taken more frequently in the fishery and speculated that they may associate with tuna at a higher rate than adult sized striped dolphin.

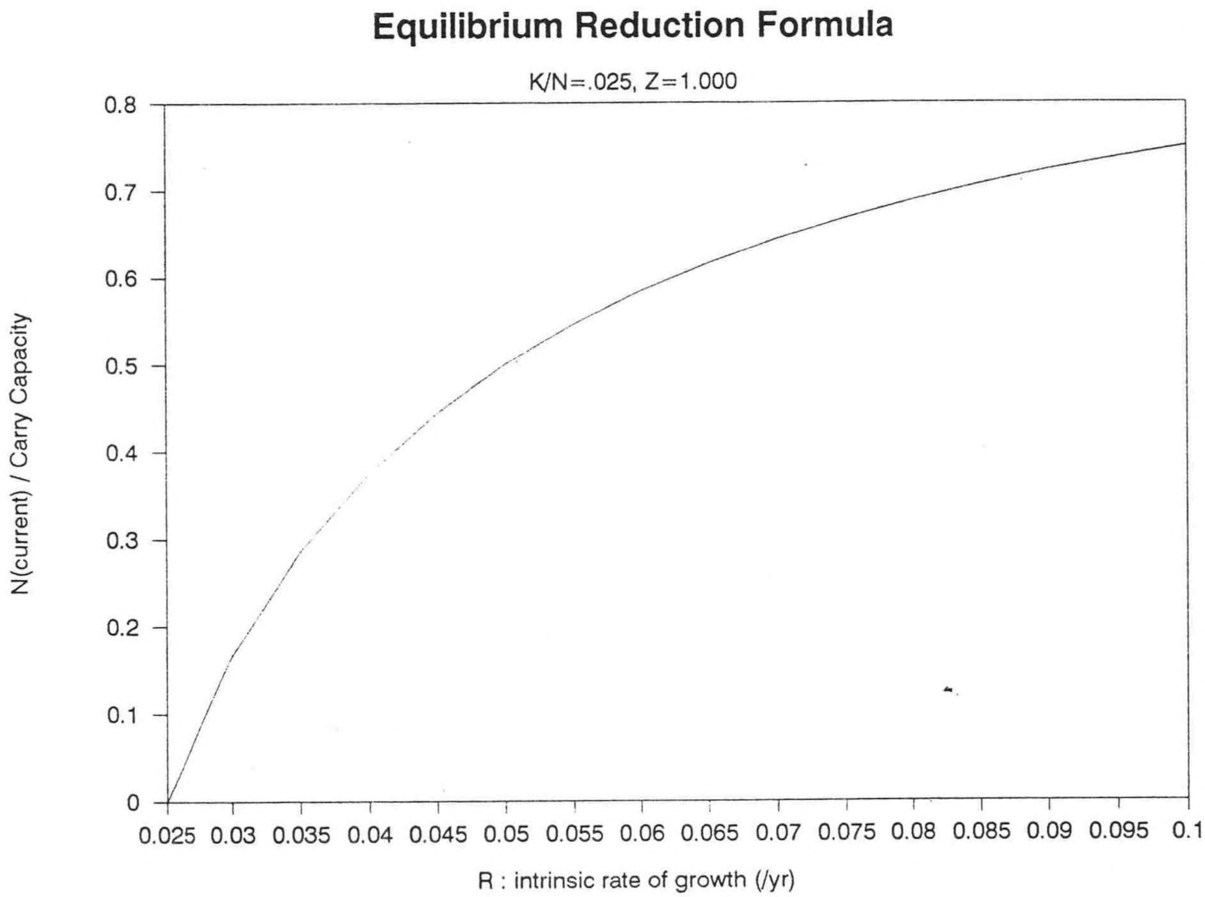
Perrin commented that initially striped dolphins had been separated into three stocks based on discontinuities in sightings. In 1983, based on additional sightings information, the recommendation to combine the southern and central stocks into a single stock was made. Based on the findings reported in this paper and additional sightings information, the basis for separating northern and southern animals into two stocks has disappeared and the species should be managed as a single stock in the ETP. The panel concurred that this species should be managed as a single stock. It was noted that the take of this species is at a level where the population effects of any mortality caused by the fishery are negligible.

**SOPS 9. Dizon, A.E., W.F. Perrin, and P.A. Akin. Stocks of dolphins in ETP: A phylogeographic classification.**

Dizon summarized the paper for the panel. The objective of the report was to update the summary of stock structure prepared by Perrin et al. (1985). A major difference in this review was the categorization of stocks into one of four phylogeographic classes as described by Dizon et al. (1992). It was pointed out that the report was completed prior to the completion of the studies on spotted and common dolphins. The final version of this report will include these recent findings. Three separate management units for spotted dolphins, following the recent work by Perrin, Schnell, and others, are proposed (coastal, northeastern, and western/southern). Four management units are proposed for spinner dolphins (Central American, eastern, whitebelly, and Hawaiian). Four management units are proposed for common dolphins (Baja neritic, northern, central, and southern), with a recommendation to further examine the relationship of animals collected off the central American coast to the central and Baja neritic stocks. Finally, a single management unit is recommended for the striped dolphin.

Reilly asked about the classification of southern and western offshore spotted dolphins. Dizon responded that he would classify this comparison as a IV a/b (i.e., category IV populations have extensive gene interchange and no subdivision by geographic barriers, the evidence for lumping into a single stock comes from distributional data and evidence for splitting into two stocks is from population parameters. Scott noted that several of the life history parameters were significantly different, which would support a classification of III (i.e., separate but with little genetic divergence). Perrin noted that the life history data were the most plastic of the phenotypic measures and that morphological measures were a more stable indicator of stock discreteness or mixing. Scott pointed out that mitochondrial DNA would not be a good indicator of stock status where matriarchal schools had high fidelity to local areas but males tended to be transient. Dizon responded that it was important in classifying stocks to use all of the measures that are available.

Alverson noted that the dolphin tagging studies in the ETP suggested long-distance movements from one side of the equator to the other and the gaps or discontinuities in life history or morphology data could often be accounted for by gaps in fishing effort. He added that there were many examples in the tuna



Equilibrium Reduction Formula
K/N=.025, Z=1.000
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
N(current) / Carry Capacity
0.025 0.03 0.035 0.04 0.045 0.05 0.055 0.06 0.065 0.07 0.075 0.08 0.085 0.09 0.095 0.1
R : intrinsic rate of growth (/yr)


F. 1(a)

literature where tagging studies had discredited existing stock definitions. Perrin responded that the length of adult tunas, which can continue growing throughout life, was more sensitive to environmental differences in different areas than was the length of adult dolphins, which do not continue to grow throughout life, and are, therefore, much less influenced by environmental features of the habitat. For that reason, differences in length and other morphometric measures tend to be genetically determined and expressed, in adults at least, with relatively little variability. This has been found to be true in mammals in general and dolphins in particular. Therefore, stock determinations that have been made for ETP dolphins based on morphological differences between stocks were likely to be more reliable than for fish.

