SEDAR 7: Gulf of Mexico Red Snapper

RED SNAPPER DATA WORKSHOP REPORT

6/17/04

Introduction:

The Data Workshop for the red snapper SEDAR was held in New Orleans April 19-23, 2004. Participants are listed in Appendix 1. Initial data compilations and exploratory analyses for SEDAR assessments are requested from participants in the form of "working documents" to be submitted in advance and evaluated over the course of the workshop. A full list of papers submitted is presented in Appendix 2.

Among the Data Workshop participants, seven working groups were established to address development of available data for stock assessment. The working groups were: 1) life history, 2) commercial statistics, 3) recreational statistics, 4) fishery dependent indexes, 5) fishery independent indexes, 6) release mortality, and 7) shrimp fleet bycatch. Participants chose which group or groups to join, and group rapporteurs reported issues and progress to Data Workshop plenary sessions several times during the week. Written reports from each working group were substantially complete by week's end, although there has been some subsequent editing, and some further analyses sketched out during the Data Workshop have been added as planned. Some additional analyses recommended at the Data Workshop were too extensive to allow completion prior to circulation of the Data Workshop report. These will be reported and evaluated at the Assessment Workshop scheduled for August, 2004. Additionally, some of the working documents submitted (e.g. SEDAR7-DW-37, 50) address topics that will be covered in more detail at the Assessment Workshop.

This report is divided into seven sections, paralleling the choice to establish seven working groups. Structure within each section was determined by each working group, following some general guidelines derived from SEDAR's for other species. Red snapper has a long history of previous assessments, so this report tends to have expanded discussion on issues that had been difficult or controversial in past work, but is fairly brief on issues that are reasonably well settled. Figures and tables remain within the individual sections, and are numbered in "Section number.figure number" sequence. One section (5.) has appendixes of its own, which are located with that section's text. Lists of references to the general literature (i.e. papers other than the working documents submitted to this Workshop) also remain with the individual sections. Citations to papers submitted to this workshop as "working documents" are made in the text using the identifying numbers assigned by the SEDAR Coordinator (in the form SEDAR7-DW-xx), and refer to the list in Appendix 2.

As is customary for Data Workshop reports, several of the sections contain recommendations for future research efforts. Many of these recommendations are intended to be considered over the next several years, and are not recommendations for work to be completed prior to the Stock Assessment Workshop portion of the red snapper SEDAR in August. In general, the timeline intended is clear from the context of a recommendation, but the SEFSC has gone through the recommendations individually to identify those needing immediate attention. Many of the recommendations to be addressed prior to August relate to the details of estimating catch at age, which could not be addressed completely at the workshop for lack of time (see also SEDAR7-DW-45, 46, and 56) There are also a few issues identified in this report for which participants could not reach a satisfactory consensus. Most of these are tied to recommendations for additional analyses, which will be developed for presentation at the Assessment Workshop.

This report is a complete and final documentation of the activities, decisions, and recommendations of the Data Workshop. It will also serve as one of 4 components of the final SEDAR Assessment Report. The final SEDAR Assessment Report will be completed following the last workshop in the cycle, the Review Workshop, and will consist of the following sections: I) Introduction; II) Data Workshop Report; III) Assessment Workshop Report; and IV) Review Workshop Report.

TERMS OF REFERENCE:

1. Evaluate stock structure and develop a unit stock definition.
2. Evaluate the quality and reliability of life-history information (Age, growth, natural mortality, reproductive characteristics); develop models to describe growth, maturation, and fecundity by age, sex, or length as appropriate.
3. Evaluate the quality and reliability of fishery-independent measures of abundance; develop indices of population abundance by appropriate strata (e.g., age, size, and fishery) for use in assessment modeling.
4. Evaluate the quality and reliability of fishery-dependent measures of abundance; develop indices of population abundance by appropriate strata for use in assessment modeling.
5. Evaluate the quality and reliability of commercial and recreational fishery-dependent data for determining harvest and discard by species; develop estimates of total annual catch including both landings and discard removals.
6. Evaluate the quality and reliability of data available for characterizing the size and age distribution of the catch (landings and discard); characterize commercial and recreational landings and discards by size and age.
7. Evaluate the quality and reliability of available data for estimating the impacts of management actions.
8. Recommend assessment methods and models that are appropriate given the quality and scope of the data sets reviewed and management requirements.
9. Provide recommendations for future research (research, sampling, monitoring, and assessment).
10. Prepare complete documentation of workshop actions and decisions, and generate a data workshop report (Section II. of the SEDAR assessment report).

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1. Life History

1.1 Stock Definitions

The life history sub-group supported the development of a two stock (east vs. west of the Mississippi River) model for the Gulf of Mexico red snapper. This separation is supported by inferential (e.g., genetic, otolith constituent) and direct evidence, and also will allow the incorporation of potential life history differences that occur in these two regions. The group also discussed the possibility of further sub-dividing the western stock based on demographic results, which suggested differences between Louisiana and Texas fish. However, there was consensus that insufficient evidence was available about reproduction, recruitment, and habitat usage (especially for age-0 and -1 fish) to support further partitioning at this time. The observed demographic differences do not correspond to geographic isolation, according to the movement studies, and may be explained by environmental factors, including the possible influence of differential fishery exploitation. The sub-group also recognized that a single stock model will be developed and will prove useful for comparisions to the old assessment and could also help understand the impacts of treating Gulf of Mexico red snapper as one stock or two. A summary of the available evidence follows:

Genetic results: Analysis of neutral microsatellite markers in red snapper indicated spatial homogeneity across the northern Gulf. However, there were three types of demographic units based on variance effective size. Higher genetic effective population sizes were detected in Louisiana than in Texas or Alabama. Results from mt-DNA analysis were similar in that female effective population size was greater in Louisiana than Texas or Alabama (Gold 2003, although Gold also pointed out that the upper 95% confidence bounds for all three areas were essentially infinite). Nested Clade analysis shows a successive history of genetic expansion and isolation, with a geographic component to the cladogram (J.R. Gold, Texas A&M, personal communication, April 2004).

Otolith constituent analysis: Good nursery discrimination was found via otolith microchemical analysis (Patterson et al. 1998). Applied to adults, findings revealed that fish harvested from the north-central gulf Gulf (AL) had most likely recruited locally. In the northwestern gulf Gulf (LA), the nursery source was primarily local but some individuals were coming from southwestern Gulf nurseries (TX) and a few other adult fish (age-5) were coming across the Mississippi River from the north-central Gulf. In the southwestern Gulf however, there was evidence of extensive mixing, with individuals coming from both the northwestern and southwestern Gulf (Cowan et al. 2002). This provides strong evidence of the interaction of fish across the northern Gulf, but is not without potential misinterpretations. The analytical tool used to produce these estimates does not explicitly test for statistical significance of any observed differences. As a result, it does not distinguish between misclassification and migration. Nonetheless, the data were consistent with observed movements, including across age-classes.

Tagging and movements: Evidence was presented of longer migrations and lower site fidelity than previously estimated (Patterson et al. 2001; SEDAR7-DW-18)), at least in the eastern Gulf. Together, these results suggest more mixing is feasible, but tagging efforts to date have focused primarily on the eastern Gulf. . Those results generally show eastward and southeastward movement from north-central Gulf to the west Florida shelf. There was more limited evidence of movement from east to west (Patterson et al., 2001; SEDAR7-DW 18). It was recognized that site fidelity estimates vary and not all the factors affecting this are understood. There was some discussion about misreporting by fishermen which could affect site fidelity estimates. It was felt that routine checks on reporting could detect much of this problem and that more information coming from acoustic tagging results could elucidate fidelity estimates (by habitat etc.), at least for adult fish.

Demographic patterns: There was evidence that fish in the eastern Gulf may mature younger and smaller than fish in the western Gulf (Woods 2003, SEDAR7-DW-35 and addendum). There was also evidence for a higher abundance of older individuals in the west compared to the east based on aged samples from the commercial long-line fishery and scientific long-line survey (SEDAR7-DW-33 and -9). Unlike long-line trends, little difference in aggregated age structure was noted in the commercial hand-line and recreational age distributions east and west, which is not surprising considering that these fisheries generally catch

younger individuals. Evidence existed for smaller size-at-age (age-2 to age-5) for fish in Texas waters compared to other states (SEDAR SEDAR7-DW-33 addendum, Cowan et al. 2002).

Other factors: The sub-group also discussed the east-west regional differences in habitat and the management issues associated with them. An example is the Texas shrimp fishery opening and its potential effect on age-0 red snapper, which is a unique western situation. Another example is the large area off Alabama that is effectively closed to trawling due to artificial reefs, which presents a unique eastern situation. These examples provided further compelling reasons to recommend regional partitions in the assessment model.

Several recommendations for future research were discussed. All of these are focused on long-term information needs, and none are a prerequisite to running the current assessment. 1) More movement information via tagging is needed from the western Gulf. There was discussion that a recreational tagging data base from the Coastal Conservation Association (CCA) may be available for this purpose. The sub-group recommended every effort be made to access and analyze this data base (by LSU researchers). 2) The results from the otolith microchemical analysis were compelling in providing estimates of mixing rates for the north-central, northwest, and southwestern Gulf. The sub-group recommends continued work to also derive mixing rates from the eastern Gulf (west Florida shelf). It was of great interest to determine if there was evidence for localized recruitment in the east or whether recruits were derived from other areas as suggested by tagging results. 3) Much more otolith microchemistry needs to be conducted on snapper off Texas, especially age 0 & 1 cohorts to aid in our understanding of the recruitment dynamics there. 4) There needs to be an examination of whether regional stock recruitment functions can be developed. It was recognized that trawl surveys, which have been previously relied upon for recruitment estimates, are conducted from Texas to the Florida/Alabama border and may not capture any localized recruitment which may occur on the west Florida Shelf. The sub-group recommended that other survey methods be examined for recruitment determination and the red snapper larval index was recognized as a candidate for this purpose.

1.2 Habitat Requirements

Most red snapper spawn from the late spring through the summer, and larvae spend their first 2 to 3 weeks or more in the plankton. An approximately 28 day PLD was identified off the Freeport Bathymetric High (Rooker et al. 2004). Fish metamorphose and drop out of the plankton to seek benthic habitat starting in late June, with recruitment continuing into September (Szedlmayer and Conti 1999). Peak settlement in Texas occurs between mid-July through August, with virtually none seen after 1 September (Rooker et al. 2004). New recruits can be found over a wide range of habitats, including open habitat (e.g., mud flats) and structured habitat (e.g., shell ridges, rock outcroppings). In the fall the growing fish move to more structured habitat, with few remaining over open habitat at the end of the first season (December). Structured habitat includes natural rock outcroppings, shell ridges, sand banks, and artificial reefs. Diet shifts occur with this shift in habitat, with significant increases in reef prey types as fish move to structured habitat (Szedlmayer and Lee 2004). Over much of the rest of the red snapper life history, fish are associated with structured habitat and show wide ranging prey types, including reef, sand, pelagic, and mixed prey types. Red snapper were also found to vary their diets with diel cycles (Ouzts and Szedlmayer 2003). New information from NMFS long-line survey suggests that larger older fish may become more independent of structured habitat and frequent open continental shelf (SEDAR7-DW-9).) This conclusion is also supported by tournament winning fish in Texas, where the winners generally come from mud bottoms with very small ($<1m^2$) structured relief ($<0.5m$) (Landre, personal observation).

1.3 Age

Numerous studies have used otoliths to age red snapper and provide basic information on growth and annulus formation (Futch and Bruger 1976, Bortone and Hollingsworth 1980, Nelson and Manooch 1982, Manooch and Potts 1997, Patterson et al. 2001,Wilson and Nieland 2001). For the 2004 assessment, three fishery-dependent data bases were combined to yield annual age structure information from 1980 and 1991-2002 (SEDAR-DW-33). Ages were derived from NMFS, Panama City laboratory (1980, 1991-2002), Louisiana State University (LSU) (1995-2002) and the Gulf States Fish Information Network (FIN)

(2002). Over 44,000 red snapper from the commercial and recreational fishery were aged from these sources. In addition, NMFS Panama City aged fish collected from fishery independent hand-line survey and from the NMFS Pascagoula long-line survey (1999-2002; SEDAR7-DW-9).

Red snapper ages ranged from 1 to 57 years. Each fishing mode caught a different range of red snapper ages, with the commercial long-line contributing the oldest individuals followed by the commercial hand-line and recreational fishery. Age distributions from the eastern and western Gulf were similar for the commercial hand-line and recreational fishery. However, the commercial long-line and fishery independent long-line survey yielded older fish in the western Gulf. Similarities in age-structure within modes was noted among years; however there was some evidence for strong year-classes in 1989 and 1995 based on age distributions in the directed fishery in both the eastern and western Gulf (SEDAR7-DW-33).

Because estimates of longevity were questioned in the last assessment, subsequent research used carbon14 bomb radiocarbon dating methods to validate longevities of 50+ years (Baker and Wilson 2001). Some aging concerns remain, including routine interpretation of annuli patterns (SEDAR7-DW-33, -34, -36, -55). In general, there was good precision among different aging facilities (average percent error about 5% or less) (SEDAR7-DW-34). However, it was noted that there were some difficulties in aging, primarily relating to the variable pattern of the first annulus. The sub-group recognized attempts to deal with this issue (marginal increment analysis, observed and back-calculated size at 1st annulus). A chemical marking experiment to examine and compare annulus formation from early and late spawned individuals was recommended as a future research objective. Dr. Steve Szedlmayer (Auburn University) indicated he had chemically marked age-0 red snapper off Alabama during August 2003. Recovery of these individuals may help elucidate the first annulus pattern. The sub-group recommended continued use of reference collections and training workshops to develop consistency, improve precision among readers and facilities, and to facilitate data corrections if current methods of interpretation change.

1.4 Growth

There have been several growth studies on red snapper in the Gulf of Mexico. Both recent and older studies have produced similar results regarding the growth coefficient K and maximum attainable size L_∞ (Patterson et al. 2001, Wilson and Nieland 2001). The sub-group recommended that in the future, growth parameters be fit with the available age data as needed for the assessment models (by region/strata). Growth models can be influenced by the use of size-biased samples, for example due to minimum size-limits. While useful for characterizing the age composition of the catch, they can be biased with respect to the underlying population growth characteristics and need to be considered with caution if being used to model population level productivity benchmarks.

1.5 Conversion Factors

Conversions for length and weight in English units were presented in the last stock assessment (Schirripa and Legault 1999) and are repeated here.

Length to weight conversions: Where required, total lengths (TL) were converted to pounds whole weight (WW) using the fitted model of Equation1. Fork lengths (FL) were converted to pounds whole weight using the model of Equation 2.

$$WW\ (lbs) = 4.40E\text{-}04 * TL\ (in)\ \wedge\ 3.056 \qquad (1)$$

$$WW\ (lbs) = 6.62E\text{-}04 * FL\ (in)\ \wedge\ 2.997 \qquad (2)$$

Commercial landings are often in gutted condition and conversions for total and fork lengths to gutted weight (GW) were also needed for several analyses. Data from the TIP samples were used to establish the relation between total length and gutted weight (Equation 3) and fork length and gutted weight (Equation 4). The resulting two equations were used to assign weights from lengths for the commercial samples, as appropriate.

$$GW\ (lbs) = 3.51E\text{-}04 * TL\ (in)\ \wedge\ 3.114 \qquad (3)$$

$$GW\ (lbs) = 6.83E\text{-}04 * FL\ (in)\ \wedge\ 2.973 \qquad (4)$$

Length conversions: Lengths were commonly recorded as either whole length or fork length. Most of the length observations from the commercial fishery were in units of fork length, as were most of the observations from the NMRFSS intercept sampling. However, other surveys took total length measurements. Conversions among length units used the regression equation of Equation 5. The few measurements of standard length in the available data that required conversion to total length used the regression of total length on standard length (SL) presented in Equation 6.

$$TL\ (in) = 0.1729 + FL\ (in) * 1.059 \qquad (5)$$

$$TL(in) = 0.0291 + SL\ (in) * 1.278 \qquad (6)$$

Weight conversions: In 1964 the then Bureau of Commercial Fisheries established a policy of recording finfish landings in units of whole weight (Udall 1964). Since most red snapper are landed in gutted condition, a conversion factor was required to convert the landed weight to its equivalent value in whole weight. A conversion factor of 1.11 was adopted for this purpose. The basis for this value is unknown. However, the Florida red snapper landings from 1986 to the present and those of all other states have been adjusted upward by this factor before entry into the computer files which constitute the historical data base for the red snapper fishery. Florida landings prior to 1986 were never converted from landed to whole weight (E. Snell, SEFSC, personal communication).

The same problem exists with other species in the data base. An evaluation of the correction factor being applied to grouper landings revealed that the conversion factor being used to convert red grouper from gutted to whole weight was in substantial error (Goodyear and Schirripa 1993). Consequently, the accuracy of the conversion factor for red snapper was evaluated by regressing total weight on gutted weight (Equation 7).

$$GW\ (lbs) = 1.106 * WW(lbs) - 0.02 \qquad (7)$$

The slope of the resulting model, 1.106 is an estimate of the conversion factor and is very close to the value currently being used. As a consequence, the conversion between whole and gutted weights used for analyses presented in this report retain the historically applied value of 1.11. This value is somewhat smaller than the value of 1.15 derived by Camber (1955). Anecdotal information suggests variability in the extent of evisceration among fishermen and variability in the ratio of gutted weight to whole weight across seasons. Consequently, additional data may lead to a better characterization the conversion rate for the commercial fishery for this stock.

Recent developed formulae for transforming length and total weight in metric units are presented in Wilson and Nieland (2001), Patterson et al. (2001), SEDAR7-DW-33 and SEDAR7-DW-52.

1.6 Reproduction

Since the 1999 Red Snapper Stock Assessment Report, new unpublished data has been produced on reproduction of red snapper in the northern Gulf (Woods 2003, SEDAR7-DW-35). It was generally recommended that these two data sets of similar methods and results be combined for use in the assessment as a more thorough analysis of reproductive biology. Care should be given to the types of samples used since size-biased sampling can lead to overestimation of reproductive output of young fish whose sizes are less than allowed for via landings.

Maturity: Based on the decision to partition the assessment model, it was recommended that maturity functions be developed for the east and west based on combining MARFIN and NMFS (Panama City) data. Doing so will give a broader geographic perspective within each region than would be allowed by each dataset alone. There was concern that reproductive output at age could be affected by selectivities for

faster growing fish in the fishery-dependent samples (ultimately affecting maturity and batch fecundity at age). It was recognized that both data sets contained some fishery-independent samples that could be used to examine this effect. There was also discussion as to whether overlapping (recent) years (1999, 2000, 2001) should be examined to avoid any historical year effect that may be present. The sub-group recommendation was to examine and standardize both data sets for source (gear) and year effect. Table 1.1 and 1.2 indicate the sample sizes and states represented by both data sets for the years that overlap.

Batch Fecundity: The subgroup recommended use of the batch fecundity-at-age relationship. While not as directly predictive as length, it avoids the need to extrapolate age from length. The sub-group also recommended use of the power function of the Von Bert relationship (asymptotic). Akaike (AIC) information criteria indicated a better fit than the Beverton Holt function (addendum to SEDAR7-DW-35). It was recognized that a relatively small number of fish over age 15 (about 9 females) affect this choice, but this is a significant improvement in terms of available observations compared to those available for the last assessment. Therefore, the sub-group views the choice of an asymptotic function for age as a hypothesis until more information is available.