Reilly asked if all of the spotted dolphin cranial measures were consistent with combining western and southern spotted dolphins into a single stock. Schnell responded that of the 30 measures reported, several did distinguish the two stocks, while most did not. Hall commented that the lack of information on social behavior and movement patterns of the different age and sex classes made interpreting the observed pattern of cranial variability in spotted dolphins difficult. He added that there are no permanent boundaries in the ETP and that certainly over time there is some exchange of animals between populations. However, the degree to which this results in genetic material being exchanged is unknown. Schnell noted that some genetic exchange is implied by the fact that we consider them a single species, but that the question is how much exchange occurs. Finally, Hall noted that the different pattern of exploitation in the western and southern portion of the ETP may in part explain the differences in life history data. Perrin agreed with Hall's assessment and added that more data would likely show the stock structure of spotted dolphins to be "radial," which is what was inferred for the stock structure of spinner dolphins. He noted that managing both northern and southern whitebelly spinner dolphin as one stock and southern and western offshore spotted dolphin as one stock was consistent. He concluded that combining the southern and western areas into a single management unit should be considered provisional until additional information on movement patterns and genetics was available.

Hall questioned the validity of managing coastal spotted dolphins as a separate stock. Perrin responded that he thought the previous recommendation to manage the coastal form as a separate stock was valid and noted that even though the coastal spotted dolphin and the offshore spotted dolphin overlap in distribution, making management difficult, the two forms are morphologically distinct. Fortunately, the level of take of the coastal stock is relatively low.

Hall asked Perrin about distinguishing between the Hawaiian spinner dolphin and the whitebelly spinner dolphin. Perrin noted that there was a clear break in the distribution of the two forms and that morphologically the two forms were distinct. Scott asked what classification would be given to eastern and whitebelly spinner dolphins. After some discussion, the panel agreed that a class III abcd/d classification was appropriate (i.e., separation with little genetic differentiation with evidence for lumping into one stock coming from information on distribution, population parameters, morphology and genetics, and evidence for splitting into two stocks coming from genetics). Hall noted that it was important to weight the different information categories because they were likely not of equal value in discriminating between stocks. Perrin responded that the weights would vary case by case. Rosel suggested that the most important information categories be denoted with capital letters in the classification scheme.

Concerning the stock structure of common dolphins, the panel concurred with the stock structure proposed by the authors. However, the classification of the Guerrero form was considered unreliable at this time due to the lack of information on the distribution of this form combined with the lack of life history material. At present the only way to classify the Guerrero form would be geographically. The panel agreed that such an approach was not necessary at this time, but the stock classification should be reviewed when additional specimen material is available. DeMaster pointed out that at present Guerrero-type animals were pooled with the central stock.

In general the panel agreed with the stock structures proposed by the authors. It was recommended that distribution plots for each stock be updated from those prepared for the 1984 status review.

**CONCLUDING COMMENTS**

Hall questioned the validity of the U.S. management practice of setting precise limits on the proportions of mortality for two stocks (i.e., eastern spinner and coastal spotted dolphins) for the non-U.S. fleet. He noted that 1) no consideration is given to the total level of mortality, and 2) this approach encourages non-U.S. fleets to increase the mortality of other stocks to reduce the percentage mortality of eastern and coastal spotted dolphins. The panel concurred that management of dolphin-fishery interactions should be based on quotas and not the species composition of the kill.

Salomons asked why the quota for the Costa Rican spinner dolphin was zero for the U.S. fleet. Perrin responded that this was likely due to the lack of population estimates in the late 1970's and early 1980's. Scott pointed out that the recent MOPS surveys estimated the Costa Rican spinner dolphin population to be something on the order of 15,000 to 20,000 animals. Gerrodette added that very few schools of Costa Rican spinner dolphins are seen in a given year during the MOPS cruises and that these estimates were made by Holt and Sexton (1986) by prorating the area occupied by Costa Rican spinner dolphins to the entire range of spinner dolphins. Therefore, these abundance estimates are likely unreliable for the purpose of establishing quotas.

The panel members concluded that a great deal of information on ETP dolphins had been collected, analyzed and reported on since the 1983 preliminary workshops. It was noted that the abundance of most of the stocks declined in the late 1970's, and after that period it has not changed significantly for almost a decade. The eastern spinner dolphin has remained unchanged for 15 years.

It was also noted that mortality levels had decreased dramatically from the 1986 level, and that the current mortality rates, based on 1990 and preliminary data from 1991, were likely sustainable for all of the stocks that are taken in the purse seine fishery for yellowfin tuna.

For at least one stock (the central stock of common dolphin), trends in life history parameters fit the expected density dependent pattern. This suggests that life history data can be used to infer trends in abundance and whether declines are associated with fishery-induced mortality or changes in the environment. It was further noted that, to be of use in making management decisions related to marine mammal-fishery interactions, the collection of life history data must be initiated at the onset of the fishery.

Panel members were in general agreement that assessments based on back-calculations would necessarily be confounded by a lack of statistically reliable mortality data in the 1960's and early 1970's and the unknown changes in the ecosystem caused by the removal of large numbers of dolphins and tuna. Where possible, the panel recommended using trends in abundance, information on mortality levels expressed as a percentage of abundance, or the absolute value of population size to assess status. Where back-calculations are determined to be necessary, back-calculations to 1972 should be performed separately from back-calculations to 1959. The panel suggested that many of the status determinations relative to 1972 abundance levels would be unambiguous without having to characterize the mortality of the fleet throughout the 1960's.

Concerning the proposed changes in stock divisions, the panel noted that abundance estimates, life history data, and distribution maps should be relatively easy to generate. It was concluded that this analysis should be completed for the northeastern spotted dolphin, the offshore spotted dolphin (i.e., western/southern stock), and long- and short-beaked common dolphins. Further, the panel recommended that, although assigning mortality levels on an annual basis to the new management units will be very difficult and time consuming, the task should be undertaken.

Appendix 1

## AGENDA FOR 1991 SOPS WORKSHOP

| | | |
|---|---|---|
| Monday | | |
| 1:00PM | 18 NOV 1991: | 1. SOPS 19 (Gerrodette) |
| | | 2. SOPS 7 (Palka) |
| | | 3. SOPS 1 (Wade and Gerrodette) |
| Tuesday | | |
| 8:30AM | 19 NOV 1991: | 4. SOPS 3 (Reilly and Fiedler) |
| | | 5. SOPS 4 (Gerrodette et al.) |
| | | 6. SOPS 8 (Edwards and Perkins) |
| 1:30PM | 19 NOV 1991: | 7. SOPS 6 (Anganuzzi et al.) |
| | | 8. SOPS 5 (Fiedler and Reilly) |
| | | 9. SOPS 2 (Wade) |
| Wednesday | | |
| 8:30AM | 20 NOV 1991: | 10. SOPS 10 (Chivers and Myrick) |
| | | 11. SOPS 13 (Bright and Chivers) |
| | | 12. SOPS 11 (Chivers and DeMaster) |
| 1:30PM | 20 NOV 1991: | 13. SOPS 12 (DeMaster et al.) |
| Thursday | | |
| 8:30AM | 21 NOV 1991: | Review of draft workshop report (11/18-20) |
| 1:30PM | 21 NOV 1991: | 14. SOPS 15 (Perrin et al.) |
| | | 15. SOPS 16 (Perryman) |
| | | 16. SOPS 14 (Heyning) |
| | | 17. SOPS 20 (Dizon et al.) |
| Friday | | |
| 8:30AM | 22 NOV 1991: | 18. SOPS 18 (Perrin et al.) |
| | | 19. SOPS 17 (Perryman and Lynn) |
| | | 20. SOPS 9 (Dizon et al.) |
| 1:30PM | 22 NOV 1991: | Review of draft workshop report (11/20-22) |

**Appendix 2**

**Status of Stocks Workshop 18-22 November 1991**
**Invitees, Participants and Observers**

Frank Alverson
Consultant
31472 Highway 395
Bonsall, CA 92003

Alejandro Anganuzzi
IATTC
P.O. Box 271
La Jolla, CA 92038

Richard Atchison
American Tunaboat Association
One Tuna Lane
San Diego, CA 92101-5896

Stephen Buckland
SASS Aberdeen Unit
Macaulay Land Use Research Institute
Craigiebuckler, Aberdeen AB9 2QJ
Scotland

Kenneth Burnham
Dept. Fisheries and Wildlife Biology
Wagar Bldg.
Colorado State University
Fort Collins, CO 80523

Douglas Chapman
Marine Mammal Commission
7106 San Bartolo
Carlsbad, CA 92008

Martin Hall
IATTC
P.O. Box 271
La Jolla, CA 92038

John Heyning
LA County Museum of Nat. Hist.
900 Exposition Blvd.
Los Angeles, CA 90007

Rod Hobbs
NMFS, NWAFC
7600 Sand Point Way, N.E., Bldg. 4
Seattle, WA 98115

Robert Hofman
Marine Mammal Commission
1825 Connecticut Ave.
N.W. Room 512
Washington DC 20009

Jeff Laake
National Ecology Research Center
4512 McMurray Ave.
Fort Collins, CO 80525-3400

Deborah Palka
NMFS, NEFC
Woods Hole, MA 02543

Patricia Rosel
Scripps Institution of Oceanography
P.O. Box 271
La Jolla, CA 92038

Gary Schnell
Oklahoma Biological Survey and Dept. of Zoology
University of Oklahoma
Norman, OK 73019

Gerry Scott
NMFS, SEFC
75 Virginia Beach Drive
Miami, Florida 33149-1099

Robert Salomons
Porpoise Rescue Foundation
P.O. Box 910271
San Diego, CA 92191

Steve Swartz
Marine Mammal Commission
1825 Connecticut Ave.
N.W. Room 512
Washington DC 20009

Barbara Taylor
NOAA Post Doctoral Research Fellow
P.O. Box 271
La Jolla, CA 92038

**NMFS Southwest Fisheries Science Center Participants and Observers:**

Izadore Barrett
Scott Benson
Susan Chivers
Douglas DeMaster
Andrew Dizon
Elizabeth Edwards
Paul Fiedler
Tim Gerrodette
James Gilpatrick
Jerry Kashiwada
Morgan Lynn
Albert Myrick
Peter Perkins
William Perrin
Wayne Perryman
Stephen Reilly
Joyce Sisson
Paul Wade
Robin Westlake

Appendix 3

**LIST OF DOCUMENTS FOR REVIEW**
**STATUS OF PORPOISE STOCKS (SOPS) WORKSHOP**
**18-22 NOVEMBER 1991, La Jolla, CA**

SOPS 1
Wade, P.R. and T. Gerrodette. 1991. Monitoring trends in dolphin abundance in the eastern tropical Pacific: analysis of five years of data. Reports of the International Whaling Commission SC/43/SM13.

SOPS 2
Wade, P.R. 1991. Estimation of historical population size of eastern spinner dolphins. NMFS SWFSC Administrative Report LJ-91-12.

SOPS 3
Reilly. S.B. and P.C. Fiedler. 1991. Interannual variability in dolphin habitats in the eastern tropical Pacific, 1986-1990. NMFS SWFSC Administrative Report LJ-91-42.

SOPS 4
Gerrodette, T., P.C. Fiedler and S.B. Reilly. 1991. Including habitat variability in line transect estimation of abundance and trends. NMFS SWFSC Administrative Report LJ-91- 37.

SOPS 5
Fiedler, P.C. and S.B. Reilly. 1991. Interannual variability in dolphin habitats and abundances estimated from tuna vessel sightings in the eastern tropical Pacific, 1975-1989. NMFS SWFSC Administrative Report LJ-91-35.

SOPS 6
Anganuzzi, A.A., K.L. Cattanach and S. Buckland. 1991. Relative abundance of dolphins associated with tuna in the eastern tropical Pacific, estimated from preliminary tuna vessel sightings data for 1990. Reports of the International Whaling Commission SC/43/SM14.

SOPS 7
Palka, D. 1991. Accounting for school bias size using a bivariate hazard rate detection function in line transect surveys of dolphins from the eastern tropical Pacific Ocean. NMFS SWFSC Administrative Report LJ-91-38.

SOPS 8
Edwards, E. and P. Perkins. 1991. Power to detect trends in dolphin abundance: estimates from tuna-vessel observer data 1975-1989. NMFS SWFSC Administrative Report LJ-91-34.

SOPS 9
Dizon, A.E., W.F. Perrin and P. Akin. 1991. Stocks of dolphins in the eastern tropical Pacific: a phylogeographic classification. NMFS SWFSC Administrative Report LJ-91-33.

SOPS 10
Chivers, S.J. and A.C. Myrick, Jr. 1991. Comparison of age at sexual maturity for two stocks of offshore spotted dolphins subjected to different rates of exploitation. NMFS SWFSC Administrative Report LJ-91-31.

SOPS 11
Chivers, S.J., and D.P. DeMaster. 1991. Potential biological indices evaluated for four species of eastern tropical Pacific dolphin. NMFS SWFSC Administrative Report LJ-91-29.

SOPS 12
DeMaster, D.P., E.F. Edwards, P. Wade, and J.E. Sisson. 1991. Status of dolphin stocks in the eastern tropical Pacific. D.R. McCullough and R.H. Barrett (Editors). Wildlife 2001: Populations. (in press).

SOPS 13
Bright , A.M. and S.J. Chivers. 1991. Post-natal growth rates: a comparison of northern and southern stocks of the offshore spotted dolphin. NMFS SWFSC Administrative Report LJ-91-30.

SOPS 14
Heyning, J.E. and W.F. Perrin. 1991. Re-examination of two forms of common dolphins (genus Delphinus) from the eastern North Pacific; evidence for two species. NMFS SWFSC Administrative Report LJ-91-28.

SOPS 15
Perrin, W.F., G.D. Schnell, D.J. Hough, J.W. Gilpatrick and J.V. Kashiwada. 1991. Re-examination of geographical cranial variation in the pantropical spotted dolphin, Stenella attenuata, in the eastern Pacific. NMFS SWFSC Administrative Report LJ-91-39.

SOPS 16
Perryman, W.L., A.E. Dizon and M.S. Lynn. 1991. Identification of common dolphin (Delphinus delphis) stocks from aerial photographs. NMFS SWFSC Administrative Report LJ-91-40.

SOPS 17
Perryman, W.L. and M.S. Lynn. 1991. Length distributions of striped dolphins from aerial photographs: are stocks identifiable? NMFS SWFSC Administrative Report LJ-91-41.

SOPS 18

Perrin, W.F., P.A. Akin, and J.V. Kashiwada. 1991. Geographic variation in external morphology of the spinner dolphin, Stenella longirostris, in the eastern Pacific and implications for conservation. Fishery Bulletin, U.S. 89(3):411-428.

SOPS 19

Gerrodette, T. 1991. Calibration of shipboard estimates of dolphin school size from aerial photographs. NMFS SWFSC Administrative Report LJ-91-36.

SOPS 20

Dizon, A.E. , P.E. Rosel and J.E. Heyning. Molecular Phylogeny of two forms of common dolphin. NMFS SWFSC Administrative Report LJ-91-32.

**BACKGROUND DOCUMENTS**

Alverson, F.G. 1980. Historical kills of porpoise by species/stock, 1959-1070. Statement at public hearings on proposed regulations governing the take of marine mammals incidental to commercial tuna fishing operations MMPAH #1980-1. Publication 80-3 Technical Bulletin Number 4, US TUNA Foundation, San Diego, CA.