Spawning frequency: Spawning frequency was observed to increase with age to about age-6. Little information exists for examination beyond this age. The sub-group recommended to reexamine combined datasets and fit an asymptotic decay function to the data and further evaluate the need to incorporate spawning frequency into the assessment. There was a concern that a combined function should be weighted by abundance estimates. While recognizing that appropriate information may not be available, the recommendation was to further investigate possible weighting procedures, for example, based on fishery-independent surveys.

There was also a need to consider an estimate for spawning season duration. It was noted that annual estimates could vary based upon opportunistic sampling. The recommendation was to use a best estimate of 150 d (Woods 2003, SEDAR7-DW-35).

1.7 Stock-Recruitment Relationship

The stock-recruitment relationship may have a strong effect on the outcome of an assessment. The most recent assessment concluded "[T]he stock-recruitment relationship could not be well estimated given the short time series, most likely due to the lack of regression range" (Schirripa and Legault 1999, p. 26). As it proved impossible to estimate the stock-recruitment parameters from observed data, they ran the model with combinations of six steepness values (ranging from 0.8 to 0.99) and two different maximum recruitment parameter values (163 or 245 million age-0 recruits), the latter numbers representing an estimate of the maximum SEAMAP survey-based recruitment estimate (from 1972) and 2/3 that value (presumed to represent an average of several high years instead of a single peak). Their objective function, a measure of the fit of the model to observed data, was maximized at a steepness of 0.975 but this fit was influenced by the assumption of maximum recruitment. The Reef Fish Stock Assessment Panel (1999) raised a concern that this steepness value did not match those of other similar species, and so recommended focusing analysis on runs using either a steepness of 0.9 or 0.95.

Given the importance of this relationship to the results of the stock assessment and the difficulty in accurately estimating its parameters, it would be valuable to explore several possible means of constructing it. One possibility would be to recreate the options examined in the past assessment, in particular the version accepted in defining red snapper stock status reference points (steepness of 0.9 and maximum recruitment of 163 million).

Another approach would be to specify a prior distribution of the values of steepness informed by examining estimates from similar species, and then produce an estimate of maximum recruitment in the model itself. This approach would be facilitated by incorporating data on the abundance of young of year red snapper, which stretch back to 1972, into the estimation procedure. It might also benefit from an examination of historical landings dating back to the 1880s, although data prior to the 1970s is not considered as reliable as more current information (it, for example, could include substantial landings from Campeche Bank, Mexico). The prior distributions for steepness could come from any of at least three meta-analyses.

McAllister (SEDAR7-DW-13,26) examined the steepness values associated with all demersal species, excluding rockfishes (Subfamiy Sebastinae). Rockfishes were excluded because these species were considered to have distinctively long lifespans and low fecundities compared to *L. campechanus*. Excluding them from demersal species produces a median steepness of approximately 0.77 with a mean of 0.71. Porch (SEDAR7-DW-50) compiled a distribution of maximum lifetime fecundity parameters (α), which are directly related to steepness, using just periodic spawners (as defined by Rose et al. 2001) from a meta-analysis by Myers and colleagues (1999). A similar approach by Rose et al. (2001) identified a mean steepness of 0.7, with a median of approximately 0.75. Both of these approaches included one rockfish species (the Pacific Ocean perch, *Sebastes alutus*), which should be excluded for the reasons stated above. Excluding them produces summary statistics as follows: steepness mean = 0.696, median = 0.745; α mean = 17.985, median = 12.85.

While the analyses by Porch and Rose and co-authors are more focused than those performed by McAllister, they still include a wide range of species (from sardines to swordfish). The list of periodic species from Rose and colleagues (2001) can be further separated into those with basic similarities to red snapper (i.e., marine, demersal, and periodic spawners). This finer separation leaves 19 species in addition to red snapper, which should not be included for obvious reasons. These 19 species are characterized by the following summary statistics: steepness mean = 0.741, median = 0.81; α mean = 22.132, median = 18 (Fig. 1.1). This latter distribution made up of species with similar basic life history traits as red snapper could be used to formulate a prior distribution for steepness when running a Bayesian version of the red snapper assessment model. This approach will complement the approach used previously of examining a range of plausible steepness and maximum recruitment values.

1.8 MSY Reference Points

It is often perceived that the calculation of maximum sustainable yield (MSY) and corresponding reference points, the biomass B_{MSY} and fishing mortality rate F_{MSY}, is strictly a scientific exercise. This perception is correct in the sense that an MSY calculation does not explicitly take consideration of the specific goals and objective of a fishery (this process informs optimum yield). However, there are important policy implications, and thus value judgments, associated with calculation of MSY and the effort that produces MSY for age structured populations (see Goodyear 1996, for example- Goodyear, C. P.1996. Variability of fishing mortality by age: Consequences for MSY. North American Journal of Fisheries Management.. 16:8-13.). These manifest themselves in specifying the selectivity of the fishery, a characterization of the relative vulnerabilities of different age classes to fishing. MSY and F_{MSY} values for the same population will vary depending on the pattern of selectivities.

Myers and Mertz (1998) provided a good illustration of this point. They showed that if fisheries avoided all fish that were not yet mature, the stock could sustain very high fishing mortality rates (i.e., a high F_{MSY}) on the older age classes. The same fishery would be much more vulnerable at lower fishing mortality rates (i.e., a low F_{MSY}) if they applied to immature fish.

These MSY reference points for red snapper are sensitive to selectivity patterns because those patterns differ dramatically among different fishing sectors, especially between bycatch in the shrimp fishery and the directed fisheries. Shrimp bycatch selects primarily for age-0 and age-1 fish and does not contribute to yield, the recreational sector primarily for age-2 to -4 fish, the commercial handline sector primarily for age-3 to -5 fish, and the commercial longline for age-5 and older fish. The choice of a selectivity pattern when calculating MSY implies an allocation of effort among the fishing sectors. Such choices represent policy rather than analysis, and thus need to be informed by policymakers and the public. At best, analysts can illustrate the importance of this decision and potential implications by presenting a range of different scenarios as in past assessments (including yield foregone). The sub-group recommended several selectivity/ effort scenarios.

1) The last assessment held selectivity at an average of the 1995-1997 levels when calculating MSY. In effect this approach would assume that any increase or decrease in fishing mortality rates would affect each fishing sector, including the shrimp industry, equally. This method of estimation is problematic if it would be more desirable and practicable to regulate the bycatch sector to a

different degree than the sectors that target red snapper. However, it has the advantage from an analytic point of view that it does not present a bias towards favoring one sector over another– clearly a policy choice, not a scientific one.

2) The selectivity and effort patterns could be set according to anticipated or desired bycatch reductions in the shrimp fishery. Current economic conditions project that effort will drop substantially in the shrimp industry due to rising fuel costs and shrinking dockside prices for shrimp (NMFS 2004). These projections indicate that total shrimp effort is likely to drop by 40% within the next 10 years. Additional bycatch reductions may be expected due to the use of bycatch reduction devices (BRDs), which have been required in the western Gulf since 1999. Presently, BRDs may only reduce red snapper bycatch by 10-15% (Foster, SEDAR7-DW-29). Studies of red snapper and shrimp behavior or requirement of different existing BRD designs may improve effectiveness (Parsons SEDAR7-DW-4), but these improvements are still under development or complicated to deploy effectively in the field. Analysts could be charged with predicting the long-term effort of the shrimp fishery and likely maximum real-world BRD effectiveness. A selectivity/ shrimp effort pattern could then be constructed based on this level of bycatch.

3) The selectivity and effort patterns could be set under the assumption that all bycatch were eliminated. Although it is extremely unlikely that all bycatch could be eliminated, this scenario would represent an ideal but theoretical description of waste-free fisheries. Mandates to reduce bycatch to the extent practicable indicate a desire to minimize waste. However, given the inevitability of catching unmarketable red snapper in the shrimp fishery, this approach might be considered unachievable and therefore impracticable.

4) Extending item 3), one could use a simple knife-edge selection near the age of maximum biomass without fishing, and an F approximating the replacement curve at maximum surplus recruitment. This approach has the advantage of making MSY a property of the stock, rather than a property of the fishery; thereby moving any allocation and selectivity discussions to the realm of Optimum Yield. The disadvantage is that MSY might for some fisheries have little practical meaning as a desirable management target.

An alternative way to address bycatch was proposed by Powers (SEDAR7-DW-51). He assumed that if one reduced bycatch to the full extent practicable, MSY might be calculated based on the maximum yield that would be achievable in the directed fisheries. Powers suggested three possible ways to assign a fishing mortality rate for bycatch—as a proportion of the directed fishing mortality rate, as a constant independent of directed fishing, or as a proportion of the fishing mortality rate that would produce MSY in the absence of any bycatch mortality. The method of modeling bycatch had dramatic results on a whole host of MSY reference points (see SEDAR7-DW-51, Fig. 1). Of concern is the range of sensitivity in estimates of B_{msy} to one of the methods identified – which essentially treats bycatch F as a form of 'natural' mortality which cannot be controlled through management intervention, since the B_{msy} reference point is more a function of the underlying stock recruit relationship than the combined fishery selectivity. Because of its implications for achieving various management objectives, the methods outlined in SEDAR7-DW-51 would require input from policymakers prior to a specific allocation between fishery sectors being adopted. As with the three approaches identified above, this one could be illustrated and the implications described to policymakers to stimulate their consideration and inform their decision.

One other alternative for determining MSY would be an ecosystem-based energetics approach. Driggers (SEDAR7-DW-12) examined the amount of prey that would be required to support various stock sizes of red snapper based on a variety of mortality, catch, and energetic considerations. He was unable to come up with a single estimate due to parameter uncertainties, nor to test those predictions against real world prey biomass levels because that information is not yet known. As a result, this approach needs further development before it can provide useful benchmarks for calculating MSY and associated reference points. Even then, selectivity and effort allocation patterns will influence the reference points as described above.

1.9 Natural Mortality

Issues to be resolved before the August 2004 SEDAR Assessment workshop:

1. No resolution could be achieved over whether the previously applied values for the natural mortality rate for age 0 (M_0) and age 1 (M_1) should be updated. The previous values came from comparing model-based estimates of age distributions to data from surveys focusing on young fish. There was a good match for overall Z in 1995 when values of $M_0 = 0.5$ and $M_1 = 0.3$ were used. However, new data has come to light, for example, SEDAR7-DW-21, which presented a new estimate of Z_0 of 2.3 yr^{-1}. However, a number of problems were identified with the interpretation of this study (including immigration and emigration effects), leaving the question of whether the new evidence was sufficient to outweigh the approach used previously.

Proposed solutions:

a) Update the evaluation of the relationship between the Fall Groundfish and summer SEAMAP age 1 indices to estimate Z for age 1 (evaluation originally conducted in Goodyear 1995); compare this with ADAPT VPA predictions of Z for age 1 conditioned on a variety of values assumed for M_0 and M_1.

b) Gather more literature on the potential decay in M with juvenile fish size.

c) Formulate a prior probability distribution for M_0 and M_1 that accounts for the sources of uncertainty in estimates of these values and the available empirical information.

2. It was agreed that the 2004 assessment should test the sensitivity of stock assessment and projection results to assuming a range of plausible values for M_0 and M_1. However, it was not decided which values should be considered for this sensitivity test.

Proposed solutions:

a. Wait until there has been a decision on the base case values to adopt for M_0 and M_1, then make decisions about the values to consider in the sensitivity tests.

b. Use a wide range of plausible values, e.g., Goodyear (1995, 1996) had used 0 to 4 yr^{-1} for M_0 and 0 to 2 yr^{-1} for M_1.

A few papers, namely SEDAR7-DW-49 and -21, suggested some possible alternatives to the values for M applied in the Goodyear (1995) and Schirripa and Legault (1999) assessments. No consensus emerged over the question of adopting revised base case values for M for age 0 (M_0) and age 1 (M_1) year fish. Considerations regarding the options for specifying M at age based on the last several stock assessments and the new options provided by SEDAR7-DW-21 and -49 are summarized in Table 1.3. Nonetheless, the sub-group remained unconvinced that new information could justify an update of the value of natural mortality rate applied for ages 2+ (M_{2+}=0.1 yr^{-1}) used in Schirripa and Legault (1999). (There is in SEDAR7-DW-8 a catch curve from the fishery-independent longline survey that might provide an upper limit on adult M (7+). The estimated Z was 0.13 (one s.e., 0.01), essentially imply the same adult M used by Schirripa and Legault.)

The rationale that had been applied to support the values for M_0 and M_1 in the last few assessments was sought and is summarized below. The sub-group generally agreed that in the upcoming stock assessment, tests of the sensitivity of stock assessment results to alternative plausible values for M_0 and M_1 should be conducted. The particular sets of values to consider for these sensitivity tests however have yet to be agreed. Subsection 1 summarizes the discussion of SEADAR-7- DW-49's proposal for revised values for natural mortality rate at age. Subsection 2 summarizes the discussion of SEDAR7- DW-21's recent field experiment based estimate of natural mortality rate for M_0. Subsection 3 reviews rationale that had been applied to support the values for M_0 and M_1 in the last few assessments.

<u>Discussion of SEDAR7-DW-49</u>

Previous estimates of the rate of natural mortality rate (*M*) for (*L. campechanus*) were briefly reviewed in this paper, together with some common approaches to produce approximations of *M* such as Hoenig (1983) and Ralston (1987). The concept that natural mortality rate decays with age was also reviewed (e.g., Shepherd and Breen 1992). The paper proposed a new formula to compute natural mortality at age for age groups 0 to 4+ years with the values constant for ages 4+ years. A decay in *M* at age was modelled by a particular fixed proportion, *p*. Ralston's approach of assuming that *M* can be approximated by doubling the growth rate, *K*, was applied to estimate a mean value for *M* over ages 0 to 4+. The formula was applied to suggest particular values for M at age assuming a variety of decay rates, *p*. While the sub-group acknowledged that this offers one new potential mechanism to set values for *M* at age, the method for assigning values for *M* at age is still arbitrary. The approach is quite a marked departure from the values for *M* in applied the 1995 and 1999 assessments, especially in that the decay in *M* at age was extended to age 4 years. In contrast, the decay in the 1995 and 1999 assessment values is confined to ages from 0 to 2 years. Some suggestions were offered to have the asymptotic age for *M* to be set at some particular life history point at which *M* could be reasoned to be constant such as the age that fish become free swimming. However, this was countered by the suggestion that there may be a variety of reasons for *M* becoming constant with age at a variety of different points in the life history. Without any empirical support, such a new proposal would be no less arbitrary than the values for *M* in the last few assessments.

Discussion of SEDAR7-DW-21

This paper describes field experiments leading to a new estimate of the M_0. The experiment set up clusters of 2x2m shell and shell/concrete block artificial reefs at approximately 20 meter spacing. Plastic pillars were erected in spaces between the reefs to signal whether shrimp trawls had swept through the experimental reef sites. None were knocked down, indicating that in the duration of the experiment, no shrimp trawls had encroached upon the experimental sites. Anti-predator cages were placed on some reefs to evaluate whether predation might be reducing the number of fish on the reefs. Cages were placed in nearby areas with no reefs but no aggregations formed about these cages. Higher densities in the caged reefs suggested that predation could be reducing the abundance of fish on non-caged reefs. However, it was noted in the sub-group that shrimp bycatch and predation may also be occurring when fish foraged at night away from the artificial reefs. Field observations were gathered from a total of 94 artificial reefs between 1999 and 2004.

The abundance of age zero fish on shell reefs was estimated at the peak of abundance in July by in situ sampling and sampling with quadrats when abundances were high. Abundances of age 1 fish on nearby concrete block reefs in July of the same year were also estimated using the same techniques. Estimates of the rate of natural mortality rate for age 0 fish (M_0") in four successive years were obtained by evaluating the annual difference in abundance between age 0 fish and age 1 fish on these artificial reef sites. It was noted at the workshop that the estimates for each of the four years could be made more accurate by using the relative abundances of the same cohort, age 0 abundance in one year and then age 1 abundance in the next year rather than age 0 and age one abundance in the same year. However, this alternate technique was hampered by a year, mid experiment, when data could not be collected. As a result, there were only two cohorts that could be examined from one year to the next. The mean of the four annual estimates, 2.3 yr^{-1}, was offered as a new empirically derived estimate of annual mortality rate for age 0 fish. This suggests an annual survival rate of a fish from 2cm to 20 cm of about 10% (=exp(-2.3)), as opposed to 52% (=exp(-(0.5+0.3/2))) from the previous two stock assessments. However, the 52% figure only accounts for natural mortality. When estimated fishing mortality is also included, the survival rate is 18% (=exp(-(0.5+0.3/2+0.35+1.4/2)) using average estimated F rates from 1995-97). This level is more consistent with the experimental findings if one assumes the fish left reefs and became vulnerable to shrimp bycatch at night.

The sub-group discussed the following potential biases in this estimate. The new estimate of M_0 may be biased by immigration and emigration of age 0 fish to or from the artificial reef sites. Net immigration from, or net emigration to, the site following the initial July measurement, could bias the estimates of M_0 either too high or too low. Dr. Szedlmayer indicated however, that tagging of some individuals on the sites indicated some emigration and migration but not extensive rates of either [but the key question here is whether one can differentiate between mortality and migration, and it is not clear that a localized tagging

experiment can make this distinction]. The habitat upon which the estimates were obtained is only one of several different types of habitat upon which age 0 fish are known to settle. This rate of natural mortality here thus might not be representative of the mean rate of natural mortality of age 0 fish when all habitats are considered. For example, a study of post-settlement red snapper in Texas showed that they grew faster and has lower mortality rates when living on nutrient-rich inshore mud bottoms than on shell ridges or offshore mud bottom (Landre, unpublished results), which could suggest the shell reef-based estimates could be too high Dispersion of age 1 fish off the reefs would also bias the estimates towards being too high.

Should assessment scientists wish to consider Szedlmayer's estimate further some additional considerations will need to be addressed. For example, M_0 in the stock assessment represents newly settled fish up to the end of the year. This may on average represent fish from a settlement in July to December. Thus M_0 would need to represent on average the rate of natural mortality for the first six months of settlement. The value derived from Szedlmayer's data represents M for the first year and thus would need to be partitioned between year 0, which encompasses the first six months, and the first half of year 1. Some assumed value would still be required to provide an annual value for M for the second half of year 1. Because it is generally regarded that the rate of natural mortality in newly settled juvenile fish must decay as the fish grows larger (as indicated in Rooker et al. 2004), then it is likely that the rate of natural mortality for the first six months of settlement would be larger than for the second six months. Thus rather than dividing Szedlymayer's value by two to obtain the value of M_0 for the first six months, some larger fraction of Szedlymayer's value might be assumed for the first six months. For example, if a value 67% of Szedlymayer's value was assumed for the first six months, then a value 33% of that would be assumed for the following six months. A value smaller than 33% Szedlymayer's value would need to be assumed for the latter six months of the first year. This example, is intended only as an illustration of how M_0 might be partitioned and a decay in M with size consistently incorporated.