Dizon, A.E., C. Lockyer, W.F. Perrin, D.P. DeMaster and J. Sisson. 1991. Rethinking the stock concept: a phylogeographic approach. Journal of Conservation Biology (in press), earlier version is US DOC NOAA NMFS SWFSC Administrative Report LJ-91-01, La Jolla, CA, USA.

Dizon, A.E., S.O. Southern and W.F. Perrin. 1991. Molecular analysis of mtDNA types in exploited population of spinner dolphins (Stenella longirostris). Reports of the International Whaling Commission (Special Issue 13):183-202.

Douglas, M.E., G.D. Schnell, and D.J. Hough. 1992. Geographic variation in cranial morphology of spinner dolphins in the eastern tropical Pacific Ocean. Fishery Bulletin (in press).

Gilpatrick, J.W., M.S. Lynn and R.L. Westlake. 1991. Image interpretation and reader variability in estimates of pelagic dolphin school sizes from vertical aerial photographs. US DOC NOAA NMFS SWFSC Administrative Report LJ-91-##, La Jolla, CA, USA.

Holt, R.S. and S.N. Sexton. 1989. Monitoring trends in dolphin abundance in the eastern tropical Pacific using research vessels over a long sampling period: analysis of 1986 data, the first year. Fishery Bulletin 88(1):105-111.

Holt, R.S., S.N. Sexton. 1992. Investigating parameters affecting relative estimates in dolphin abundance in the eastern tropical Pacific from research vessel surveys in 1986, 1987, and 1988. Report of the International Whaling Commission 42:(in press).

Lo, N.C.H. and T.D. Smith. 1986. Incidental mortality of dolphins in the eastern tropical Pacific, 1959-72. Fishery Bulletin 84(1):27-34.

Perrin, W.F. 1990. Subspecies of Stenella longirostris (Mammalia: Cetacea: Delphinidae). Proceedings of the Biological Society of Washington, 103:453-463.

Perrin, W.F., M.D. Scott, G.J. Walker, and V.L. Cass. 1985. Review of geographical stocks of tropical dolphins (Stenella spp. and Delphinus delphis) in the eastern Pacific. NOAA Technical Report NMFS 28.

Punsly, R.G. 1983. Estimation of the number of purse-seiner sets on tuna associated with dolphins in the easter Pacific Ocean during 1959-1980. Inter-American Tropical Tuna Commission Bulletin 18:229-299.

Smith, T.D. 1983. Changes in size of three dolphin (Stenella spp.) populations in the eastern tropical Pacific. Fishery Bulletin 81(1):1-13.

Smith, T.D. 1979. Report of the status of porpoise stocks workshop (August 27-31, 1979, La Jolla, California). US DOC NOAA NMFS SWFC Administrative Report LJ-79-41.

SWFSC Staff. 1976. Annual report of the workshop on stock assessment of porpoise involved in the eastern Pacific yellowfin tuna fishery. US DOC NOAA NMFS SWFC Administrative Report LJ-76-29, La Jolla, CA, USA.

Wade, P. and T. Gerrodette. 1992. Monitoring trends in dolphin abundance in the eastern tropical Pacific: analysis of five years of data. Report of the International Whaling Commission 42:(in press).

Appendix 5

# ABSTRACTS

## STATUS OF PORPOISE STOCKS (SOPS) WORKSHOP

**18-22 November 1991**
**La Jolla, California**

NOAA / National Marine Fisheries Service / Southwest Fisheries Science Center

# MONITORING TRENDS IN DOLPHIN ABUNDANCE IN THE EASTERN TROPICAL PACIFIC: ANALYSIS OF FIVE YEARS OF DATA

Paul R. Wade and Tim Gerrodette

Reports of the International Whaling Commission
SC/43/SM13

Large-scale research vessel surveys were conducted annually from 1986 through 1990 by the U.S. National Marine Fisheries Service to monitor the relative abundance of dolphin populations in the eastern tropical Pacific Ocean. The species of primary interest for the surveys were dolphin stocks taken incidentally by tuna purse seiners. A stratified analysis gave estimates of relative abundance of nine stocks of four species (spotted, spinner, striped, and common dolphins), using line transect methods, for all five years. No significant trends in population size were detected for any dolphin stock during 1986-90, although the statistical power of detecting a trend was low.

# ESTIMATION OF HISTORICAL POPULATION SIZE OF EASTERN SPINNER DOLPHINS

Paul R. Wade

Administrative Report LJ-91-12

An assessment of the status of the stock of eastern spinner dolphins (Stenella longirostris orientalis) in the eastern tropical Pacific is required by U. S. law under the Marine Mammal Protection Act, as they suffer mortality in the tuna purse-seine fishery that occurs in that region. Current estimates of abundance from research vessel surveys were used in combination with estimates of mortality from tuna vessel observer data to estimate the pre-exploitation or historical population size for the eastern spinner stock, using the back-calculation technique of Smith (1983). A range of values was used for the current population size, the maximum net recruitment rate (MNPL), z (the shape parameter that sets maximum net productivity level), and the number of animals killed relative to the estimated mortality. Relative population sizes (current population size divided by historical population size) ranged from 0.18 to 0.73. In most cases, relative population size was well below MNPL. Only 1 out of 42 parameter combinations resulted in a relative population size above MNPL. Using the best estimates for $R_m$, MNPL, and the level of mortality resulted in relative population sizes of 0.26 and 0.44 for the low and high current population estimates respectively, a range substantially below MNPL. These results indicate that the stock of eastern spinner dolphins is probably depleted.

# INTERANNUAL VARIABILITY IN DOLPHIN HABITATS IN THE EASTERN TROPICAL PACIFIC, 1986-1990

Stephen B. Reilly and Paul C. Fiedler

Administrative Report LJ-91-42

We used canonical correspondence analysis (CCA), an eigenvector ordination technique that includes direct gradient analysis, to investigate habitat use by spotted, spinner, striped and common dolphins in the eastern tropical Pacific during 1986 - 1990. Data were collected during annual research vessel cruises conducted in August - November of each year. Environmental variables included in the analyses were: surface temperature, salinity, sigma-t, and chlorophyll, thermocline depth and thickness. The dominant pattern in the species-environment relationship (1st canonical axis) separated common dolphins from spotted and spinner dolphins, based on their associations with cool upwelling habitat and warm tropical habitat, respectively. The second axis separated whitebelly spinners from eastern spinners. Both occurred in tropical water, but were separated primarily by thermocline topography. The species - environment correlations were 0.67 on the first axis, 0.42 on the second. Overall, the environmental data explained 15% of the variance in the species data. For individual school types this ranged from 36% for common dolphins to 6% for striped dolphins. Interannual variability in the species data was small, but judged significant by a Monte Carlo randomization test. Interannual variance was insignificant after removing variance associated with Comparison of age at sexual maturity for two stocks of offshore spotted dolphins subjected to different rates of exploitation environmental variables.

# INCLUDING HABITAT VARIABILITY IN LINE TRANSECT ESTIMATION OF ABUNDANCE AND TRENDS

Tim Gerrodette, Paul C. Fiedler and Stephen B. Reilly

Administrative Report LJ-91-37

Based on a canonical correspondence analysis of 5 years of research vessel surveys in the eastern tropical Pacific, habitat scores which index the quality of habitat for 3 species of tropical dolphins are computed. Three different indices of abundance based on interannual changes in habitat quality are derived from these habitat scores. The habitat index best correlated with an index of abundance based on line-transect analysis of sightings is used to adjust the line-transect estimates, weighting the adjustment by the amount of variance explained by the canonical correspondence analysis.

# INTERANNUAL VARIABILITY IN DOLPHIN HABITATS AND ABUNDANCES ESTIMATED FROM TUNA VESSEL SIGHTINGS IN THE EASTERN TROPICAL PACIFIC, 1975-1989

Paul C. Fiedler and Stephen B. Reilly

Administrative Report LJ-91-35

The results of a canonical correspondence analysis (CCA) of data from research vessel surveys of the eastern tropical Pacific, consisting of dolphin school sightings and concurrent environmental variables, were applied to time series of estimated dolphin abundances from tuna vessel sightings. Habitat quality was calculated from historical bathythermograph data using CCA ordination results. For spotted and eastern spinner dolphins, annual abundance estimates or interannual changes in those estimates are significantly correlated with habitat quality. This effect is at least partly due to expansion of high quality habitat beyond the geographic ranges assumed for the abundance estimate. We discuss ways that environmental data could be used to reduce error in dolphin abundance estimates.

# RELATIVE ABUNDANCE OF DOLPHINS ASSOCIATED WITH TUNA IN THE EASTERN TROPICAL PACIFIC, ESTIMATED FROM PRELIMINARY TUNA VESSEL SIGHTINGS DATA FOR 1990

A.A. Anganuzzi, K.L. Cattanach and S.T. Buckland

Reports of the International Whaling Commission
SC/43/SM14

The relative abundance of eastern tropical Pacific stocks of three dolphin species are estimated from preliminary tuna vessel data for 1990, using the methods described by Buckland and Anganuzzi (1988a). Anganuzzi and Buckland (1989), and Buckland, Cattanach and Anganuzzi (in prep.). For most stocks associated with the tuna fishery, there is no evidence of trends in population size in recent years, as assessed by five-year tests for trend. For the northern most stock of spotted dolphins, a significant negative trend is obtained, but the more powerful method of Buckland et al. (in prep.) fails to confirm this trend, suggesting it may be spurious.

# ACCOUNTING FOR SCHOOL BIAS SIZE USING A BIVARIATE HAZARD RATE DETECTION FUNCTION IN LINE TRANSECT SURVEYS OF DOLPHINS FROM THE EASTERN TROPICAL PACIFIC OCEAN

Debbie Palka

Administrative Report LJ-91-38

A traditional assumption of line transect theory is the probability of detecting an item is a function of only the perpendicular distance between that item and the transect line. However, in the case of schools of dolphins, it is possible the size of the school also influences the probability of detecting that school. This assumption is investigated by fitting the data to a bivariate hazard rate detection function which incorporates both perpendicular distance and school size.

The bivariate detection function reflects the effect of school size on the detectability by including another parameter "c". If c=0 then there is no school size effect. Because of this fact, it is possible to statistically test for school size bias. Also, by using this new parameter an adjusted mean school size and adjusted abundance estimate can be calculated.

The bivariate hazard rate model was applied to the 1986 to 1990 National Marine Fisheries Service line transect survey data from the Northern offshore spotted and Southern striped dolphins of the eastern tropical Pacific Ocean. The bivariate method yield abundance estimates that were lower than that resulting from the univariate hazard rate model. Also, it was shown the probability of detecting a Northern offshore spotted dolphin school is influenced by school size while the detectability of Southern striped dolphins is not influenced by school size.

**POWER TO DETECT TRENDS IN DOLPHIN ABUNDANCE: ESTIMATES FROM TUNA-VESSEL OBSERVER DATA 1975-1989.**

Elizabeth F. Edwards and Peter Perkins

Administrative Report LJ-91-34

Weighted linear regressions were calculated for 5, 8, and 10-year series of abundance indices for 8 stocks of eastern tropical Pacific (ETP) dolphins. Abundance indices were derived from tuna-vessel observer data (TVOD) collected 1975-1989. The statistical power of conclusions about the absence of trend was calculated for those series with statistically insignificant regressions ($P > 0.10$; 2-sided alternative). Detectable trend was then calculated for each series as a function of series length and estimated standard error of the estimated trend for each series. Estimates of power and detectable trend were derived using the non-central t distribution assuming Type I ($\alpha$) and Type II ($\beta$) error levels = 0.10.

Power estimates for the eight stocks of ETP dolphins for apparent rates of change between 0 and 100% per year were generally low (10-50%), even for 10-year series. Detectability of trends increased dramatically with increases in series length, but decreased to ecologically or managerially relevant levels (ca. 5% per year) only for northern spotted dolphins and only for series 8-10 years in length. For all other stocks, detectable trends were rarely less than 25% per year, regardless of series length.

Detecting relatively small linear trends in dolphin abundance using TVOD and standard weighted linear regression techniques is apparently not feasible except perhaps for northern spotted dolphins. More versatile, curvilinear smoothing methods may be more effective, although definitive conclusions await simulation testing.

# STOCKS OF DOLPHINS IN THE (STENELLA SPP. AND DELPHINUS DELPHIS) EASTERN TROPICAL PACIFIC: A PHYLOGEOGRAPHIC CLASSIFICATION

Andrew E. Dizon, William F. Perrin, and Priscilla A. Akin

Administrative Report LJ-91- 33

Current information is reviewed that provides clues to the intraspecific structure of dolphins incidently killed in the yellowfin tuna purse-seine fishery of the eastern tropical Pacific (ETP). Current law requires that management efforts are focused on the intraspecific level, attempting to preserve locally adapted genetic variation. Four species are reviewed: spotted (*Stenella attenuata*), spinner (*S. longirostris*), striped (*S. coeruleoalba*), and common (*Delphinus delphis*) dolphins. For each species, distributional, demographic, phenotypic, and genotypic data are summarized, and the putative stocks are categorized based on four hierarchal phylogeographic criteria relative to their probability of being evolutionarily significant units (ESUs).

For spotted dolphins, no changes in stock divisions or criteria from the current management practices are recommended; this may change, depending on the results of a study underway. For the striped dolphin, we find little reason to continue the present division into geographical stocks. For common dolphin, we strongly reiterate an earlier recommendation that the Baja neritic form and the northern offshore form be managed separately; recent morphological and genetic work may result in recognition of these as separate species. Finally, we note that the stock structure of the ETP spinners is a complex one with the whitebelly form exhibiting characteristics of a hybrid swarm between the eastern and pantropical subspecies. There is little morphological basis at present for division of the whitebelly spinner into northern and southern stocks. We recommend continued separate management of the pooled whitebelly forms, however, despite their hybrid/intergrade status. Steps should be taken to ensure that management practices do not reduce the abundance of eastern relative to whitebelly spinners; to do so may lead to increased invasion / replacement of the eastern genome or ranges.

SOPS10

# COMPARISON OF AGE AT SEXUAL MATURITY FOR TWO STOCKS OF OFFSHORE SPOTTED DOLPHINS SUBJECTED TO DIFFERENT RATES OF EXPLOITATION

Susan J. Chivers and Al C. Myrick, Jr.

Administrative Report LJ-91-31

We examined the average age at attainment of sexual maturity (ASM) and associated reproductive parameters for evidence of density compensatory responses in two recognized stocks of the spotted dolphin, *Stenella attenuata*. The northern and southern stocks were compared because they have both been reduced in abundance. Consequently, decreasing trends in ASM and increasing trends in pregnancy rate were predicted for each stock. A lower ASM and higher pregnancy rate were predicted for the northern stock because this stock is more depleted. No statistically significant temporal trends were detected, but the mean parameter estimates were contrary to our predictions and imply a lower reproductive rate for the northern stock. The ASM was significantly different between the stocks: 11.12 years (SE = 0.229) for the northern stock and 9.78 years (SE = 0.264) for southern stock. The pregnancy rates, though not significantly different, were 0.27 and 0.34 for the northern and southern stocks, respectively. The observed results suggest that the populations are not responding in a straightforward way to increases in per-capita availability of resources. Possible additional explanations may include (1) stock differences, (2) non-linear dynamics of population compensatory responses, (3) physiological stress, or (4) changes in carrying capacity.