A third study (Rooker et al. 2004) was briefly discussed in which an estimate of 0.12 d^{-1} for the first 10 days of settlement was obtained. This estimate was based on catch curves for age 47-57 day old yoy and, using a ~28 d PLD estimate, would make these cohorts between 20 to 30 days post-settlement. This implied a potentially much higher estimate of M_0. However, the extrapolation of this value to the remaining period of the year is not currently possible because this value is likely to decay as the fish grows larger and the rate of decay in M_0 over the first year is currently unknown.

Despite these limitations some members of the sub-group suggested that this new estimate be considered to formulate a revised base case input value of M_0 and M_1 for the stock assessment of red snapper. While biasing effects could occur due to migration or the age interval over which calculations are made and this site might not be representative, the experimental protocol applied was rigorous and the estimate provided was not implausible. Yet, no consensus could be reached at the meeting. It was suggested that before such a proposal could be considered, the rationale provided for the base case values of M_0 and M_1 in the 1995 and 1997 stock assessments be retrieved. It was agreed, however, that the sensitivity of stock assessment results to a range of possible values for M_0 and M_1 be evaluated in the upcoming stock assessment to account for potential effects of uncertainty in these values of stock assessment results. A set of potential values of M_0 and M_1 for this sensitivity analysis has yet to be recommended.

It was subsequently suggested that the available data be compiled to formulate a prior probability distribution for the parameters M_0 and M_1 that could be used in Bayesian stock assessment methods for red snapper (e.g., SEDAR7-DW-50). The prior would incorporate all available information and also reflect the uncertainty over the values for these parameters. It is intended that this prior be formulated to be ready for the August 2004 stock assessment.

Review of justifications for the values for M_0 and M_1 in Goodyear (1995)

A review of Goodyear (1995) revealed that the values, 0.5 and 0.3 yr^{-1}, adopted in this stock assessment for M_0 and M_1 appear to have been assumed initially and later checked against evidence. For example, on page 40 in the section on shrimp discard mortality it is stated that "Natural mortality was assumed to be 0.5 for age 0 and 0.3 for age 1". Similarly on p. 43, in the SPR analysis, it is stated "Analyses assume natural

mortality (M) to be 0.5 at age 0, 0.3 at age 1, 0.1, 0.15 or 0.2 for ages 2-30." In the section on natural mortality on p. 7,8 (which appears to be largely repeated in Schirripa and Legault 1999), a variety of techniques are presented to utilize other life history and sample information to approximate Z for ages of two years and older; an approach for checking the consistency of the assumed values for M_0 and M_1 is provided on page 41.

On page 41, two different approaches are offered to estimate Z in the first year from the midpoint of the 2nd trimester to the midpoint of the 3rd trimester. One is a regression of fall groundfish survey catch rates on summer SEAMAP survey catch rates. It is assumed here that "if the catchability of age-1 red snapper is the same in the summer SEAMAP and Fall Groundfish surveys, the decay in their relative abundances between the two surveys would be an estimate of the mortality between the two periods." The slope estimate of 0.473 suggests a value for Z of 0.75 (0.75=-ln(-0.473)), for this particular period between the middle of the 2nd and middle of the 3rd trimesters. This trimesterly estimate expanded to an annual estimate this becomes 2.25 yr^{-1}. The second approach was to apply the ADAPT VPA method, assuming a value of M_0 = 0.5 and M_1 = 0.3, and M_{2+}=0.1 and the shrimp bycatch estimates. The reported estimate of Z for the same trimester period was 0.86 yr^{-1}. This gives an annual value of Z of about 2.58 yr^{-1} for age 1 fish. Assuming the same values for M_1, M_{2+}, but instead a value of 0.15 for M_0, the trimester value for Z was 0.79. Assuming a value of 0.2 for M_0, gave a trimester estimate of Z of 0.71. The extrapolated annual value of Z of 2.58 yr-1, assuming M_{2+} = 0.1, appears to be slightly higher than the annual estimates in Figure 82 of Goodyear (1995) which were estimated instead on a trimesterly basis. Thus the values of M_0 = 0.5 and M_1=0.3 give approximately consistent estimates of the trimester estimate of Z from the Fall Groundfish – summer SEAMAP index. Yet the annual extrapolated value for Z appears to be rather high. The sensitivity of ADAPT predictions of the trimester Z for age one fish to different values for M_0 and M_1 however were not reported.

In summary, this approach still provides a means to evaluate whether ADAPT VPA predictions of trimester Z for age 1, are consistent with predictions using the regression of summer SEAMAP survey cpue on Fall Groundfish survey cpue for age 1. Unless the VPA calculation applied has been misinterpreted, this method seems only to cross check the M_1 values assumed in the VPA. Because cohort abundances are back-calculated, this method still does not appear to provide a mechanism to ground truth assumed values for age 0 fish. Moreover, only the value of M_1 after the middle of the 2nd trimester are utilized in predicting the 2nd-3rd trimester Z value. If only this latter segment of the year is used to ground-truth values for M_1, this could potentially give a negatively biased estimate of M_1. This is because the rate of natural mortality could be expected to decay in fish between 6 months old (beginning of age 1 category in stock assessment model) to fish 18 months. This model-based approach to ground-truthing values for M_1 also assumes that the catchabilities of age 1 fish are the same between the Fall groundfish survey and the summer SEAMAP survey. Nonetheless, this approach still provides a mechanism to evaluate consistency of model predictions and observed catch per unit effort (CPUE) values for age 1. It is recommended that this analysis be updated using more up-to-date estimates of Summer SEAMAP survey and Fall Groundfish survey CPUE for age 1. It is also recommended that a wider variety of M_1 values be applied to check consistency of VPA predictions of 2nd-3rd trimester Z values for age 1 with the age 1 survey age catch rate estimates of this trimester Z. Further, it is recommended that additional trawl cpue data be compiled to obtain additional independent approximations of Z for early life history phases of red snapper, especially, phases earlier than those of age 1 fish in the mid 2nd trimester.

During plenary discussion it was pointed out that SEDAR7-DW-2 constructed similar estimates of Z_0 based on regressing fall (age 0) and subsequent summer surveys (age 1). Those results averaged over surveys since 1987 indicate an average Z of 1.8 largely representing the loss from age 0 to age 1. It was subsequently suggested that the newly compiled observer dataset on red snapper bycatch in the shrimp trawl fishery be considered to provide additional independent empirical annual and possibly monthly estimates of Z for age 0 fish. This is a dataset compiled from joint National Marine Fisheries Service and Gulf and South Atlantic Fisheries Foundation observer programs. The observers on board shrimp trawlers sampled all snapper bycatch in shrimp trawl hauls and the data have been compiled for thousands of hauls in Gulf waters. Average catch rates of age 0 and age 1 fish by location and month are available for several years. A catch-curve analysis of these data will permit estimation of Z over monthly intervals between

September when age 0 fish become fully susceptible to shrimp trawl gear and June before the age 1 fish migrate to habitats where they become less susceptible to shrimp trawl gear.

For the SPR analysis, projections and base case shrimp bycatch mortality rate estimates in Goodyear (1995), base case values of 0.5 and 0.3 were assumed for M_0 and M_1. In shrimp by-catch sensitivity tests, values ranging from 0 to 4 for M_0 and 0 to 2 for M_1 were considered. In the text on p. 41 it is stated that "Natural mortality for the cohort through the end of its first calendar year (age 0) was set to 2 times greater than during its second calendar year (age 1). This expansion permitted an expansion of the range of natural mortality considered for younger fish. This convention is purely arbitrary and does not reflect any particular expectation that the level of natural mortality is actually 2 times greater than in the older fish." Of these ranges of values it is stated on p. 42 that "it is likely that the actual natural mortality is well within the range of values examined." No further justifications for these particular values of 0.5 and 0.3 could be found in the Goodyear (1995) document. No such justification could be found either in the Schirripa and Legault (1999) document. It thus appears that the base case values of 0.5 and 0.3 originated from, and were justified in, Goodyear (1995) and have not been modified or updated since then. Neither has there been much attention given to the uncertainty in these values, except for the 1995 test of sensitivity of shrimp bycatch values to a range of values for M_0 and M_1.

The limited attention given to the assumed values for M in the 1995 stock assessment was addressed in McAllister's serving on the Science and Management Panel in the August 1997 Peer Review of Red Snapper (*Lutjanus campechanus*) Research and Management in the Gulf of Mexico. Commenting on the use of the assumed values of 0.5 and 0.3 for M_0 and M_1 in Goodyear's ADAPT sequential population analysis: Regarding the VPA projections,"… no sensitivity analysis was conducted on M for age 0 and age 1. [While] there is considerable uncertainty in these two quantities and unlike for the value of M for ages 2+, there was no empirical analysis presented to support these values. During the panel meetings Benny Galloway presented one laboratory study to indicate that these two values could be much larger. Reasonable alternative[s] could perhaps be 1.0 and 0.5. More work is needed to attempt to obtain better guesses at values for these quantities."

<u>Natural Mortality Summary</u>

With recent research on possible values for M for age 0 fish, scientists are now in a position to consider updating the previously assumed values for M_0 and M_1 with some empirically based estimates. Some further scrutiny of Szedlmayer's study (SEDAR7-DW-21) will be required before the new estimate in this study might be considered as a basis to provide updated base case values or prior probability density functions for M_0 and M_1. Considerations regarding the options for specifying M at age based on the last two stock assessments and the new options provided by SEDAR7-DW-21 and -49 are summarized in Table 1.3. The following points summarize the issues that remain to be resolved before the August 2004 stock assessment.

1. No resolution was achieved over whether the values assumed for the natural mortality rate for age 0 (M_0) and age 1 (M_1) should be updated.

•On Szedlmayers's paper #21 estimate of M_0 (2.3 yr^{-1}), it was recognized that the estimate could be biased by

•Immigration and emigration of age 0 fish to and from the study site

•The non-representative features of the artificial reefs employed (e.g., they could entail either higher or lower predation risk for age 0 fish when compared to natural sites).

•Use of same-year on site abundance estimates of age 0 and age 1 rather than cohort based estimates

Nonetheless, the overall Z values for the first full year post-settlement were relatively similar across a range of estimation procedures, including Szedlmayer's field work and Schirripa and Legault's model-based values used in the last red snapper assessment.

Proposed solutions:

•Update the regression of the age 1 fall groundfish survey cpue on the summer SEAMAP cpue age 1 index to approximate Z for age 1, and comparisons with VPA estimates of Z_1 (Goodyear 1995) (q assumed the same)

•For example Goodyear (1995) had obtained:

Z_1(VPA, M_1=0.3, M_0=0.5, M_{2+}=0.1)=2.52 yr^{-1}; Z_1(SEAMAP) =2.25 yr^{-1}

•In the updated analysis compare SEAMAP estimates of Z_1 with VPA predicted values for Z_1 using M_0 and M_1 set at different values.

•SEDAR7–DW-2 constructed similar estimates of Z_0 based on regressing fall (age 0) and subsequent summer survey; utilize these estimates also.

•Analyze the dataset compiled from joint National Marine Fisheries Service and Gulf and South Atlantic Fisheries Foundation observer programs to estimate Z_0 between September and July, and evaluate whether these data contain sufficient information to estimate trimester values for Z.

•Gather more literature on the potential decay in M with juvenile fish size.

•Formulate a prior probability distribution for M_0 and M_1 that accounts for the sources of uncertainty in estimates of these values and the available empirical information.

2. It was agreed that the 2004 assessment should test the sensitivity of stock assessment and projection results to assuming a range of plausible values for M_0 and M_1. However, it was not decided which values should be considered for this sensitivity test.

Proposed solutions:

•Wait until there has been a decision on the base case values to adopt for M_0 and M_1, then make decisions about the values to consider in the sensitivity tests.

•Use a wide range of plausible values, e.g., Goodyear (1995, 1996) had used 0 to 4 yr^{-1} for M_0 and 0 to 2 yr^{-1} for M_1.

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Table 1.1. Sample numbers of female red snapper for two maturation data sets by region and state from east to west, 1999-2001.

Region	State	NMFS 2004	Woods 2003
East	FL	200	
	AL	31	1029
	MS	16	
	East Total	247	1029
West	LA	68	653
	TX	105	
	West Total	173	
Total	Total	420	1692

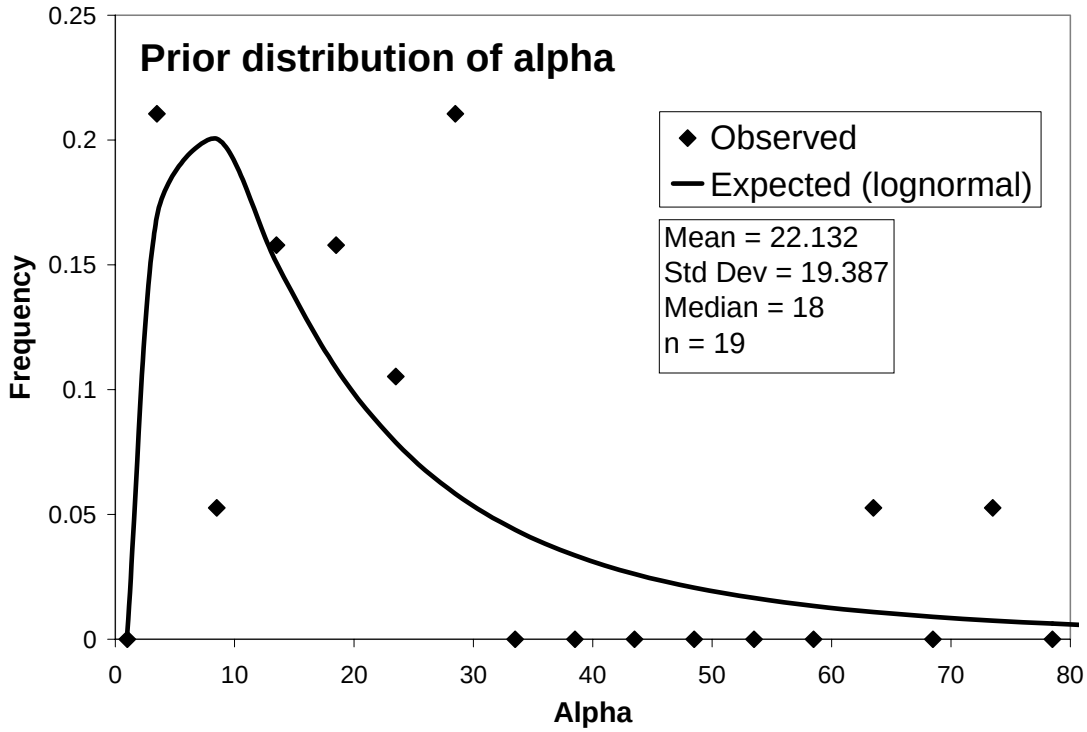
Table 1.2. Sample numbers of red snapper for 2 batch fecundity data sets by region and state from east to west, 1999-2001.

Region	State	NMFS 2004	Woods 2003
East	FL	43	
	AL	18	142
	MS	5	
	East Total	66	142
West	LA	9	81
	TX	19	
	West Total	28	81
Total	Total	94	223

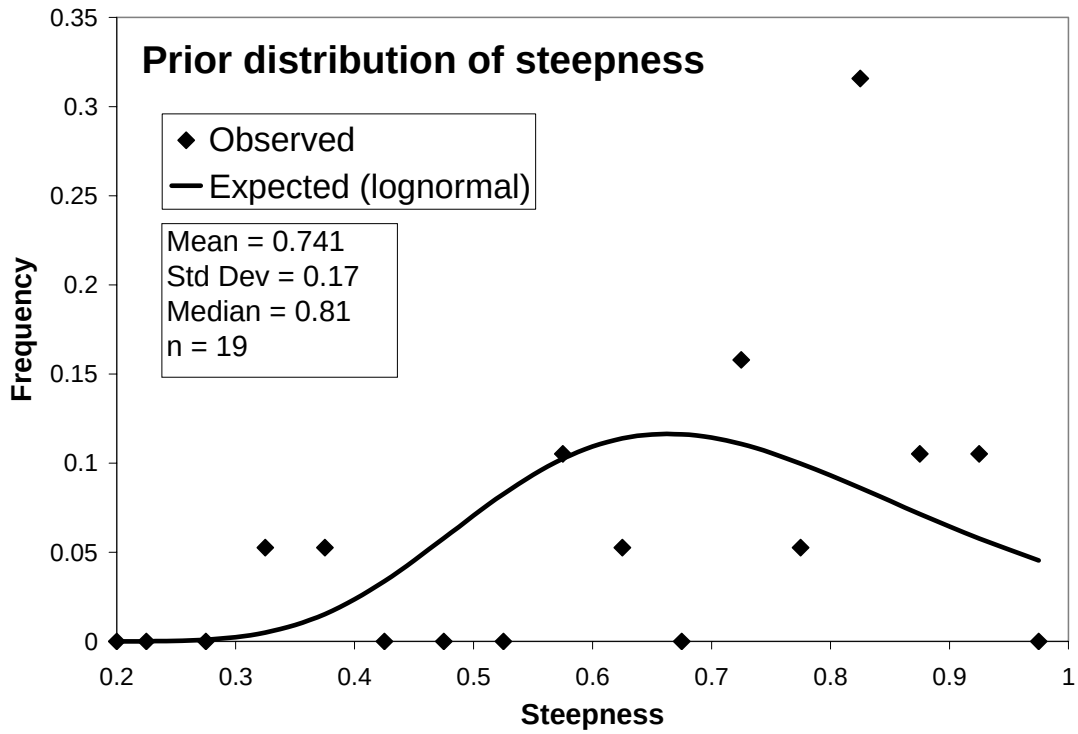
Table 1.3. Considerations regarding the options for specifying M at age based on the last two stock assessments (Goodyear 1995; Schirripa and Legault 1999) and the new options provided by SEDAR7 DW21 and SEDAR7 DW49 are summarized in Table 1.1.