# POTENTIAL BIOLOGICAL INDICES EVALUATED FOR FOUR SPECIES OF EASTERN TROPICAL PACIFIC DOLPHIN

Susan J. Chivers and Douglas P. DeMaster

Administrative Report LJ-91-29

We tested for correlation between several life history parameters with year and estimates of population abundance for four species of eastern tropical Pacific dolphin. The parameters we selected were the percentage of mature females and the percentage of mature females in each reproductive condition: pregnant, lactating, and simultaneously pregnant and lactating. Data collected between 1974 and 1990 on spotted, spinner, common and striped dolphins were used for the analyses. The life history data are collected from individual dead dolphins by observers placed aboard tuna purse-seine vessels by the National Marine Fisheries Service and the Inter-American Tropical Tuna Commission. If the sample sizes were large enough, we analyzed each species by stock.

# STATUS OF DOLPHIN STOCKS IN THE EASTERN TROPICAL PACIFIC

Douglas P. DeMaster, Elizabeth F. Edwards,
Paul Wade and Joyce E. Sisson

Wildlife 2001: Populations.
D.R. McCullough and R.H. Barrett (Editors).

Since the passage of the Marine Mammal Protection Act, approximately 1.6 million dolphins have been drowned incidentally during purse seine fishing operations for yellowfin tuna in the eastern tropical Pacific. The three species of pelagic dolphins primarily involved in this fisheries interaction are the spotted dolphin (Stenella attenuata), spinner dolphin (Stenella longirostris) and common dolphin (Delphinus delphis). We review the status of these species relative to stock structure, current population size, levels of fishery-related mortality and trends in abundance. Abundance estimates have been derived from two sources: data collected by observers on research vessels and data collected by observers on tuna vessels. Estimates of incidental mortality are currently derived only from data collected by observers on tuna vessels. There is no evidence of any significant trends (increases or decreases) in abundance for any of these three species in recent years. However, declines in abundance have been detected over the last fifteen years.

# POST-NATAL GROWTH RATES: A COMPARISON OF NORTHERN AND SOUTHERN STOCKS OF THE OFFSHORE SPOTTED DOLPHIN

Andrea M. Bright and Susan J. Chivers

Administrative Report LJ-91-30

Postnatal growth rates for the northern and southern stocks of spotted dolphin are compared for females under two hypotheses of population compensatory responses. We hypothesized (1) a trend of increased body growth rates between 1973 and 1989 in response to decreased population abundance and a presumed increase in per capita resources for each stock, and (2) a faster first year growth rate for calves from the northern stock relative to those from the southern stock because the northern stock has been reduced farther below carrying capacity than the southern stock. However, no statistically significant differences were found to support either hypothesis. A Laird-Gompertz growth model predicted length for one year olds as 122.8 cm for the northern stock and 124.3 cm for the southern stock. Two year olds were predicted to be 141.3 cm in length for the northern stock and 142.1 cm for the southern stock. The average length-at-birth was calculated as 83.1 cm for the northern stock and 86.4 cm for the

**RE-EXAMINATION OF TWO FORMS OF COMMON DOLPHINS (genus Delphinus) FROM THE EASTERN NORTH PACIFIC; EVIDENCE FOR TWO SPECIES.**

John E. Heyning and William F. Perrin

Administrative Report LJ-91-28

Two forms of common dolphins occur sympatrically in the Southern California Bight; a long-beaked form and a short-beaked form. We re-examined the two forms based on 318 specimens, including only full adults in morphometric analyses. Color pattern separates the two forms completely, as do total length and all measures of rostral length. Numerous additional features, such as vertebral count and tooth counts, show modal differences. The short-beaked form appears synonymous with Delphinus delphis. The long-beaked form is equivalent to the nominal species Delphinus bairdii, Dall, 1873, for which the type specimen has been lost. We propose a neotype for this species, although we note that this may represent a junior synonym. Many of the differences in color pattern between the two forms seem to hold for other ocean basins, with some variation. Other workers have also found short- and long-beaked forms in other regions. The levels of differences we see in this region of sympatry are equal to or greater than those for some other full species of small oceanic dolphins. Further work should resolve whether these differences are consistent over a wider geographic range and whether the designation of two or more full species of common dolphins is warranted. In any case, the two forms represent separate breeding populations and should be assessed and managed separately.

# RE-EXAMINATION OF GEOGRAPHICAL AND CRANIAL VARIATION IN THE PANTROPICAL SPOTTED DOLPHIN, STENELLA ATTENUATA, IN THE EASTERN PACIFIC

William F. Perrin, Gary D. Schnell, David J. Hough,
Jim W. Gilpatrick and Jerry V. Kashiwada

Administrative Report LJ-91-39

The spotted dolphin (Stenella attenuata) is found throughout much of the eastern tropical Pacific Ocean. A previous study evaluated morphological variation in skull morphology, but now specimens are available for a greater portion of the range. Also , corrections have been made in data and an assessment made of repeatability of character measurements. We reassessed geographic variation in 30 cranial features (26 morphometric measure and 4 tooth counts) based on 611 museum specimens. All characters except two tooth counts showed statistically significant geographic variation, while 21 of the 30 characters exhibited significant sexual dimorphism. Males were larger in most characters; females are larger in some length measurements involving the rostrum and ramus. As in previous analyses, inshore S. attenuata were found to be very distinctive, so subsequent analyses focused on offshore spotted dolphins from 29 5° latitude-longitude blocks. Mantel tests and matrix correlations for 19 of the 30 features demonstrated significant "regional patterning," while 22 of the characters were shown to have "local patterning." Principle components, canonical variates, and cluster (UPGMA and function-point) analyses also were employed to assess geographic variation. In the eastern portion of the range, the subdivision between northern and southern offshore S. attenuata found in the previous investigation was confirmed. In general, blocks to the west (including one encompassing part of the Hawaiian Islands) were more like the southern blocks than blocks of the northeast. A general concentric pattern of geographic variation--similar to that found for the spinner dolphin (S. longirostris) --is suggested. Product-moment correlations, Mantel tests, and matrix correlations were used to assess covariation of morphological features and 13 environmental variables. Morphological patterns were similar to those found in a number of environmental variables, particularly water depth, solar insolation (January and July), surface salinity, and thermocline depth (winter and summer). Comparisons of morphological variation in spotted dolphins and spinner dolphins based on corresponding data for 16 blocks indicated strong correspondence in general trends summarized in the first principle components and first canonical variables. Geographic patterns in 13 of the 30 morphological characters showed statistical correspondence based on Mantel tests, while product-moment correlations were significant for 15 of the characters. These correlations based on data for corresponding blocks were positive for twelve characters, but negative for the length of the

temporal fossa and the number of teeth in the upper left and upper right tooth rows.

# IDENTIFICATION OF GEOGRAPHIC FORMS OF COMMON DOLPHINS (*DELPHINUS DELPHIS*) FROM AERIAL PHOTOGRAPHS

Wayne L. Perryman and Morgan S. Lynn

Administrative Report LJ-91-40

At least four morphologically distinct geographic forms of common dolphins are found in the eastern Pacific. We compared length data for common dolphins photographed from the northern, central and southern regions as defined by Perrin et al. (1985) and found significant differences in average length for adult animals (>150 cm) and for "adult females" defined as animals accompanied by calves. Analyses of back-calculated birth dates demonstrated differences in timing of reproduction between the geographically adjacent forms. Length distributions from aerial photographs and those from samples collected the purse seine fishery were strikingly similar providing mutual support for the validity of each. This work demonstrates a new, non-invasive method for obtaining unbiased life history and morphological data.