Papers	Apparent base case values for M	Considerations	Sensitivity tests?
Goodyear (1995)	M_0 = 0.5 yr^{-1} M_1 = 0.3 yr^{-1} M_{2+} = 0.15 yr^{-1}	Values for M_{2+} justified based on Pauly (1980) and Hoenig (1983) and sample and life history information for red snapper. No explicit justifications offered for the values assumed for M_0 and M_1. A belief is stated that the actual values for M_0 and M_1 should fall well within the range of values for these parameters in the sensitivity tests of shrimp bycatch mortality estimates. Because M_0 operates only for the first year, the annual survival rate of age 0 fish implied is exp(-(0.5+0.3/2) = 0.52. VPA predictions of the mid 2nd to mid third trimester Z (Z_{t23}) for age 1, utilizing the value of 0.3 for M_1 were cross checked with a prediction of Z for age 1 based on a regression of the Fall Ground fish survey cpue on the summer SEAMAP CPUE. When M_{2+} = 0.1, values of Z_{t23} = 0.86 and 0.75 were obtained was also incorporated. These values would need to be expanded to annual values to obtain annual Z's of approximately 2.58 and 2.25 yr^{-1}, respectively.	M_{2+} = 0.10 and 0.20 yr^{-1} also tried for SPR and stock projection analysis Sensitivity of Bycatch mortality estimates to values for M_1 from 0 to 2 yr^{-1} and M_0 from 0 to 4 yr^{-1} evaluated.
Schirripa and Legault (1999)	M_0 = 0.5 yr^{-1} M_1 = 0.3 yr^{-1} M_{2+} = 0.1 yr^{-1}	Values for M_{2+} justified based on Pauly (1980) and Hoenig (1983) and updated sample and life history information for red snapper. No explicit justifications offered for the values assumed for M_0 and M_1.	No tests of sensitivity of stock assessment results to values for natural mortality
SEDAR7 DW49	A variety of options with M_0 starting at 0.4 and decreasing to 0.26 for age 4+ to M_0 starting at 1.28 and decreasing to 0.08 for ages 4+.	Values for average M at age justified based on Ralston (1987) and Hoenig (1983) and sample and life history information for red snapper. A decay function for M at age is proposed: M_i = 2k(1-p)i-2 where k is the growth rate (0.16yr^{-1}) and p is an inputted parameter to specify the rate of decay in M with age. The paper offers an explicit and transparent quantitative rule for specifying a decay in natural mortality rate at age. However, justifications for the age at which natural mortality rate becomes asymptotic and the decay rate will be required. The equation does not permit empirical estimates of M at age to be incorporated.	Not applicable
SEDAR7 DW21	A field experiment was designed to provide an estimate of natural mortality rate for age 0 fish.	The experimental protocol was rigorously designed and executed. The estimate of M0 is obtained from averaging across annual estimates for four cohorts. Net emigration of age 0 fish away from the experimental site from after the age 0 census and before the age 1 census could positively bias estimates of M_0; net immigration of age 0 fish to the site after the age 0 census and before the age 1 census could negatively bias estimates of M_0. The sample site utilized artificial 2x2m shell reefs upon which age 0 fish settled and 2x2 concrete block/ shell reefs upon which age 1 fish settled. This artificial habitat may provide superior protection from predation relative to other habitats used by age 0 and age 1 fish and could negatively bias estimates of natural mortality. The value of 2.3 yr implies an annual survival rate of about 0.1 for fish between 2cm and 20cm.	Not Applicable

		Values for M_0 and M_1 would need to be derived from this annual estimate of 2.3 yr^{-1}, taking into account that M_0 in the first year is only for six months and the decay in natural mortality rate as fish size increases.	



a)



b)

Figure 1.1. Distributions of stock recruitment parameters from marine demersal species with a periodic life history. a) α, the maximum lifetime fecundity, and b) steepness, a representation of recruitment levels expected at low abundance. Points represent frequencies, lines represent fitted lognormal distributions.

2. Commercial Fishery Statistics

2.1 Commercial Landings

Commercial landings statistics are the quantities and value of seafood products sold to established (licensed) wholesale and retail seafood dealers. Currently, these data are collected by trip ticket programs managed by the state fishery agencies in Florida, Alabama, and Louisiana (SEDAR7-DW-20). Dealers in Mississippi and Texas are required to submit monthly reports that provide quantity and value by species. Prior to the implementation of the trip ticket programs, landings statistics were collected by NMFS/state employees that visited the seafood dealers monthly and recorded the quantities and value purchased for each species for a calendar month. In addition, the agents would assign an estimate of the type of gear and fishing area where the landings were caught.

The Southeast Fisheries Science Center (SEFSC) has maintained the commercial landings statistics (also know as, general canvass landings statistics) in a regional database since the mid 1980's. The states provide the landings statistics from their trip ticket or monthly program to the SEFSC and these data are summarized and maintained in the same format as the historical general canvass data. The objective of the SEDAR Data Workshop is to provide a final (agreed upon) data set that contains the landings at the following level of resolution - year, month, gear, fishing area (the NMFS statistical grids), and state/county where the fish were landed. The Panel also requested that the SEDAR landings data set for red snapper be extended as far back in time as possible. The Panel recognizes that landings data for the "older" years may not be available at the desired level of resolution, but the Panel still recommends that all historical data be included with explanations of the data limitation included.

As described in Working Paper, SEDAR-DW-22, the SEFSC maintains the general canvass database for the southeast region. The general canvass database includes landings data from 1962 through 2003. However, as noted in SEDAR-DW-22, there are several situations during the 1962-2003 time series that the data do not meet the desired level of resolution. The following identifies these situations:

1. only annual data are available for 1962 - 1977;
2. for Florida, gear and fishing area are not available for monthly data for 1977 - 1984;
3. for Louisiana, gear and fishing area are not available for 1990 - 1999,
4. for Texas, an unusually large of allocations of red snapper landings were assigned to shrimp trawl gear for 1978 - 1983;
5. for Texas, gear and fishing area are not available for 1990 - 2003.

The Workshop Panel recognized the lack of resolution for the 1962 - 1977 period; however, the Panel did not see a need to distribute the annual percentages by gear and fishing area by month for this time period.

For the landings on the west coast of Florida during the period 1977 - 1984, data on the allocation of landings gear and fishing area are available from the Florida annual general canvass data. The concern is whether landings are distributed evenly throughout the year or whether there are seasonal patterns which result in uneven landings by gear throughout the year. The monthly data from the Florida trip ticket program were analyzed to determine if the landings by gear are different throughout the year for handline and bottom longline gears. For both the period 1991 - 1995 and 1996 - 2003, the average percentages for these two gear types by month are very similar throughout the year. For example, the average percent of the landings by handline gear for 1991 - 1996 varies between 87.4 % and 98.3 % throughout the year. Given these similarities, the Panel agreed that the percentage allocations from the annual general canvass can be applied to the monthly general canvass data to provide the desired resolution for the SEDAR data base.

As noted in the 3rd item, gear allocations are not available for the Louisiana landings from 1990 through 1999. The Panel agreed that the percentages by gear from the SEFSC logbook program should be used. The Panel also noted that the logbook data are essentially the only alternative for gear allocations during this period.

The 4th item relates to the gear allocations for Texas landings during 1980 - 1983. For this 4 year period, approximately 50 to 60% of the landings were reported from shrimp trawls. The Panel agreed that such a large allocation to this gear type is highly unlikely. Several Panel members stated that the fishery for red snappers was undergoing a transitions during this period. The landings statistics from the 1962 - 1977 period show commercial landings of red snapper from shrimp trawl and it is likely that commercial landings of the shrimp trawl fishery continued through the 1978 - 1983 period. In 1984, a 12" minimum size limit went into effect and the commercial landings of red snapper from shrimp trawls decreased appreciably. In 1980, a small fleet of bottom longline vessels fished off the Texas coast and introduced bottom longlining to the fishery. Because shrimp trawlers were relatively easily re-rigged for bottom longline fishing, this provided these vessels with an alternative to shrimping during the off-season. The large percentages of the commercial landings during the 1978 - 1983 period suggests that these landings were not adequately allocated to either hook & line fishing or the newly introduced bottom longline fishery. The Panel notes that Goodyear, 1995, presents allocations by gear for a shrimp trawl index; however, the method used to allocate the red snapper landings by gear type was not described in the assessment. At this time, no reliable allocations by gear are available for this 4 year period.

The last item is similar to the 3rd item in which gear allocations are not available for Texas landings for the period 1990 - 2003. The Panel agreed that the gear allocations from the SEFSC logbook program should be used to provide the best estimate of the landings by gear for this period.

In summary, the Panel recommends that for 1990 and later the gear allocations available in the general canvass (trip ticket) data be retained and the gear allocations from the SEFSC logbook data be used for Louisiana (1990 - 1999, the Louisiana trip ticket data have gear designations for 2000 - 2003) and for Texas landings.

The Panel also considered the allocations of landings by fishing area (i.e., the statistical grid established by the NMFS). Because the logbook data are reported by fishermen and are likely to provide a more realistic distribution of fishing areas, the Panel recommends using the logbook data to identify the allocations of landings by fishing areas. It was noted that annual allocations provide a better distribution than monthly allocations because some areas and months may not be covered by the logbook reporting.

The SEFSC general canvass landings data will be the basis for the SEDAR landings data base for the red snapper assessment with the adjustments for gear and fishing area specifications as noted above. The annual landings of red snapper by gear categories are presented in Table 2.1 and the annual landings by east and west Gulf are presented in Table 2.2.

2.2 Size Frequency Data

Size frequency data are collected as part of the Trip Interview Program (TIP), as well as the biological component of GulfFIN. These programs are cooperative data collection activities between the NMFS/SEFSC and the coastal states along the Gulf of Mexico . Hard part (otoliths and spines) and tissue samples are also collected as part of both the TIP and the FIN. These data are used to estimate life history parameters and are discussed in that section of the SEDAR report.

The TIP began in 1984 and data from that year through 2002 are included in the SEDAR Workshop. A total of 174,185 red snapper were sampled (measured and/or weighed) from commercial fisheries during this period and are included in the size frequency analysis. Of those samples, 93.3% were caught from handline gear and 5.6% were caught by bottom longline gear. The numbers of trips from which samples

were taken and the numbers of red snapper samples are presented in Table 2.1 and Table 2.2, respectively, in SEDAR-DW-45. It should be noted that only the samples where the area of catch was reported along with the size frequency sample are included in the size frequency analysis in SEDAR-DW-45. The conclusions from these analyses are:

- red snapper sampled from landings on the west coast of Florida that were caught in grids 1 - 7 had a consistently larger proportion of larger fish than landings that were caught in grids 8 - 10 off the Florida Panhandle;
- the differences in sizes of red snapper sampled from grids 1 - 7 and grids 8 - 12 could not be explained by the samples from vessels with a Class I permit endorsement vs a Class II permit endorsement; and
- red snapper samples landed on the Florida west coast with electric handlines (aka, bandit rigs) were larger than fish landed by manual handline gear for the period 1984 - 1988.

The Panel noted two possible explanations for the differences in size frequency distributions between the two strata for the eastern Gulf (first bullet). These differences may be due to a difference in the way the fishing is conducted in these two areas. In the southern area, grids 1-7, it appears that red snapper caught with handlines may be incidental to the grouper fisheries; whereas the fishery in the northern area, grids 8-12, may be from trips directed at red snapper. The second reason for considering the two strata for the eastern Gulf is the differences in sample sizes for the two areas. The influence of sample size on the size frequency distributions is analyzed in SEDAR-DW-43. The sample sizes of the individual trips in the grids 1-7 are generally smaller than the sample sizes for the trips in grids 8-12.

The size frequency data for red snapper samples suggest the following stratification for calculating catch-at-size distributions for the commercial harvest:

- For handline gear, which includes the manual and electric/power assisted reel in a single category, three area stratification can be considered. These strata are grids 1-7, grids 8-11 (or 12) and grids 12 (or 13) to 21.

- For bottom longline gear, the size frequency support two strata, grids 1 - 10 and grids 11 - 21.

The TIP data were analyzed to determine if species misidentification, i.e., other species being misidentified as red snapper or red snapper being identified as other species, in the SEDAR Working Paper, SEDAR-DW-44. The conclusions of this analysis show that neither of the two misidentification scenarios represent a significant portion of the red snapper landings during the period, 1994 - 2003.

2.3 Discards by the commercial directed fishery

In August 2001, the SEFSC initiated a program to collect information on the numbers of fish that are being discarded in the Gulf of Mexico reef fish and South Atlantic snapper-grouper fisheries. To collect this information, the SEFSC developed a form that supplements the existing vessel logbooks that are currently mandatory for these fisheries. The data reported from the supplemental discard reporting are presented in SEDAR-DW-22.

A generalized linear model (GLM) was used to estimate the statistical parameters that are significantly correlated with the numbers of red snapper that were discarded during the two years, 8/1/2001 - 7/31/2003. Separate GLM's were analyzed for the 3 major types of gear (bandit rigs, manual handline and bottom

longline gear) used in the directed fishery for red snapper. The results of the GLM's provided the combinations of parameters that were to calculate the average numbers of red snapper discarded. From the average numbers of discards per trip and the numbers of trip reported during the period 8/1/2001 - 7/31/2002, a total of 738,900 red snapper were estimated to have been discarded during this 12 month period. From the estimated weights provided by the fishermen on the supplemental discard form, the mean weight of fish released by handline gear was 2.35 pounds, the mean for bandit rig vessels was 2.9 pounds and the mean weight for bottom longline vessels was 6.49 pounds. Using these means, the estimated weight of the red snapper discarded during the period 8/1/2004 - 7/31/2004 is 2.1 million pounds (i.e., 108.6 thousand at 2.35 pounds from Table 8, 623.8 thousand at 2.9 pounds from Table 9 and 6.5 thousand at 6.49 pounds from Table 10 of SEDAR-DW-22).

One recommendation from the Panel was to calculate the average weights for the red snapper discarded during the open and closed seasons separately. The concern is that a 2.35 to 2.9 pound fish is a legal size and it is unlikely that fish of this size would be discarded during the open season. For the period 8/1/2001 - 7/31/2003, the mean weight reported for the red snapper discarded during the open seasons was 1.96 pounds and the mean weight of the discarded red snapper during the closed seasons was 4.25 pounds.

From the research conducted by Nieland, Baker, Fischer and Wilson (presentation at the SEDAR meeting), an estimated 69% of the red snapper discarded were dead or remained on the surface. During the project, a total of 399 fish (25 potential discards per trip) were measured and aged. The mean length of these fish was 335 mm (TL) and the distribution by age was 7.3% age 1, 85.5% age 2, 6.8% age 3 and 0.5% age 4. It is assumed that the trips sampled in the LSU project were conducted during the open season and therefore, the vast majority of the red snapper discarded during the open season would have been age 2. Under that assumption, the study does not provide any data on discards during the closed seasons.

Table 2.1. Red snapper landings (whole weight, thousands of pounds) for the Gulf of Mexico by gear categories, 1996 - 2003*.

Year	Bandit Rig	General Handline	Bottom Longline	Other**	Unknown	Total
1962		12,231		241		12,472
1963		13,176		150		13,326
1964		13,758		294		14,053
1965		13,802		253		14,055
1966		12,770		328		13,098
1967		12,016		482		12,498
1968		10,522		604		11,126
1969		9,556		462		10,018
1970		8,245		717		8,963
1971		8,392		494		8,886
1972		8,276		634		8,910
1973		7,898		704		8,602
1974		8,374		564		8,938
1975		7,936		326		8,263
1976		7,224		306		7,530
1977		5,383		290		5,674
1978		4,504		153	388	5,045
1979		4,619		130	215	4,964
1980		4,351	139	403	119	5,012
1981		4,969	229	348	419	5,966
1982		5,321	298	526	264	6,409
1983		5,844	544	477	416	7,281
1984		4,453	1,133	156		5,742
1985		3,092	718	96	531	4,438
1986		2,566	887	102	410	3,965
1987		2,256	798	64	239	3,357
1988		2,894	741	92	333	4,060
1989		2,315	525	43	216	3,100
1990		2,036	226	28	372	2,662
1991	4	2,114	100	8	15	2,241
1992	9	2,974	44	15	0	3,043
1993	0	3,300	62	15	28	3,405
1994	0	2,981	109	9	152	3,252
1995	0	2,868	47	2	37	2,954
1996	0	4,261	34	55	1	4,351
1997	1	4,703	44	76	0	4,823
1998	10	4,608	35	39	1	4,694
1999	35	4,689	128	21	4	4,877
2000	1,320	3,320	192	7	5	4,844
2001	1,552	2,946	150	15	4	4,666
2002	2,168	2,469	149	36	1	4,823
2003	2,461	1,771	183	29	1	4,445

* Source: Southeast Fisheries Science Center, General Canvass Landings Statistics, Miami, FL 33149

** The "Other" category includes the lesser used types of gear such as: nets, shrimp trawls, etc.

Table 2.2. Red snapper landings (whole weight, thousand of pounds) for the Gulf of Mexico by eastern and western areas*, 1962 - 2003**.

Year	Eastern	Western	Outside	Unknown	Total
1962			14	12,457	12,472
1963	3,002	3,818	4,191	2,315	13,326
1964	3,607	3,590	6,856		14,053
1965	3,713	3,646	6,696		14,055
1966	3,099	3,041	6,958		13,098
1967	2,907	4,231	5,360		12,498
1968	2,618	5,161	3,347		11,126
1969	2,442	4,187	3,388		10,018
1970	2,309	4,653	2,000		8,963
1971	2,224	5,366	1,297		8,886
1972	2,374	4,842	1,694		8,910
1973	2,713	4,867	1,022		8,602
1974	3,768	4,434	737		8,938
1975	3,577	3,933	753		8,263
1976	3,288	3,327	915		7,530
1977	2,264	2,873	537		5,674
1978	2,016	2,677	353		5,045
1979	2,045	2,466	454		4,964
1980	1,990	2,561	462		5,012
1981	2,305	3,193	468	0	5,966
1982	2,516	3,733	160		6,409
1983	2,827	3,919	119	416	7,281
1984	2,000	3,669	73		5,742
1985	1,074	2,284	248	832	4,438
1986	614	2,667	233	451	3,965
1987	548	2,206	288	314	3,357
1988	687	2,969	81	323	4,060
1989	474	2,323	1	302	3,100
1990	503	1,501	14	643	2,662
1991	337	1,400	25	479	2,241
1992	365	2,050	10	618	3,043
1993	276	2,511	5	612	3,405
1994	278	2,381	21	572	3,252
1995	187	2,496	8	263	2,954
1996	296	4,026	26	2	4,351
1997	276	4,535	12	0	4,823
1998	406	4,275	12		4,694
1999	597	4,240	39	0	4,877
2000	695	4,141	7	0	4,844
2001	818	3,824	15	9	4,666
2002	1,132	3,661	20	10	4,823
2003	1,076	3,335	32	1	4,445

* Eastern Gulf is the area in statistical grids 1 through 12. Western Gulf is the area in statistical grids 13 through 21. The "Outside" is the area for fishing in grids greater than 21.

** Source: Southeast Fisheries Science Center, General Canvass Landings Statistics, Miami. FL

3. Recreational Statistics

3.1 Recreational Landings

Recreational catch estimates are provided by the Marine Recreational Fishery Statistics Survey (MRFSS), NMFS Headboat Survey, and the Texas Parks and Wildlife Department Coastal Creel Survey (TPWD). Table 3.1 shows the annual estimated catch for red snapper from each survey.

There have been active discussions of MRFSS issues ongoing for some time (see e.g. SEDAR7-DW-27), and the working group spent a good deal of time addressing possible anomalies in the survey results.

After 1998, MRFSS implemented a new methodology to estimate charterboat effort (For-Hire-Survey, FHS). This change in methodology for effort estimation affects the catch estimates since they are the product of estimated effort and observed catch-per-unit effort. Estimates from the previously used method (MRFSS) and the new FHS can not be directly compared because estimates from the old methods have been shown to be biased. Conversion factors to correct for the bias are necessary in order to use Charterboat effort and landings from 1986-1997 and the FHS estimates for 1998-2003 as one time series. Conversion factors can be estimated based on ratios of estimates from old and new methodology which were made simultaneously starting in 1998. Note that from 1981 to 1985 charterboat and headboat were combined into one mode, thus conversion factors for charterboat estimates cannot be applied prior to 1986.

Two preliminary sets of conversion factors were estimated and used to convert 1986-1997 charterboat landings. The general approach to estimate the conversion factors was to use GLM to identify significant factors and predict conversion factor values. The first model included ZONE (Inshore, >3 miles and <3 miles) and WAVE as significant factors for the combined data from the states of LA, MS and AL and only ZONE for the data from FL (note that FL had to be treated separately because ZONE is defined as Inshore, >10 miles and <10 miles). The second model did not include the zone 'Inshore' and had WAVE as the only significant factor. The group agreed that further work is necessary to estimate better conversion factors and new estimates will be presented to the stock assessment working group.

An estimated directed catch-per-trip (cpue) analysis of red snapper by state and year revealed an outlier in Mississippi in 1989. The data in wave 5, Sep-Oct, 1989 contained two angler interviews from the same Private boat mode trip, each reporting 25 red snapper landed (type B1 catch), and a single Private boat mode angler-interview with 4 red snapper landed by 4 anglers (type A catch). The resultant catch per angler-trip was considerably higher than the typical and resulted in an unusually large estimate of red snapper harvest for the wave and the entire year. The group recommended substitution for the Private mode, wave 5, 1989, Mississippi catch estimate, replacing the estimated value with the average of wave 5, Private boat mode, 1988 and 1990. This substitution has been made in the annual estimated catch of red snapper (Table 3.1). Note that the group used catch-per-trip (cpue) analysis to identify outliers instead of examining catch estimates because the inter-annual variability of red snapper catch estimates made it difficult to identify data anomalies.

Complete coverage for estimating recreational catch in Gulf states began in 1986, with the Headboat Survey expanding to include the Gulf, the TPWD survey covering Texas, and MRFSS covering all but headboats in other states (SEDAR7-DW-19). Before 1986, MRFSS and TPWD surveys both operated intermittently and incompletely in TX. Consistent estimates of private boat and charterboat landings in the TPWD data are only available beginning in wave 3,1984 but headboats were sampled by TPWD only during wave 3, 1983 through wave 4, 1984. For the empty cells identified in the period 1981-85 for both MRFSS (including all modes and states in wave 1, 1981) and TPWD, possible substitution schemes need to be investigated.In addition, the group acknowledged that estimated MRFSS landings for the period 1981-1985 have a high degree of uncertainty due to the small number of fish sampled. The group recommended that the uncertainty resulting from low sample sizes and lack of data for both MRFSS and TPWD during 1981-1985 be taken into consideration in the construction of the stock assessment models.

In 2002, LA Headboat owners did not report catch and effort data. The reported catch/effort data from LA in 2001 were used by the Headboat Survey to estimate the LA landings for 2002. The LA red snapper landings are less than 7% of the total headboat red snapper landings in 2002. The group notes that TPWD landing estimates are not final and that new estimates for Texas will be provided which might result in significant changes for 1983-1997 and minor changes for 1998-2002. However, these estimates might not be available for this assessment.

3.2 Recreational Discards

Information about discards is routinely collected through the existing MRFSS methodology. At the present time, there are no estimates of live discards from Headboats and only limited data from TX. The group discussed using the discard estimates from a special study of Headboats in TX for the period August-September 1999 (Dorf 2003) to estimate discard ratios. It was concluded that Dorf's data might not be representative since it was collected close to the end of the fishing season when the proportion of undersized fish is thought to be higher. Campbell et al. presented discard ratios for TX for the period May 2003-present. The group recognized that Campbell's work will be valuable for future assessments. But Diaz (SEDAR7-DW-58) showed that discard ratios vary on an annual basis. Thus, the group was concerned about applying Campbell's discard ratios for years previous to 2003. The group recommended applying the MRFSS discard ratios estimated for the rest of the Gulf of Mexico (Table 3.2) to the TPWD and Headboat data series. The group also recommended that given some concerns raised by the SEDAR about appropriateness of applying MRFSS discard ratios to TPWD and Headbot surveys, an assessment run be conducted without discards to measure the sensitivity of the results to the discards estimates.

3.3 Recreational Sampling Intensity

The percentages of landings observed in the MRFSS, TX Parks and Wildlife and NMFS Headboat surveys were calculated using the observed (or reported) and estimated landings (Tables 3.3-5). The percentages are generally 0.1 to 1.3 annually in the MRFSS, 0.7 to 5.8 annually (2.9 overall) in the TPWD survey, and are typically above 80% in the Headboat Survey, particularly in TX, where most landings of red snapper from headboats occur.

The percentages of landings for which length was measured were also calculated (Tables 3.6-7). The percentages were highest in the Headboat survey (1.13 to 2.73% annually, 1.78% overall) and TPWD survey (0.35 to 2.53 annually, 1.16% overall). Annual percentages in the MRFSS were 0.02 to 0.8, 0.2 overall, but were above 0.5 since 1999 due mainly to increased charterboat sampling.

3.4 Recreational Catch-at-Length and Catch-at-Age

At the present time, very limited data on sizes of live discards are available. Dorf (2003) provided red snapper size composition caught by headboats operating in TX waters, but the temporal coverage of her study is limited (Aug-Sep 1999). Campbell et al. also presented preliminary results from TX for 2003-04. The group recognized that Campbell's work will be valuable for future assessments. However, the group did not recommend applying Campbell's 2003 discard size composition for years prior to 2002 since the 2003 data can not reflect the possible effect of year class strength on the size composition of prior years. The group emphasized the need for more systematic information on discards size composition.

The recreational size data from MRFSS, TPWD, and Headboat Survey indicated flexibility in estimating CAS for the entire Gulf or for east and west strata. The group decided not to make any specific recommendation on where to establish the boundary between east and west areas.

In developing the Catch-at-Age, available FIN size and age data will be reviewed and used in the calculations.

Table 3.1: Red snapper estimated landings (MRFSS is A+B1 and uses the charterboat estimates made with the old method).

YEAR	MRFSS	Headboat	TPWD	TOTAL
1981	1,874,662			1,874,662
1982	1,433,438			1,433,438
1983	2,618,628		254,713	2,873,341
1984	671,864		233,793	905,657
1985	890,249		45,945	936,194
1986	827,623	332,558	34,597	1,194,778
1987	782,174	329,156	49,007	1,160,337
1988	715,762	438,080	71,848	1,225,690
1989	563,132	383,521	97,644	1,044,297
1990	390,817	203,785	26,445	621,047
1991	639,731	280,509	49,099	969,339
1992	972,318	447,228	118,645	1,538,191
1993	1,494,515	496,472	292,264	2,283,251
1994	1,009,847	527,616	199,598	1,737,061
1995	772,112	377,995	72,029	1,222,136
1996	692,021	977,801	42,464	1,712,286
1997	1,126,242	396,121	87,383	1,609,746
1998	1,318,861	321,647	97,394	1,737,902
1999	1,207,474	166,305	54,171	1,427,950
2000	974,559	169,164	56,735	1,200,458
2001	1,087,575	167,700	67,320	1,322,595
2002	1,429,525	213,633	91,216	1,734,374
TOTAL	23,493,129	6,229,291	2,042,310	31,764,730

Table 3.2: Proportion of animal released alive (Type B2) to all catches (Type A + Type B1+Type B2) based on MRFSS catch estimates by year and state.

	State					
Year	TX	LA	MS	AL	FL	TOTAL
1981	0.01	0.01		0.04	0.08	0.03
1982		0.01	0.05	0.002	0.04	0.02
1983		0.001				0.001
1984					0.27	0.03
1985	0.52	0.12			0.06	0.17
1986		0.02		0.05	0.07	0.05
1987		0.07	0.29	0.15	0.06	0.09
1988		0.37	0.15	0.001	0.17	0.22
1989		0.37	0.27	0.05	0.40	0.35
1990		0.61	0.79	0.56	0.45	0.58
1991		0.53	0.60	0.62	0.53	0.58
1992		0.41	0.59	0.39	0.58	0.49
1993		0.39	0.58	0.43	0.2	0.39
1994		0.52	0.53	0.48	0.37	0.47
1995		0.57	0.45	0.43	0.41	0.49
1996		0.40	0.65	0.60	0.66	0.59
1997		0.38	0.76	0.64	0.60	0.62
1998		0.43	0.73	0.57	0.46	0.51
1999		0.71	0.54	0.60	0.62	0.62
2000		0.51	0.80	0.70	0.57	0.62
2001		0.47	0.75	0.70	0.61	0.65
2002		0.43	0.77	0.65	0.57	0.60
TOTAL	0.32	0.26	0.61	0.50	0.47	0.45

Table 3.3. Percent of estimated red snapper landings (A + B1) which were recorded in the MRFSS intercepts. Type A are seen by the sampler and Type B1 are self-reported by the fishers who are interviewed (Data for LA 2001 to be added).

	STATE OF INTERCEPT					
	AL	FL	LA	MS	TX	GULF TOTAL
	% Sampled	% Sampled	% Sampled	% Sampled	% Sampled	% Sampled
year						
1983	0.3046	0.1274	0.1171	0.0456	9.4241	.1927
1984	0.2640	0.2297	0.1960	7.7299	0.0619	0.2139
1985	0.0981	0.0744	0.0781	1.0174	0.0889	0.0868
1986	0.3733	0.2478	0.3470	8.3351	.	0.3047
1987	0.4361	0.3899	0.3578	1.6134	.	0.4254
1988	0.3044	0.0998	0.0526	0.5076	.	0.1382
1989	0.1980	0.0698	0.0513	0.1172	.	0.1069
1990	0.1905	0.2280	0.2263	1.1552	.	0.2559
1991	0.4311	0.9675	0.2612	0.2796	.	0.5323
1992	0.6190	0.6111	0.4644	0.3603	.	0.5280
1993	0.1587	0.1216	0.0754	0.1632	.	0.1294
1994	0.2382	0.2418	0.1246	0.1396	.	0.2026
1995	0.1620	0.0733	0.0905	0.7273	.	0.1488
1996	0.0922	0.1216	0.1525	0.2344	.	0.1260
1997	0.2247	0.2987	0.2559	0.1753	.	0.2504
1998	0.5809	0.3059	0.2775	0.2889	.	0.3784
1999	1.2414	0.7498	0.2918	0.5508	.	0.8779
2000	1.1667	1.5503	0.4163	1.0243	.	1.3230
2001	0.8030	0.8005	.	0.7268	.	.
2002	0.6777	1.0891	0.8047	0.5248	.	0.9075

Table 3.4. Percent of estimated red snapper landings which were recorded in the TX Parks and Wildlife Department recreational harvest survey. (TPWD estimates correspond to Type A catch in MRFSS.)

1983	4.548
1984	5.766
1985	3.141
1986	3.781
1987	3.563
1988	2.516
1989	1.194
1990	3.479
1991	2.475
1992	1.419
1993	0.695
1994	1.337
1995	4.271
1996	5.793
1997	3.222
1998	2.406
1999	2.632
2000	3.328
2001	3.749
2002	2.272
Total	2.921

Table 3.5. Percent of estimated red snapper landings which were recorded in the NMFS Headboat Survey logbooks. Logbooks were not available from vessels operating in Area 24 (LA) in 2002, but estimates were made by the survey using logbooks from 2001.
Area 23 = AL/NW FL, 24 = LA, 25-27 = SE-SW TX.

	Area					
	23	24	25	26	27	Total
1986	13.427	53.836	69.657	59.998	55.893	63.368
1987	36.247	37.940	96.387	69.020	76.224	86.096
1988	75.817	31.300	76.440	70.681	80.451	73.189
1989	74.713	86.992	90.273	73.699	84.490	86.386
1990	93.114	77.925	88.730	79.245	95.631	87.689
1991	85.849	87.847	86.838	59.166	93.750	82.086
1992	83.285	80.798	90.571	93.244	92.027	89.759
1993	87.647	60.455	90.681	88.785	92.848	87.218
1994	92.256	70.299	83.086	91.569	97.070	85.644
1995	91.758	81.388	80.370	93.824	91.981	85.428
1996	97.408	47.773	81.414	90.364	97.856	82.004
1997	91.863	76.084	65.754	69.176	98.097	72.528
1998	90.322	94.736	86.504	96.352	89.649	90.074
1999	90.923	46.753	96.912	97.840	88.034	87.556
2000	93.055	62.933	99.401	98.519	9.886	89.828
2001	92.742	52.945	99.916	88.777	92.339	90.076
2002	82.163	0.000	95.646	98.086	96.936	85.490
Total	86.506	64.908	84.225	85.065	84.826	83.179

Table 3.6. Percent of estimated red snapper landings which were measured (length) in MRFSS and TPWD surveys.

A. MRFSS intercepts. Landings estimates are for Type A+B1 (all fish killed, including discarded dead).

B. TX Parks and Wildlife recreational harvest survey. Landings estimates correspond to Type A (does not include those discarded dead).

	A. MRFSS						B. TPWD
	TX	LA	MS	AL	FL	Total	TX
1981	0.0168	0.0068		0.0299	0.0337	0.0175	
1982		0.0449	0.0485	0.0192	0.0396	0.0358	
1983	0.1769	0.0637	0.0456	0.0175	0.0970	0.0517	1.55665
1984	0.0619	0.0628	0.2089	0.0148	0.1056	0.0575	1.98979
1985	0.1555	0.0437	0.0462	0.0154	0.0129	0.0429	1.53880
1986		0.1746	1.1711	0.1142	0.0141	0.0731	1.06946
1987		0.2749	0.0647	0.2287	0.0624	0.1153	0.95088
1988		0.0336	0.3839	0.1600	0.0276	0.0657	0.67921
1989		0.0489	0.0204	0.0742	0.0182	0.0405	0.34616
1990		0.1243	0.1037	0.0911	0.0405	0.0888	1.43316
1991		0.1940	0.1344	0.3286	0.0296	0.1909	1.09778
1992		0.1810	0.2204	0.4204	0.1416	0.2778	0.53015
1993		0.0564	0.0886	0.0872	0.0629	0.0731	0.27749
1994		0.0775	0.0805	0.1174	0.0488	0.0856	0.52355
1995		0.0704	0.0719	0.0863	0.0601	0.0755	1.89229
1996		0.0926	0.1326	0.0710	0.0378	0.0714	2.53391
1997		0.0762	0.0981	0.1330	0.1685	0.1347	1.56209
1998		0.1555	0.1673	0.3748	0.2097	0.2486	1.35019
1999		0.1920	0.4039	1.0472	0.5475	0.6865	1.47496
2000		0.1049	0.8081	1.1498	0.8261	0.8496	1.95999
2001		0.0357	0.4826	0.7942	0.5952	0.6405	1.76173
2002		0.4595	0.4378	0.6059	0.5622	0.5715	1.18181
Total	0.0700	0.0535	0.1471	0.2757	0.2574	0.1983	1.15962

Table 3.7. Percent of estimated red snapper landings from the NMFS Headboat Survey logbooks which were measured (length). Although logbooks from vessels operating in Area 24 (LA) in 2002 were not available, dockside sampling was conducted.

	Area					
	27	26	25	24	23	Total
1986	3.05	10.34	0.81	1.66	0.96	1.93
1987	4.01	3.51	0.88	4.25	2.06	1.88
1988	2.94	2.80	0.25	1.94	1.51	1.13
1989	2.25	4.86	0.34	10.38	2.70	1.71
1990	4.06	2.54	0.96	5.16	2.14	2.28
1991	3.15	0.98	0.65	3.31	3.23	1.40
1992	5.59	1.23	1.35	5.05	2.13	1.99
1993	6.33	0.58	0.97	3.47	1.05	1.50
1994	4.75	0.81	0.91	1.80	2.80	1.41
1995	7.68	1.26	1.96	3.73	1.92	2.32
1996	4.44	1.03	1.06	2.66	1.75	1.52
1997	5.05	0.18	0.38	5.27	2.35	1.30
1998	3.70	2.60	1.52	8.76	2.82	2.73
1999	2.97	2.30	0.85	9.28	1.30	2.52
2000	4.07	0.35	0.05	19.38	2.00	2.58
2001	2.13	1.25	0.47	11.13	1.29	1.91
2002	3.77	1.42	0.15	6.83	1.67	1.70
Total	3.96	1.69	0.86	5.05	1.94	1.78

4. Fishery-Dependent Indexes

4.1 Commercial Fishery Catch Rates

4.1.1 Commercial Handline

SEDAR7-DW-47 used data from the National Marine Fisheries Service (NMFS) reef fish logbook program to develop two abundance indices for red snapper. Since no size data are available in the logbook data base, data from only those years of consistent minimum allowable size were included in the analyses (1996-2003). The first index used data collected from vessels with class 1 permits (allowing possession or landing of up to 2,000 pounds of red snapper) fishing during red snapper open seasons only. The pattern of open seasons has not been consistent during the time series examined.

The second index used an association statistic to identify species which are frequently caught along with red snapper; this statistic was then used to identify trips with a higher probability of catching red snapper, that is, trips which might be directed at species assemblages which include red snapper. Data from those trips were used to develop the second abundance index. The status of the season (open or closed) was considered as a factor.

The Fishery Dependent Indices Working Group had concerns regarding the utility of the commercial catch rates as indices of the population because of size and trip limits combined with the lack of discard information. However, size and trip limits have been consistent across the time period and are less restrictive than those of the recreational fishery, with the likely result that a lower proportion of fish are discarded. Therefore, the Working Group recommended that the index could be considered for use in the assessment, given that the available data may be analogous to that of an index derived using catch data from a (highly) size-selective gear.

It is not possible to distinguish between electric and non-electric handline in the data until 2001. If catch rates are different between the gears, it is possible that a changing proportion of effort split between these gears could have an influence which is not accounted for. It should be possible to evaluate any differences in catch rates in future years as more data become available.

The Working Group was also concerned about the potential impact of the current multiple, short open seasons on catch rates (as opposed to fewer, extended open seasons which occurred in the past). The Working Group investigated the possibility that the change to shorter open seasons may have reduced the duration of fishing trips, which in turn may have reduced the geographic coverage of the fishing effort. No evidence was found of such a decline in trip duration (Figure 4.1).

Due to the high proportion of trips with catch, a lognormal analysis might be more appropriate than a delta-lognormal analysis. The Working Group suggested that the lognormal approach should be employed when conducting revised analyses and that the diagnostics should be examined to confirm suitability of this approach.

The eastern and western Gulf nominal catch rate trends for Class I permitted vessels during open seasons were examined (Figure 4.2). The nominal catch rate trends are somewhat different (although a year*region interaction was not important in fitting the standardized index). The Working Group recommended that indices be calculated separately for the eastern and western Gulf to permit flexibility in the assessment and for use in sensitivity analyses.

The available fisheries data (including both commercial and recreational) include many trips with a low probability of catching red snapper due to unrecorded covariates such as depth, fishing location, bait, bottom type, gear configuration, weather, etc. The Working Group noted that each of the available papers presenting fishery dependent abundance indices included an analytical approach to identify trips likely to be directed at red snapper. These approaches eliminated trips which are unsuccessful in catching any member of an associated species assemblage and/or restricting to the most successful vessels. The

Working Group considered that these were reasonable treatments of the available data. However, the Working Group suggested that modifications to restrictions based upon the associated species assemblage could be explored. These modifications could include: 1) defining upper cutoffs (retaining trips only if species with a higher association statistic are caught) AND lower cutoffs (rejecting trips if any of these less associated species are caught), this could address possible split effort on trips, 2) utilizing biological/life history information to define association statistic cutoffs, and 3) setting cutoff levels independently between regions (as these association statistics are relative measures).