# LENGTH DISTRIBUTION OF STRIPED DOLPHINS FROM AERIAL PHOTOGRAPHS: ARE STOCKS IDENTIFIABLE?

Wayne L. Perryman and Morgan S. Lynn

Administrative Report LJ-91-41

We compared length data for 18 schools of striped dolphins (Stenella coeruleoalba) from northern and southern stocks (as defined by Perrin et al. 1985) and found no significant differences in average length for adult animals ( >180 cm) or for adult females defined as dolphins closely accompanied by a calf. Analyses of back-calculated birth dates for striped dolphins, < 155 cm, revealed a broad pulse in reproduction extending from late October through April. Sample size was inadequate to compare timing of reproduction between the northern and southern regions. The structure of striped dolphin schools in the eastern Pacific demonstrates a similar pattern that has been reported for schools of this species taken in the drive fishery in Japan. In both regions, individuals are segregated into schools on the basis of their lengths.

# GEOGRAPHIC VARIATION IN EXTERNAL MORPHOLOGY OF THE SPINNER DOLPHIN *STENELLA LONGIROSTRIS* IN THE EASTERN PACIFIC AND IMPLICATIONS FOR CONSERVATION

William F. Perrin, Priscilla A. Akin, and Jerry V. Kashiwada

Fishery Bulletin, U.S. 89(3):411-428

Variation in color pattern, dorsal fin shape, and body length exhibit sharp north/south gradients centered at about 5-10°N latitude and east/west gradients at about 120-125°W longitude. A conservation zone with boundaries in these regions would provide protection for the morphologically unique eastern spinner dolphin *Stenella longirostris orientalis*. A radical pattern of geographic variation in the eastern Pacific and a complex pattern of discordant variation outside the core range of *S.l. orientalis* suggest that the present separate management of "whitebelly" spinner dolphins (which comprise a broad zone of hybridization/intergradation between *S.l. orientalis* to the east and the pantropical spinner dolphin *S.l. longirostris* to the west and southwest) north and south of the Equator may not be justified on the grounds of conservation of distinct populations.

# CALIBRATION OF SHIPBOARD ESTIMATES OF DOLPHIN SCHOOL SIZE FROM AERIAL PHOTOGRAPHS

Tim Gerrodette

Administrative Report LJ-91-36

Accurate counts of 171 dolphin schools based on high-quality aerial photographs were compared with shipboard observer estimates of the same schools. Several methods of adjusting observer estimates were assessed using a cross-validatory approach, and a best procedure was determined for each observer. For 10 of 23 observers, estimates of school size were improved by calibration against schools of known size; for the other 13, estimates were not so improved. A weighted mean of the observers' calibrated estimates provided the best combined estimate of school size, based on minimum squared error. Overall, dolphin school size was accurately estimated by observers on research vessels, although there was considerable variability in the estimates.

# MOLECULAR PHYLOGENY OF TWO FORMS OF COMMON DOLPHIN

Andrew E. Dizon, Patricia E. Rosel, and John E. Heyning

Administrative Report LJ-91-32

Using genetic sequence information, we examined differentiation among and within samples of two types of *Delphinus delphis* that inhabit coastal waters of California and are killed incidently in fishing operations. One has a larger overall size, a larger skull, and a longer rostrum. Color pattern in adults also is distinguishing. Uncertainty exists as to the proper taxa level to apply. Using the polymerase chain reaction, we amplified the control region of mtDNA from 20 samples and determined the nucleotide sequence of 440 base pairs spanning the most variable portion of the control region. Phylogenies were made using *D. delphis* from the Black Sea and *Orcinus orca*, and *Cephalorhynchus commersonii* as outgroups. Initial results indicate that for the region sequenced, the long-beaked form is genetically homogenous and distinct from the short-beaked form, which in turn is more closely related to the Black Sea animals.

## Administrative Law Judge Findings

Table 4. Estimated Current and Future ETP Porpoise Population Levels.

| Species/Stock Management Unit | Estimated 1979 Population | 1979 Status[1] | Adjusted 1979 Population[3] | Adjusted 1979 Status[1] | Projected 1990 Status[2] |
|---|---|---|---|---|---|
| **Spotted dolphin** | | | | | |
| northern offshore | 3,150,000 | .63 | 6,115,000 | .85 | .92 |
| southern offshore | 638,700 | .95 | | | .93 |
| coastal | 193,200 | .42 | 414,600 | .76 | .89 |
| **Spinner dolphin** | | | | | |
| eastern | 418,700 | .27 | 918,800 | .55 | .71 |
| northern whitebelly | 486,600 | .78 | | | .83 |
| southern whitebelly | 264,900 | .90 | | | .90 |
| **Common dolphin** | | | | | |
| northern tropical | 216,900 | .97 | | | .94 |
| central tropical | 848,400 | .89 | | | .94 |
| southern tropical | 477,100 | 1.00 | | | .99 |
| **Striped dolphin** | | | | | |
| northern tropical | 50,600 | 1.00 | | | .98 |
| central tropical | 213,300 | .99 | | | 1.00 |
| southern tropical | 483,000 | 1.00 | | | 1.00 |

[1] Proportion of pre-exploited stock size.

[2] Projected from adjusted population for northern offshore coastal spotted, and eastern spinner dolphin and from estimated 1979 population for all other populations; includes assessment for equal levels of U.S. and non-U.S. porpoise mortality; incorporates actual 1980-84 mortality; assumes 1985-89 mortality will occur in same proportion as 1979-84 mortality by species.

[3] Adjusted in accordance with court directive only for northern offshore spotted, coastal spotted, and eastern spinner due to question about status of population; other populations were and continue to be healthy and no adjustment was necessary.

**Appendix 7**

DRAFT
November 1991

Equilibrium Reduction Equations
to Estimate Eastern Spinner Dolphin Abundance

by

R. Deriso and A. Anganuzzi
Inter-American Tropical Tuna Commission

The objective of this note is to show how equilibrium calculations can be structured to address the status of dolphin stocks. If we assume the Smith (1983) model of population abundance for Eastern Spinner Dolphins, as given in equation (1) of Wade (1991) is valid, then we can use that equation, along with the assumption that the current population is at equilibrium, to estimate the abundance of the population relative to its carrying capacity. We use the population model,