4.1.2 Commercial Landings from Shrimp Trawlers

Historically, red snapper of commercial size were taken as a bycatch in shrimp trawls and were commonly sold until the provisions of the Amendment 1 to the Reef Fish Fishery Management Plan became effective in 1990 (GFMFC 1989). These landings represented a small but consistent part of the commercial red snapper landings, and since they are taken incidental to the shrimp fishery, the catch rates should reflect the relative abundance of red snapper. Catch, effort and catch per effort for this component of the fishery are given in Figure 4.3. Effort is thousands of days fished offshore Alabama-Texas in depths from 5 to 50 fathoms. Catch per day- fished fluctuated at a level of about 3 kg from 1967-1974, declined to 0.47 kg, recovered to 1.43 kg in 1983 then continued to decline to a low of 0.13 kg in 1989.

The age composition of the fish sold from the shrimp trawls is unknown. Only 12 red snapper were sampled from this component of the fishery Figure 4.4). However, additional samples from the shrimp bycatch characterization studies are available for comparison. These were truncated to the minimum size observed in the TIP samples to eliminate fish that were too small to be sold (Figure 4.4). Both data sets suggest that the sold bycatch was made up mostly of small fish, but larger fish were occasionally found in the catch.

Although shrimp trawlers were exempted from possession limits of the Fisheries Management Plan (GMFMC 1981), red snapper had to be at least 30.5 cm (12 in) fork length to be sold. The FMP rules became effective in November 1984. Given the modal size of the small sample of Figure 4.4, it is likely that some or all of the decline observed after 1984 resulted from compliance with the minimum size. Amendment 1 to the FMP (GMFMC 1989) prohibited the sale of red snapper caught by shrimp trawls. If the decline after 1983 was the result of the minimum size then the decline from the early 1970s could be interpreted as a decline in recruitment because of the small size of the fish involved. The increased cpue observed in 1981 and 1983 would have been associated with the relatively strong year classes in 1979 and 1981 recruiting to the fishery at age 2.

Analyses corresponding to Figure 4.3 were presented in an earlier report (Goodyear and Phares 1990) and elicited comments from fishermen. Anecdotal reports and testimony of individuals before the Gulf of Mexico Fisheries Management Council suggested that some or most of these landings were the result of handline catches of the shrimp vessel crews while at anchor. Further, it was argued that some or even most of the subject landings were from Mexican waters prior to their closure to U.S. shrimpers. The likely effect of the former argument would be to change the units from days fished to days anchored which are probably highly correlated. Consequently, the basic trends in Figure 4.3 would not be altered. As for the latter argument, these analyses are restricted to catches that were believed to have been from U.S. waters by the port agents who assigned the areas of capture. Further, Bradley and Bryan (1975) found that shrimp fishermen marketed the larger snappers caught in their trawls and discarded those too small to sell. There is no basis apparent from the available data to support the contention that a significant proportion of the landings from shrimp vessels recorded as caught from US waters were actually caught by handlines or from Mexican waters.

However, at this writing, the Commercial Statistics working group has not able to reconcile the shrimp trawl landings values in Figure 4.3 with the current General Canvass data base. Efforts continue.

4.2 Recreational Fishery Catch Rates

4.2.1 MRFSS and Texas Parks and Wildlife Dept. Survey Catch Rates

SEDAR7-DW-41 used two sources of recreational catch rates to develop two alternative indices of abundance for red snapper: the Marine Recreational Fisheries Statistics Survey (MRFSS) and Texas Parks and Wildlife Department's Recreational Angler Creel Survey (TPWD).

The first index was intended to replicate the recreational index used during the most recent red snapper assessment (Schirripa and Legault 1999) using a similar technique. This index was constructed using MRFSS intercept data from 1981-2003 and TPWD catch and effort data from 1983-1989. TPWD data were not included after 1989 because strict minimum size and bag limits were mandated in 1990. Unlike MRFSS data which include fish landed and observed by the interviewer (A), dead fish not observed by the interviewer (B1; e.g., unavailable, filleted, used for bait, discarded dead at sea) and fish released alive (B2), TPWD data only record fish observed by the interviewer (A). TPWD data are not appropriate to combine with MRFSS intercept data after the 1990 regulations because the proportion of red snapper discarded by the recreational fishery may have increased significantly; it was presumed that prior to 1990 most landed fish were available for observation in the TPWD survey and that the number of discarded fish in the Texas fishery was negligible. All headboat, charter boat and private boat trips that fished in "oceanic" areas using hook and line gear were included in the dataset used to construct the first standardized index of abundance. Shore mode and inshore fishing trips were excluded as they very seldom land red snapper.

The second index was constructed using only MRFSS intercept data, applying the same restrictions as above. Trips were excluded if they did not catch a least one red snapper, or one of a species determined to typically be associated with red snapper in catches (using methodology similar to that of SEDAR7-DW-47). Texas data within the MRFSS data set were excluded from the analysis due to insufficient sampling (n=59).

The Working Group had several concerns regarding these indices. The Working Group discussed whether or not headboat data should be excluded from the analysis (it is only present 1981-1985). Although the potential effect of that mode may have been accounted for in the model, the analysis of the mode may be complicated by its presence only in the early period. The Working Group concluded that it was most appropriate to initially exclude the headboat data from future analyses. The headboat data could subsequently be included if determined to be statistically warranted.

The Working Group noted that the approach used to develop Index 1 (intended to replicate the methods of Schirripa and Legault, 1999) includes a great deal of effort not directed at red snapper (proportion positive < 10% in most years). Also, the binomial model component is most appropriate if proportion positive is between 20% and 80%. The Working Group therefore recommended that the index may not be appropriate for base case application.

The MRFSS data were examined and a considerable increase in the proportion of fish discarded (live or dead) over time was observed (Figure 4.5). This was likely the result of changes in management measures (bag and size limits). The increasing proportion discarded is likely the reason for the overall increasing trend. If the discard rates seen in the MRFSS data are reflective of the Texas fishery, the initial presumption that discard rates in Texas were negligible before 1990 appears to be invalid. MRFSS discard proportions were below 10% prior to 1988, but increased thereafter.

The eastern and western Gulf nominal catch rate trends were examined (Figure 4.6) and appear to be different. The indices are based upon MRFSS data from 1990 onward, which are derived mainly (and increasingly) from Alabama-Florida. The Working Group recommended that separate indices be calculated for the EAST and WEST and that the resulting indices be used for the assessment, as appropriate.

4.2.2 Headboat Survey Catch Rates

SEDAR7-DW-42 developed several indices using the NMFS's Beaufort Headboat Survey data from 1986-2002. For one set of analyses, indices were developed separately for EAST (Dry Tortugas – Alabama) and WEST (Louisiana – Texas) zones, as defined from the Headboat Survey statistical landings areas. Data were restricted to periods when the season was open. A subset of headboat vessels considered to be consistently directing effort at red snapper was defined by: 1) Ranking vessels within each year and zone by average catch rate, 2) keeping only vessels which appear in more than half the years of the survey, and 3) keeping only vessels which have an average CPUE rank above the median for the zone. These restrictions resulted in an analysis data set with 10 vessels in the WEST and 21 vessels in the EAST. A continuous variable was defined (bag limit * number of anglers); examination of frequency distributions indicated that the distribution of catches for individual trips was usually (although not always) truncated at this value. Unfortunately, there is no information on discards available in the Headboat survey data set.

An alternative analysis approach, in which more restrictive criteria were used to define trips likely to be directed at red snapper, was used to produce a third index. In this case, the EAST and WEST zones were ***not*** analyzed separately. Again, data were restricted to periods when the season was open. Data were further restricted to full day trips (3/4 – 1 day in length); red snapper catch rates were highest on these trips. Data were also restricted to trips on which the catch included red snapper or at least one of a (zone-specific) list of species typically associated with red snapper in the catch. A subset of headboat vessels considered to be consistently directing effort at red snapper was defined by the same approach taken in the first set of analyses. These restrictions resulted in an analysis data set with 29 vessels.

The Working Group considered that the headboat indices might have very limited utility, since the proportion of the catch discarded was almost certainly changing over time in response to management measures (changing bag limits and size limits) as well as stock abundance and size distribution changes. However, the analysis may be providing some insight into population and/or fishery trends. For example, it was noted that both nominal and standardized catch rate trends (for kept fish only) varied between the EAST and WEST zones; catch rates in the EAST tended to be lower, but increasing over time, whereas catch rates in the WEST tended to be higher, but decreasing over time.

The Working Group recommended that the headboat indices not be used for the assessment because of the expected effects of the changes in management measures.

4.3 References:

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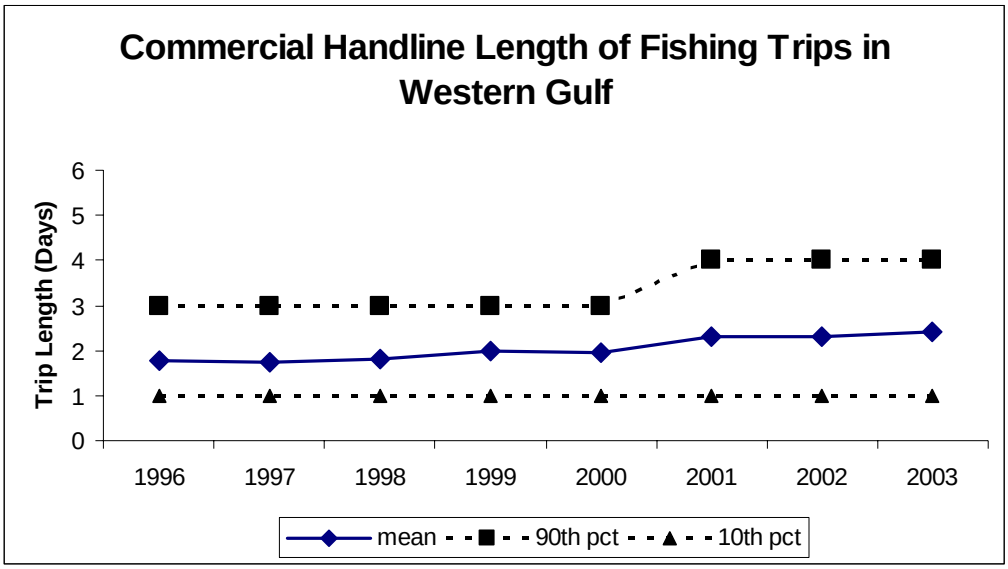
Schirripa, M.S. and C.M. Legault. 1999. Status of the red snapper in U.S. waters of the Gulf of Mexico: updated through 1998. NOAA Fisheries (NMFS), Southeast Fisheries Science Center, Miami Laboratory. SFD-99/00-75.



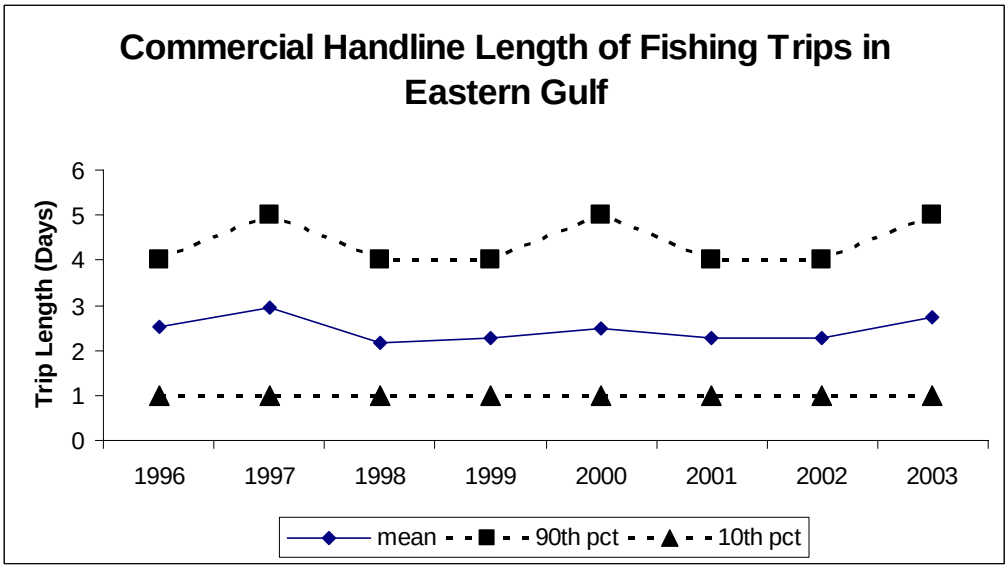


Figure 4.1: Historical trend in trip duration by Class I permitted vessels during open red snapper seasons.

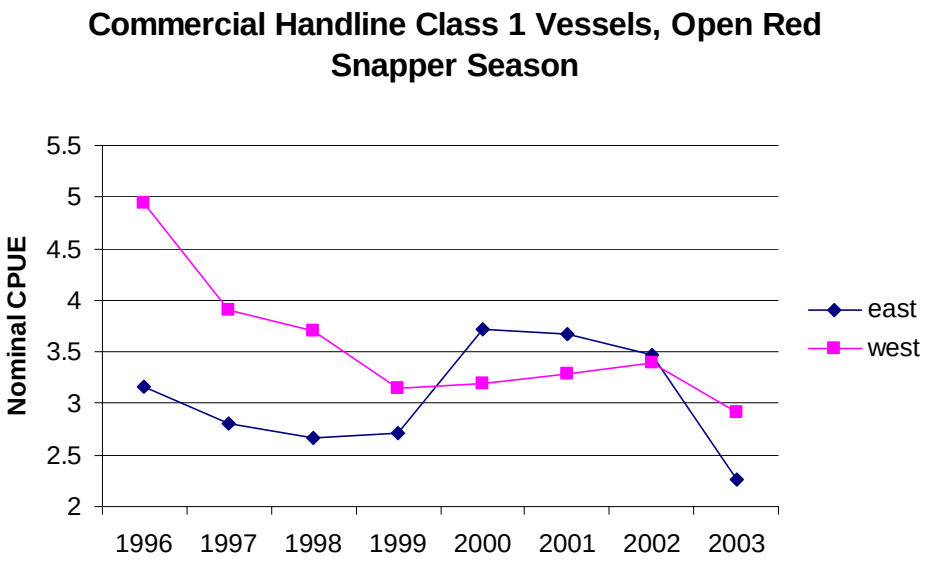


Figure 4.2: Historical trend in observed catch rates (eastern and western Gulf of Mexico) by Class I permitted vessels during open red snapper seasons.

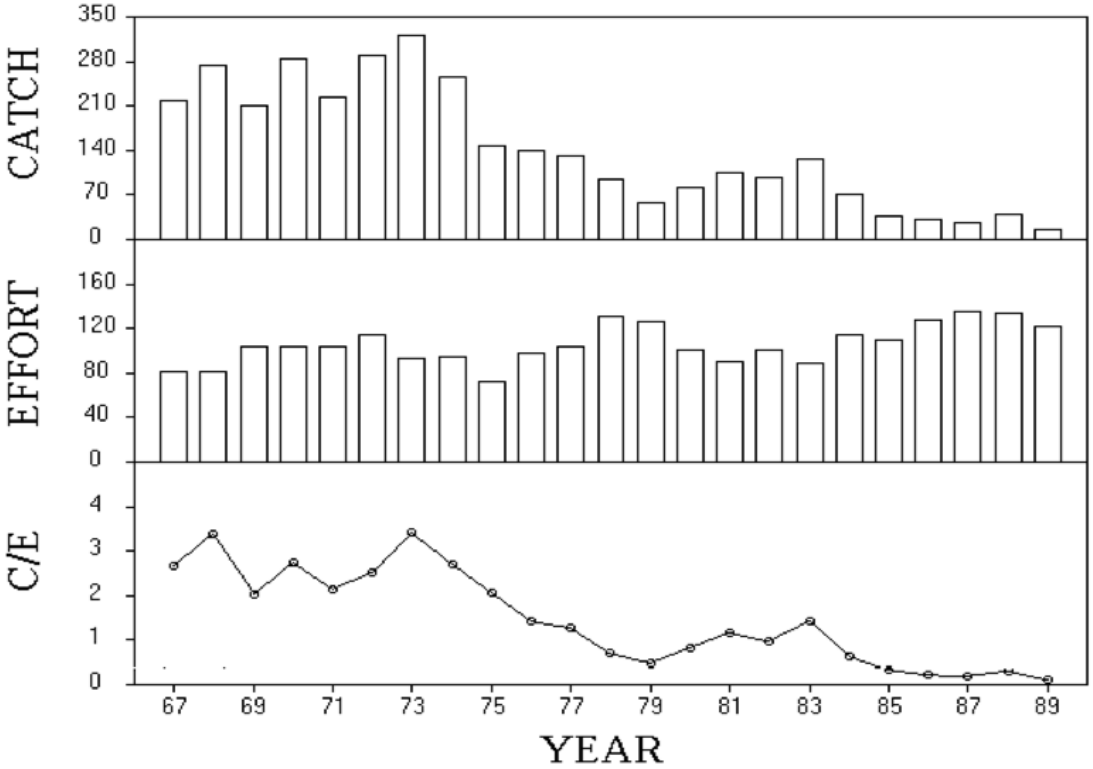


FIGURE FDI-3. Landings, effort, and catch per unit effort for red snapper sold from the bycatch of shrimp trawls 1967-1989.

Figure 4.3.

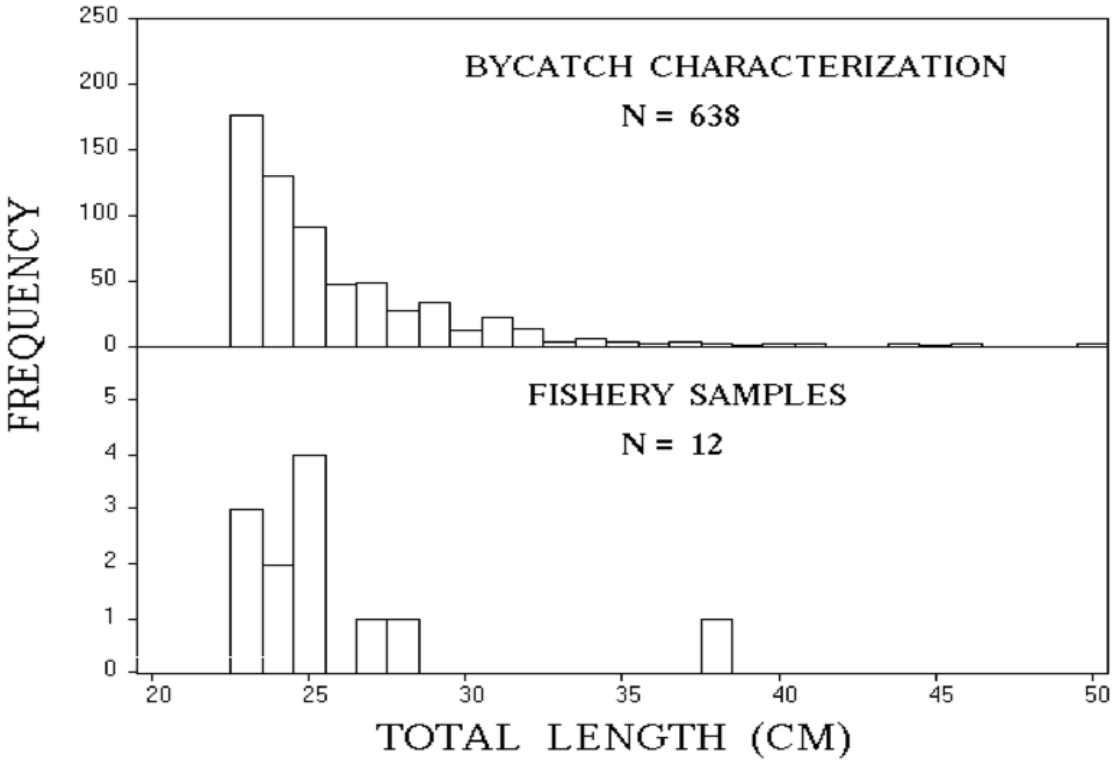


FIGURE FDI-4. Length frequencies for red snapper lengths from TIP samples and from bycatch characterization samples truncated at the minimum size observed in the TIP samples.

Figure 4.4.

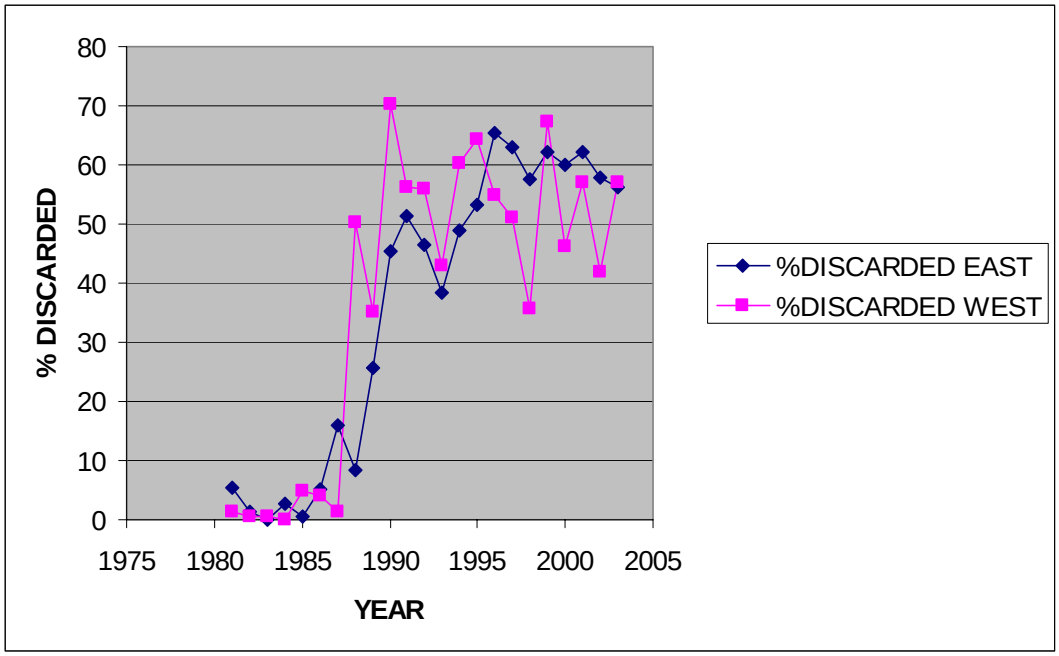


Figure 4.5: Historical trend in discarded catch (both live and dead discards) percentage from MRFSS data.

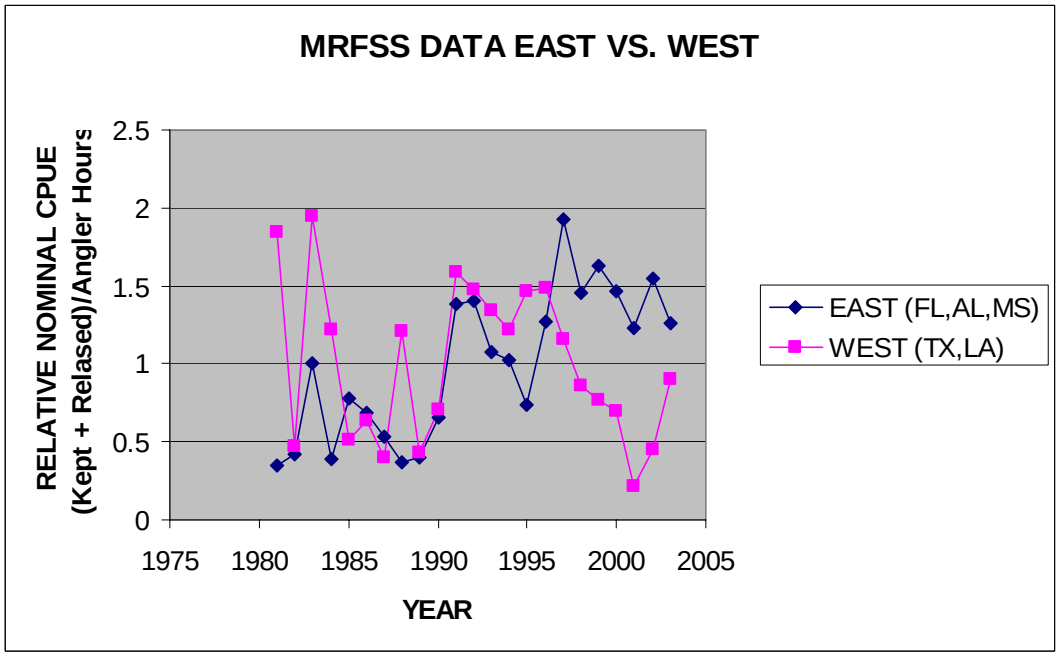


Figure 4.6: Historical trend in observed relative catch rates (eastern and western Gulf of Mexico) from MRFSS data (relative trend calculated by dividing each series by its mean).

5. Fishery-Independent Indexes

In preparation for the SEDAR, five fishery independent surveys were analyzed and indices of relative abundance developed. These were the National Marine Fisheries Service Southeast Area Monitoring and Assessment Program (SEAMAP) shrimp/bottomfish surveys, SEAMAP icthyoplankton surveys, SEAMAP reef fish survey, shark/snapper/grouper bottom longline survey, and the small pelagics trawl survey. An additional survey was conducted by Auburn University off the coast of Alabama. Of these surveys, only the shrimp/bottomfish index had been used in prior red snapper stock assessments. The remaining surveys were not included in earlier stock assessments for a variety of reasons.

Very little discussion centered on the use of SEAMAP shrimp/bottomfish surveys data, since indices of relative abundance derived from these surveys have been used in previous assessments. The data include density estimates (number caught per hour fished) from 1972 to 1986, in the northern Gulf of Mexico (between 88˚ 00´ and 91˚ 30´ W longitude, during the fall season in depths of 9.1 to 91.5 meters (5 to 50 fathoms), and survey from Mobile to Brownsville, fall 1987-2002, and summer 1982-2003. These data were collected with standard gear and survey methods, and are explained in detail in SEDAR7-DW-1. There is also a summary of fishing power issues available in SEDAR7-DW-53. Arithmetic means were used in previous assessments. We employed a Bayesian analysis here (SEDAR7-DW-2) to fill missing cells and link separate surveys. The Bayesian central tendency estimates closely mimic the arithmetic values, but the procedure produces estimates with nearly lognormal error distributions upon accounting for missing cells and surveys covering less than the full SEAMAP range. We discussed partitioning age classes 0 and 1, particularly for the summer survey, for better estimates of Z. This work will be based on the data processing reported in SEDAR7-DW-17, and will be continued prior to the assessment workshop.

Data from SEAMAP ichthyoplankton samples were not used in earlier assessments because larval red snapper could not be distinguished from other lutjanids. Recent advances in identification of larval red snapper have made it possible to develop time series back to the 1980s, and to develop annual indices of abundance for red snapper from fishery independent surveys (SEDAR7-DW-14). Annual indices of frequency of occurrence and abundance of red snapper larvae were developed for the SEAMAP summer bottomfish surveys (1982-2002), fall plankton surveys (1985-2002) and both survey combined (1982-2002) for both neuston net and bongo net collections. The initial recommendation was to use the annual frequency of occurrence of larvae in neuston samples from SEAMAP summer shrimp/bottomfish and fall plankton surveys combined. The recommendation was based on this index's high correlation with adult red snapper abundances over the time period 1984 to 1997 (SEDAR7-DW-14). The fishery independent indices working group examined all possible larval indices over the period 1982 to 2002 using all combinations of variables: Gulf region (east or west of 89.15 ° W longitude); gear (neuston or bongo); survey time frame (June/July or late August to mid October) in addition to the recommended index. Tables listing these indices are given in Appendix 5.1. It is evident that percent frequency of occurrence has increased over the time series for all the examined indices as did abundance of larvae in non-zero tows. The workgroup reviewed data of standardized abundance categories and the frequency of abundance categories for samples in which red snapper larvae were caught (positive catch samples). The plots indicate higher frequencies of the standardized abundance categories over the time series and an increase in the frequencies of the higher abundance categories for both the neuston and bongo collections (Appendix 2).

There was discussion whether to include both survey time frames (summer and fall) in formulating the larvae red snapper index. A combined survey index was favored because it would cover a greater portion of the red snapper spawning season and area. The workgroup also compared model-based (GLM mixed model) for the combined survey estimates of annual frequency of occurrence to design-based estimators for both the bongo and neuston gears and found little to no difference in the estimates (Table 5.1). Standard errors were somewhat greater for the model-based than the design-based estimators but the group considered the former to be more realistic and, therefore, recommends use of a model based larval red snapper index. At this time the group recommends that annual frequency of occurrence, and not mean abundance be the index metric used in the upcoming assessment. Stock size has been shown to be correlated with the geographic area occupied by eggs and larvae of Pacific sardine and northern anchovy (Mangel and Smith 1990; Hunter and Lo 1993). Assuming this is true for red snapper, it can be argued that larval occurrence would provide a more useful index of stock size than estimates of mean annual

abundance which are, at present, unadjusted for age composition of larval catches. Prior to the assessment in August personnel at the Mississippi Labs will develop an age-corrected abundance index using the age/length relationship for red snapper larvae in Comyns (1992; Final Report MARFIN Grant No. NA37FF0050-02). This new index of larval red snapper abundance will then be evaluated. Also separate indices for the eastern and western Gulf will be developed prior the formal stock assessment this summer.

Data from SEAMAP reef fish survey were analyzed and red snapper abundance indices developed (SEDAR7-DW-15). This survey was designed to sample hard bottom habitat with relief; and although limited in spatial coverage, it samples a part of the population not covered by the other surveys. The biggest weakness of this survey is uncertainly about size and age of fish observed by the cameras. Although no red snapper were directly measured the workgroup recommended that size of individual red snappers be estimated by comparing sizes with other species of fishes either measured with lasers or captured in traps. Two indices of abundance were developed; frequency of occurrence and number of red snapper per sampling site. Two estimators were examined for each index as well, one using design-based estimates of mean number (or frequency) of red snapper and associated standard errors and a second using model-based estimates. The workgroup recommended that the model-based estimates of number of red snapper per site be used since it controlled the high survey mean value in 1992 that occurred as a result of a single large aggregation of red snapper being observed and that the estimated standard errors were much lower than those from the design-based estimates.

The working group concluded that the SEAMAP shrimp/bottomfish, ichthyoplankton and reef fish surveys would provide the most useful fisheries independent indices for the purposes of stock assessment at this time. These three indices correspond with each other giving us confidence that they reflect trends in red snapper abundance in the Gulf of Mexico (Figure 5.1).

Data from a relatively new shark/snapper/grouper longline survey were presented for the first time (SEDAR7-DW-9, see also 8 and 11). This survey consists of three years of data, and provides insights into the distribution and abundance of older, offshore stocks of large red snapper. The workgroup felt that a three-year time series was not appropriate for the current assessment, but noted that this survey would probably be valuable for future assessments. The most important contribution to the SEDAR from the longline survey is information pertaining to the previously undocumented age distribution of large red snapper in offshore waters and computed instantaneous mortality rates (0.13 per year, one std err 0.01), which may provide an upper limit on M for adult snapper.

Small pelagic survey data were analyzed and indices of abundance developed (SEDAR7-DW-10). Indices from these surveys were found to be correlated with shrimp/bottomfish surveys, but workgroup discussions suggested that this index did little to improve the overall estimates as surveys were spatially and temporally disjunct and differed with regard to methodologies and objectives. The group recommended that this index not be included in the final recommended fishery independent indices.

Additional data and information considered by the working group:

An additional data set concerning recruitment of juvenile red snapper to experimental artificial reef sites off Alabama was presented to the workgroup (SEDAR7-DW-21). Data indicate first recruits of red snapper quickly colonize artificial shell/block habitats. SCUBA visual surveys of age-0 to age-1 abundance were used to estimate mortality for 1998, 1999, and 2002, and in 2001 estimates were based on multiple surveys (n = 4) of the same age-0 year class. The workgroup felt that this data set might be useful to the life history group. However, as with the NMFS longline survey data, the group felt that this short time series in a localized area was not a particularly useful index of red snapper abundance for the current stock assessment.

A climatological model of mean monthly wind driven surface currents was applied to data on the location of capture of adult red snapper taken during NMFS shark/snapper/grouper longline survey (Dr. Don Johnson, pers. commun., Gulf Coast Research Laboratory, Ocean Springs, MS). The objective of this exercise was to track the movement of red snapper eggs and larvae assuming that spawning occurred at location of capture of adult red snapper. The model assumed larvae remained in the plankton for duration

of 20 and 30 days at which time they presumably settled on nursery grounds. Net transport of larvae spawned on the Florida shelf was west of the adult collection sites. There was no indication of larval movement west of the DeSoto Canyon in the northern Gulf. Larval transport in the northcentral Gulf of Mexico, specifically the Mississippi Bight, showed a similar pattern of net westward movement. Net transport off the Florida Panhandle was offshore whereas fish spawned off Mobile Bay remained inshore of the 100 m isobath. The Mississippi River mouth did not appear to be a barrier to westward movement of larvae across the outflow of the River. Snapper spawned off Louisiana and Texas coasts remained inside the 100 m isobath west of Mobile Bay with the exception of an offshore of movement predicted for a limited number of larvae due south of the Mississippi River delta. These data suggest that there is little to no movement of larval red snapper from the western to the eastern Gulf of Mexico.

Literature Cited

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Hunter, J.R. and Lo, N.C.-H. 1993. Ichthyoplankton methods for estimating fish biomass introduction and terminology. Bull. Mar. Sci. 53(2):723-727.

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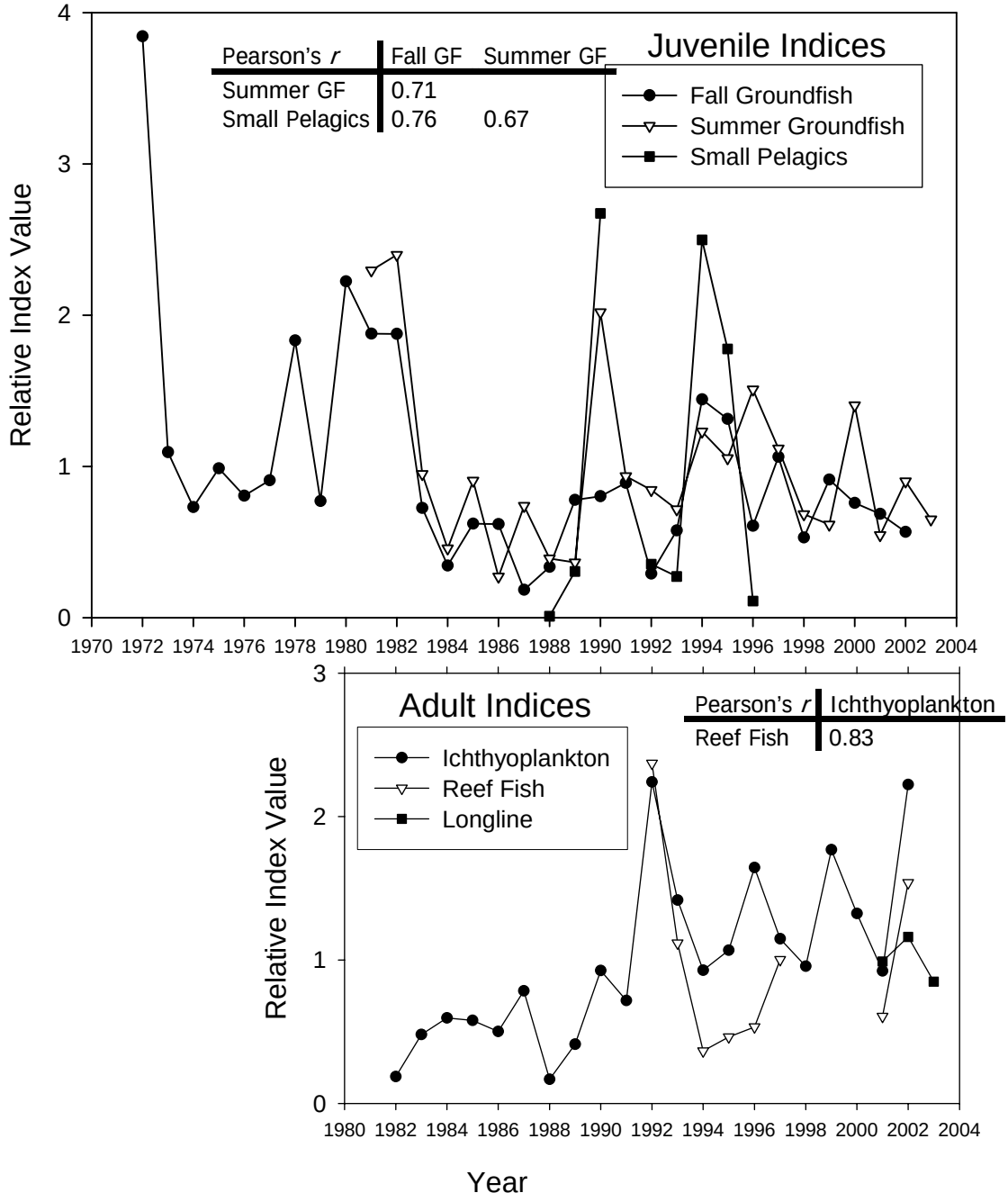

Figure 5.1. Comparison of standardized indices from fisheries-independent surveys. Correlation coefficients illustrate similarity in trends between surveys within each survey type (i.e. Juvenile and Adult Indices).

Table 5.1. Model- and design-based red snapper larval indices of annual frequency of occurrence from neuston and bongo net samples taken during SEAMAP Summer Shrimp/Bottomfish and Fall Ichthyoplankton surveys in the Gulf of Mexico, 1982 to 2002.