$$N(t+1)=N(t)-K(t)+RN(t)[1-(N(t)/H)**Z]$$

which at equilibrium, implies

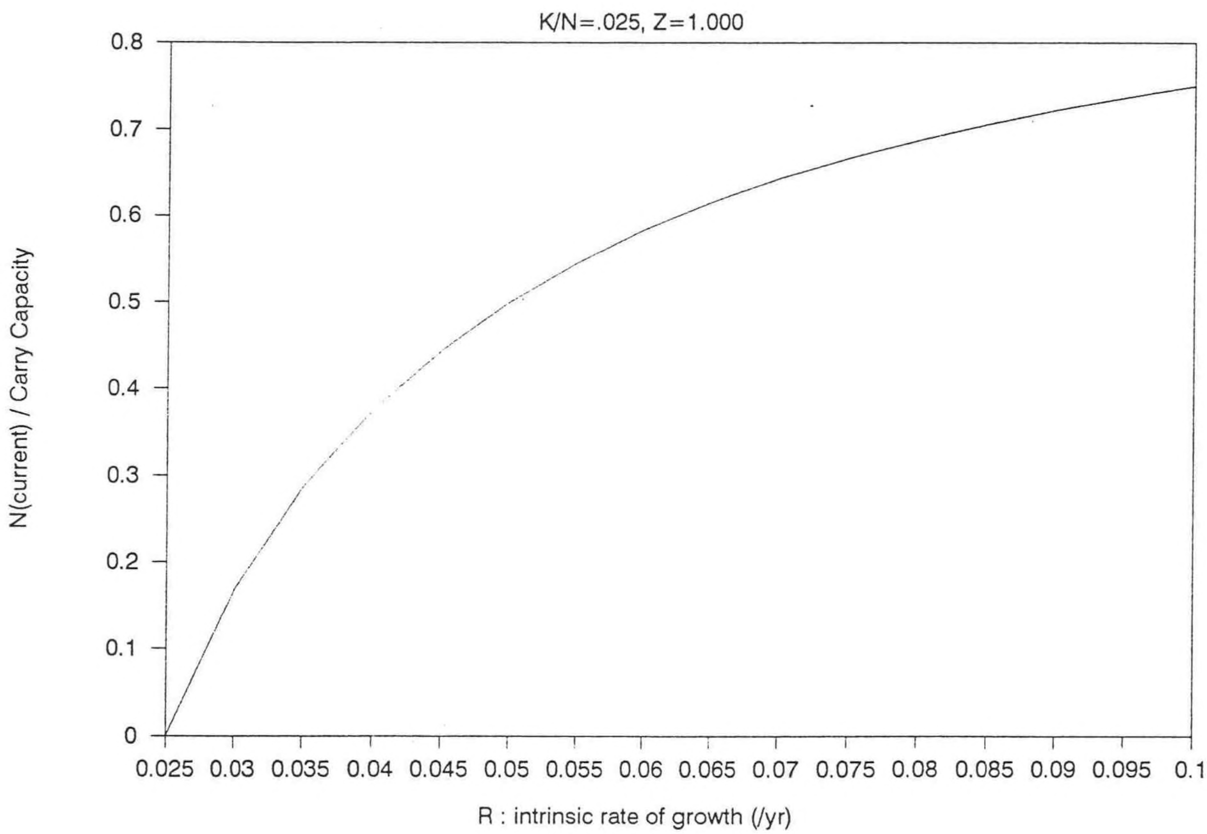
$$N/H=[1-K/(NR)]**(1/Z)$$

where H is the carrying capacity, N is equilibrium abundance, K is the annual kill, R is the intrinsic rate of growth, Z is a parameter.

The equilibrium formula above was applied to the Eastern Spinner dolphin population for two of the assumed values of Z listed in Wade (1991) of Z=1.0 ( the logistic case) and Z=3.482 (the skewed case where MNPL=65% of H). Recent kill rates of Eastern Spinner dolphins are annually about K/N=.025. Figures 1(a) and 1(b) show the fractional reduction in the dolphin population from equilibrium for the two Z values and as a function of the assumed intrinsic rate of growth. Intrinsic rates of growth of less than 0.05 are required for the population to be lower than MNPL for the logistic model (Z=1.0), whereas intrinsic rates of growth of less than 0.035 are required for the population to be lower than MNPL for the skew model (Z=3.482). Intrinsic rates of growth above those values imply the population is above MNPL.

The calculations of this paper show that the issue of the status of the dolphin populations relative to carrying capacity can be addressed without relying on problematical mortality data from the historical incidental mortalities. The results also point out the importance of the values chosen for intrinsic rate of growth (R) and skewness parameter (Z) to conclusions about the status of the population. Interestingly, for any given intrinsic rate of growth we are less likely to believe the population is below MNPL with the right-skewed production models (where Z>1.0) than with the standard logistic model (Z=1.0).

## Equilibrium Reduction Formula



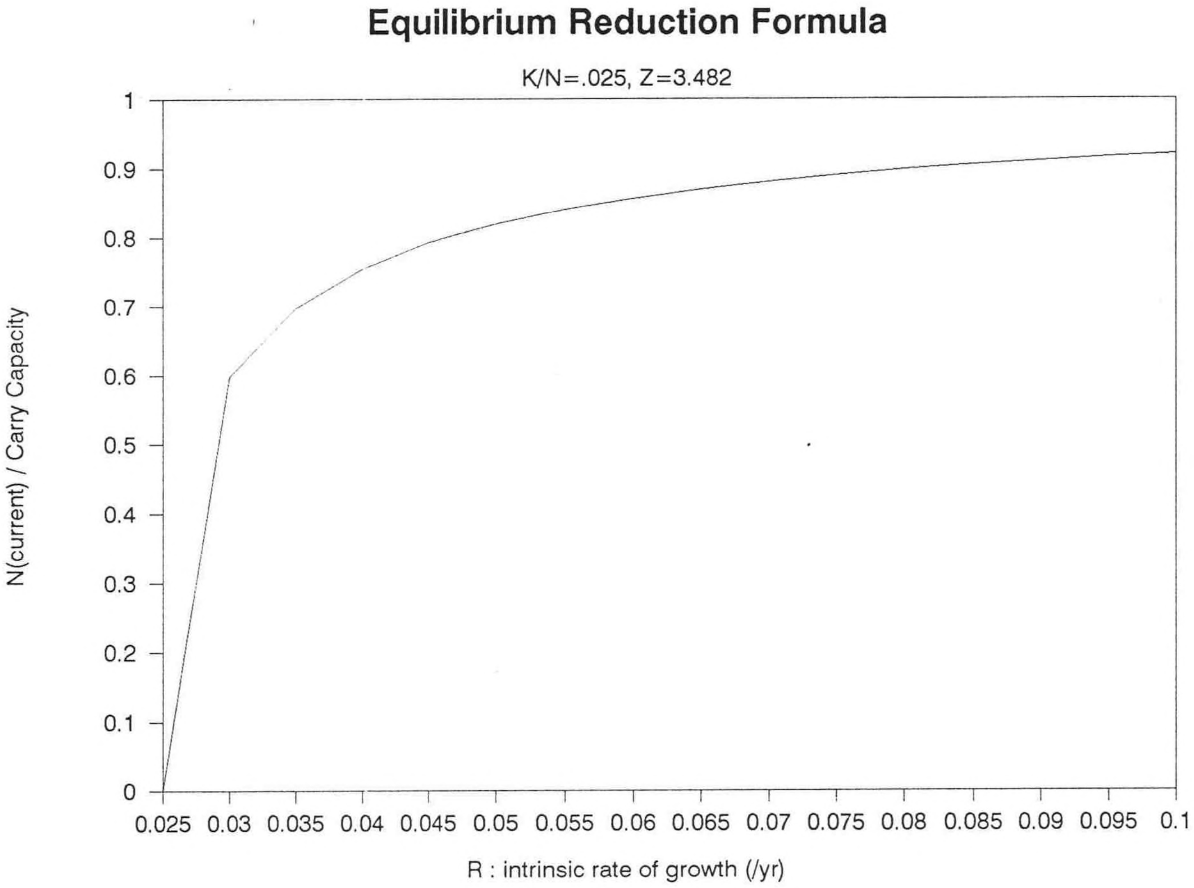

Equilibrium Reduction Formula
K/N=.025, Z=3.482
N(current) / Carry Capacity
R : intrinsic rate of growth (/yr)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.025 0.03 0.035 0.04 0.045 0.05 0.055 0.06 0.065 0.07 0.075 0.08 0.085 0.09 0.095 0.1

Fig 1(b)