		Neuston Model-Based Estimators		Neuston Design-Based Estimators			Bongo Model-Based Estimators		Bongo Design-Based Estimators	
Year	**Number of Samples**	**% Frequency of Occurrence**	**Standard Error**	**% Frequency of Occurrence**	**Standard Error**	**Number of Samples**	**% Frequency of Occurrence**	**Standard Error**	**% Frequency of Occurrence**	**Standard Error**
1982	73	1.37	2.33	1.37	1.37	76	9.43	3.59	11.84	3.73
1983	57	3.51	3.51	3.51	2.46	59	5.34	3.38	6.78	3.30
1984	69	4.35	3.30	4.35	2.47	70	6.78	3.32	8.57	3.37
1985	71	4.23	3.20	4.23	2.40	91	7.73	2.96	8.79	2.98
1986	191	3.66	1.65	3.66	1.36	214	8.36	2.12	7.94	1.85
1987	192	5.73	1.94	5.73	1.68	215	7.33	2.08	6.98	1.74
1988	163	1.23	1.25	1.23	0.86	125	6.03	2.52	5.60	2.06
1989	166	3.01	1.66	3.01	1.33	128	9.17	3.05	8.59	2.49
1990	148	6.75	2.45	6.76	2.07	128	6.75	2.90	6.25	2.15
1991	172	5.23	2.00	5.23	1.70	129	10.45	3.23	10.08	2.66
1992	159	16.35	3.19	16.35	2.94	167	10.93	2.69	10.18	2.35
1993	174	10.34	2.58	10.34	2.32	175	6.80	2.39	6.29	1.84
1994	177	6.78	2.17	6.78	1.89	176	6.77	2.23	6.25	1.83
1995	154	7.79	2.50	7.79	2.17	153	14.05	3.43	12.42	2.67
1996	150	12.00	2.99	12.00	2.66	150	12.77	3.15	11.33	2.60
1997	179	8.38	2.34	8.38	2.08	179	16.08	3.13	15.08	2.68
1998	43	6.97	5.12	6.98	3.93	45	12.39	5.79	11.11	4.74
1999	186	12.90	2.73	12.90	2.46	186	13.68	2.84	12.37	2.42
2000	176	9.66	2.50	9.66	2.23	184	21.58	3.30	20.11	2.96
2001	178	6.74	2.17	6.74	1.88	175	16.12	3.14	14.86	2.70
2002	148	16.21	3.30	16.22	3.04	152	20.81	3.54	19.74	3.24

Appendix 5.1

Tables 5.1-18. Annual indices of frequency of occurrence, and mean abundance of red snapper larvae from SEAMAP plankton surveys for each combination of survey time frame (Summer Bottomfish, Fall Plankton and Summer Bottomfish/Fall Plankton combined), gear (neuston or bongo) and spatial area (entire GOM, western GOM and Eastern GOM). Number of Sampels (N), Mean abundance (A), standard error of abundance (A-SE), frequency of occurrence (F0), percent frequency of occurrence (%FO) and standard error of frequency of occurrence (FO-SE). Mean abundance is expresses as the number of larvae per 10 minute tow for neuston collections, and as the number of larvae under 10 m^2 of sea surface for bongo net collections. Percent frequency of occurrence (%FO) is the ration of positive samples to total samples.

Table 5.1.1. Neuston Summer Bottomfish.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	73	0.01370	0.01370	1	1.3699	1.3699
1983	57	0.12281	0.10641	2	3.5088	2.4588
1984	69	0.10145	0.06243	3	4.3478	2.4730
1985	61	0.06557	0.03959	3	4.9180	2.7917
1986	49	0.04082	0.04082	1	2.0408	2.0408
1987	62	0.17689	0.08119	6	9.6774	3.7854
1988	36	0.02662	0.02662	1	2.7778	2.7778
1989	41	0.00000	0.00000	0	0.0000	0.0000
1990	10	0.00000	0.00000	0	0.0000	0.0000
1991	46	0.21739	0.13871	4	8.6957	4.2004
1992	49	0.55102	0.39130	7	14.2857	5.0508
1993	49	0.22442	0.11760	5	10.2041	4.3691
1994	51	0.26799	0.17542	5	9.8039	4.2054
1995	30	0.00000	0.00000	0	0.0000	0.0000
1996	30	0.26501	0.20143	3	10.0000	5.5709
1997	56	0.37500	0.32189	4	7.1429	3.4727
1998	10	0.19868	0.19868	1	10.0000	10.0000
1999	44	0.22727	0.12535	5	11.3636	4.8398
2000	54	0.22063	0.15670	3	5.5556	3.1464
2001	47	1.32674	1.18045	5	10.6383	4.5460
2002	52	0.90059	0.48333	10	19.2308	5.5187

Table 5.1.2. Bongo Summer Bottomfish.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	76	0.3150	0.11086	9	11.8421	3.7309
1983	59	0.3415	0.16758	4	6.7797	3.3010
1984	70	0.3415	0.14135	6	8.5714	3.3701
1985	67	0.6589	0.26357	8	11.9403	3.9914
1986	73	0.7244	0.27844	9	12.3288	3.8746
1987	74	0.4335	0.20090	6	8.1081	3.1948
1988	37	0.6261	0.34004	4	10.8108	5.1753
1989	40	0.5237	0.31011	4	10.0000	4.8038
1990	37	0.1896	0.18959	1	2.7027	2.7027
1991	48	0.4346	0.23487	4	8.3333	4.0315
1992	50	1.8071	0.81302	9	18.0000	5.4884
1993	50	0.3668	0.27993	2	4.0000	2.7994
1994	50	0.7811	0.38992	5	10.0000	4.2857
1995	29	0.1806	0.18062	1	3.4483	3.4483
1996	30	3.2193	1.85679	6	20.0000	7.4278
1997	56	1.4573	0.68608	8	14.2857	4.7184
1998	10	12.6087	8.33579	3	30.0000	15.2753
1999	44	1.4021	0.50848	9	20.4545	6.1513
2000	54	2.3087	0.58215	15	27.7778	6.1524
2001	48	1.5023	0.53031	9	18.7500	5.6933
2002	51	2.3802	0.64982	15	29.4118	6.4438

Table 5.1.3. Neuston Fall Ichthyoplankton.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1985	10	0.00000	0.00000	0	0.0000	0.00000
1986	142	0.09859	0.04825	6	4.2254	1.69413
1987	130	0.15385	0.08562	5	3.8462	1.69317
1988	127	0.00787	0.00787	1	0.7874	0.78740
1989	125	0.20000	0.09837	5	4.0000	1.75977
1990	138	0.13516	0.05795	10	7.2464	2.21496
1991	126	0.07162	0.03771	5	3.9683	1.74603
1992	110	0.51059	0.14744	19	17.2727	3.62069
1993	125	0.28801	0.13335	13	10.4000	2.74132
1994	126	0.07937	0.03305	7	5.5556	2.04879
1995	124	1.29032	0.61686	12	9.6774	2.66579
1996	120	0.42042	0.16414	15	12.5000	3.03170
1997	123	0.39632	0.15855	11	8.9431	2.58357
1998	33	0.09091	0.06691	2	6.0606	4.21800
1999	142	0.57505	0.19324	19	13.3803	2.86702
2000	122	0.91803	0.37889	14	11.4754	2.89750
2001	131	0.08189	0.03381	7	5.3435	1.97250
2002	96	0.49705	0.20160	14	14.5833	3.62108

Table 5.1.4. Bongo Fall Ichthyoplankton.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1985	24	0.00000	0.00000	0	0.0000	0.00000
1986	141	0.27711	0.10275	8	5.6738	1.95518
1987	141	0.59565	0.28534	9	6.3830	2.06598
1988	88	0.21323	0.14119	3	3.4091	1.94548
1989	88	0.59051	0.22712	7	7.9545	2.90101
1990	91	0.44990	0.17575	7	7.6923	2.80883
1991	81	0.50529	0.17676	9	11.1111	3.51364
1992	117	0.36824	0.13645	8	6.8376	2.34338
1993	125	0.40297	0.15457	9	7.2000	2.32129
1994	126	0.52468	0.34959	6	4.7619	1.90476
1995	124	1.07801	0.33683	18	14.5161	3.17625
1996	120	1.06405	0.50993	11	9.1667	2.64518
1997	123	0.93805	0.25231	19	15.4472	3.27196
1998	35	0.15194	0.10715	2	5.7143	3.98075
1999	142	0.46209	0.13597	14	9.8592	2.51056
2000	130	1.40213	0.39742	22	16.9231	3.30130
2001	127	1.08859	0.39033	17	13.3858	3.03341
2002	101	1.08919	0.38726	15	14.8515	3.55610

Table 5.1.5. Neuston Summer Bottomfish and Fall Ichthyoplankton Survey Combined.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	73	0.01370	0.01370	1	1.3699	1.36986
1983	57	0.12281	0.10641	2	3.5088	2.45882
1984	69	0.10145	0.06243	3	4.3478	2.47303
1985	71	0.05634	0.03409	3	4.2254	2.40441
1986	191	0.08377	0.03736	7	3.6649	1.36316
1987	192	0.16129	0.06350	11	5.7292	1.68158
1988	163	0.01202	0.00847	2	1.2270	0.86493
1989	166	0.15060	0.07431	5	3.0120	1.33060
1990	148	0.12602	0.05409	10	6.7568	2.07023
1991	172	0.11060	0.04626	9	5.2326	1.70290
1992	159	0.52305	0.15720	26	16.3522	2.94230
1993	174	0.27011	0.10120	18	10.3448	2.31540
1994	177	0.13372	0.05579	12	6.7797	1.89497
1995	154	1.03896	0.49801	12	7.7922	2.16705
1996	150	0.38934	0.13719	18	12.0000	2.66219
1997	179	0.38965	0.14784	15	8.3799	2.07685
1998	43	0.11597	0.06807	3	6.9767	3.93095
1999	186	0.49278	0.15070	24	12.9032	2.46470
2000	176	0.70406	0.26773	17	9.6591	2.23301
2001	178	0.41059	0.31296	12	6.7416	1.88468
2002	148	0.63883	0.21393	24	16.2162	3.04016

Table 5.1.6. Bongo Summer Grounfish and Fall Ichthyoplankton Survey Combined.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	76	0.31498	0.11086	9	11.8421	3.73091
1983	59	0.34149	0.16758	4	6.7797	3.30100
1984	70	0.34151	0.14135	6	8.5714	3.37010
1985	91	0.48510	0.19607	8	8.7912	2.98484
1986	214	0.42968	0.11715	17	7.9439	1.85291
1987	215	0.53984	0.19924	15	6.9767	1.74147
1988	125	0.33545	0.14167	7	5.6000	2.06476
1989	128	0.56964	0.18311	11	8.5938	2.48701
1990	128	0.37465	0.13644	8	6.2500	2.14795
1991	129	0.47899	0.14074	13	10.0775	2.66076
1992	167	0.79903	0.26486	17	10.1796	2.34693
1993	175	0.39264	0.13589	11	6.2857	1.83995
1994	176	0.59752	0.27325	11	6.2500	1.82981
1995	153	0.90792	0.27633	19	12.4183	2.67495
1996	150	1.49509	0.55257	17	11.3333	2.59696
1997	179	1.10050	0.27533	27	15.0838	2.68251
1998	45	2.92011	1.94290	5	11.1111	4.73779
1999	186	0.68445	0.16074	23	12.3656	2.42024
2000	184	1.66817	0.32924	37	20.1087	2.96289
2001	175	1.20207	0.31796	26	14.8571	2.69629
2002	152	1.52236	0.33966	30	19.7368	3.23898

Table 5.1.7. Neuston Summer Bottomfish Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	53	0.01887	0.01887	1	1.8868	1.8868
1983	39	0.17949	0.15530	2	5.1282	3.5782
1984	54	0.12963	0.07951	3	5.5556	3.1464
1985	52	0.07692	0.04633	3	5.7692	3.2649
1986	39	0.05128	0.05128	1	2.5641	2.5641
1987	50	0.18000	0.09342	5	10.0000	4.2857
1988	31	0.03092	0.03092	1	3.2258	3.2258
1989	32	0.00000	0.00000	0	0.0000	0.0000
1990	7	0.00000	0.00000	0	0.0000	0.0000
1991	42	0.23810	0.15168	4	9.5238	4.5844
1992	44	0.61364	0.43525	7	15.9091	5.5778
1993	44	0.22727	0.12950	4	9.0909	4.3840
1994	46	0.23191	0.18991	3	6.5217	3.6807
1995	28	0.00000	0.00000	0	0.0000	0.0000
1996	25	0.31802	0.24111	3	12.0000	6.6332
1997	50	0.42000	0.36037	4	8.0000	3.8756
1998	8	0.24834	0.24834	1	12.5000	12.5000
1999	39	0.23077	0.13970	4	10.2564	4.9216
2000	50	0.23829	0.16911	3	6.0000	3.3927
2001	44	1.41720	1.26069	5	11.3636	4.8398
2002	45	1.04068	0.55640	10	22.2222	6.2675

Table 5.1.8. Bongo Summer Bottomfish Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	56	0.4275	0.1479	9	16.0714	4.9522
1983	39	0.5166	0.2499	4	10.2564	4.9216
1984	55	0.4346	0.1782	6	10.9091	4.2424
1985	57	0.7222	0.3054	7	12.2807	4.3860
1986	63	0.8393	0.3206	9	14.2857	4.4441
1987	62	0.5174	0.2386	6	9.6774	3.7854
1988	31	0.7473	0.4032	4	12.9032	6.1205
1989	31	0.5763	0.3896	3	9.6774	5.3978
1990	31	0.2263	0.2263	1	3.2258	3.2258
1991	44	0.4741	0.2556	4	9.0909	4.3840
1992	45	2.0079	0.8993	9	20.0000	6.0302
1993	45	0.4076	0.3108	2	4.4444	3.1068
1994	45	0.7713	0.4248	4	8.8889	4.2903
1995	27	0.1940	0.1940	1	3.7037	3.7037
1996	25	3.8631	2.2126	6	24.0000	8.7178
1997	50	1.5641	0.7653	7	14.0000	4.9570
1998	8	15.7609	10.2262	3	37.5000	18.2981
1999	39	1.5818	0.5680	9	23.0769	6.8348
2000	50	2.3600	0.6177	14	28.0000	6.4143
2001	44	1.5265	0.5705	8	18.1818	5.8818
2002	45	2.4814	0.7242	13	28.8889	6.8329

Table 5.1.9. Neuston Summer Bottomfish Eastern Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	20	0.00000	0.00000	0	0.0000	0.0000
1983	18	0.00000	0.00000	0	0.0000	0.0000
1984	15	0.00000	0.00000	0	0.0000	0.0000
1985	9	0.00000	0.00000	0	0.0000	0.0000
1986	10	0.00000	0.00000	0	0.0000	0.0000
1987	12	0.16393	0.16393	1	8.3333	8.3333
1988	5	0.00000	0.00000	0	0.0000	0.0000
1989	9	0.00000	0.00000	0	0.0000	0.0000
1990	3	0.00000	0.00000	0	0.0000	0.0000
1991	4	0.00000	0.00000	0	0.0000	0.0000
1992	5	0.00000	0.00000	0	0.0000	0.0000
1993	5	0.19934	0.19934	1	20.0000	20.0000
1994	5	0.60000	0.40000	2	40.0000	24.4949
1995	2	0.00000	0.00000	0	0.0000	0.0000
1996	5	0.00000	0.00000	0	0.0000	0.0000
1997	6	0.00000	0.00000	0	0.0000	0.0000
1998	2	0.00000	0.00000	0	0.0000	0.0000
1999	5	0.20000	0.20000	1	20.0000	20.0000
2000	4	0.00000	0.00000	0	0.0000	0.0000
2001	3	0.00000	0.00000	0	0.0000	0.0000
2002	7	0.00000	0.00000	0	0.0000	0.0000

Table 5.1.10. Bongo Summer Bottomfish Eastern Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	20	0.00000	0.00000	0	0.0000	0.0000
1983	20	0.00000	0.00000	0	0.0000	0.0000
1984	15	0.00000	0.00000	0	0.0000	0.0000
1985	10	0.29775	0.29775	1	10.0000	10.0000
1986	10	0.00000	0.00000	0	0.0000	0.0000
1987	12	0.00000	0.00000	0	0.0000	0.0000
1988	6	0.00000	0.00000	0	0.0000	0.0000
1989	9	0.34259	0.34259	1	11.1111	11.1111
1990	6	0.00000	0.00000	0	0.0000	0.0000
1991	4	0.00000	0.00000	0	0.0000	0.0000
1992	5	0.00000	0.00000	0	0.0000	0.0000
1993	5	0.00000	0.00000	0	0.0000	0.0000
1994	5	0.86957	0.86957	1	20.0000	20.0000
1995	2	0.00000	0.00000	0	0.0000	0.0000
1996	5	0.00000	0.00000	0	0.0000	0.0000
1997	6	0.56738	0.56738	1	16.6667	16.6667
1998	2	0.00000	0.00000	0	0.0000	0.0000
1999	5	0.00000	0.00000	0	0.0000	0.0000
2000	4	1.66667	1.66667	1	25.0000	25.0000
2001	4	1.23626	1.23626	1	25.0000	25.0000
2002	6	1.62152	1.07043	2	33.3333	21.0819

Table 5.1.11. Neuston Fall Ichthyoplankton Survey Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1985	10	0.00000	0.00000	0	0.0000	0.00000
1986	59	0.23729	0.11426	6	10.1695	3.96869
1987	56	0.08929	0.05270	3	5.3571	3.03619
1988	62	0.00000	0.00000	0	0.0000	0.00000
1989	62	0.40323	0.19575	5	8.0645	3.48631
1990	62	0.26857	0.12333	9	14.5161	4.51027
1991	63	0.12698	0.07330	4	6.3492	3.09685
1992	55	0.89556	0.27972	14	25.4545	5.92784
1993	63	0.52381	0.26082	10	15.8730	4.64089
1994	56	0.17857	0.07256	7	12.5000	4.45941
1995	56	2.80357	1.34416	10	17.8571	5.16428
1996	56	0.88304	0.34249	14	25.0000	5.83874
1997	55	0.74242	0.34052	7	12.7273	4.53534
1998	19	0.10526	0.10526	1	5.2632	5.26316
1999	68	0.87657	0.37187	11	16.1765	4.49870
2000	67	1.59701	0.67890	12	17.9104	4.71982
2001	58	0.11822	0.06436	4	6.8966	3.35631
2002	58	0.77019	0.32569	13	22.4138	5.52348

Table 5.1.12. Bongo Fall Ichthyoplankton Survey Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1985	24	0.00000	0.00000	0	0.0000	0.00000
1986	58	0.56269	0.22817	6	10.3448	4.03378
1987	67	1.12848	0.58948	7	10.4478	3.76511
1988	37	0.35417	0.30008	2	5.4054	3.76874
1989	36	1.32651	0.52292	6	16.6667	6.29941
1990	35	1.03456	0.42163	6	17.1429	6.46349
1991	35	0.87024	0.36577	6	17.1429	6.46349
1992	61	0.70630	0.25507	8	13.1148	4.35790
1993	63	0.79955	0.29948	9	14.2857	4.44408
1994	56	1.03334	0.77823	4	7.1429	3.47266
1995	56	2.14144	0.71293	14	25.0000	5.83874
1996	56	2.28011	1.07480	11	19.6429	5.35714
1997	55	1.95947	0.52939	16	29.0909	6.18063
1998	19	0.16129	0.16129	1	5.2632	5.26316
1999	70	0.58619	0.18171	10	14.2857	4.21263
2000	67	2.14205	0.72245	15	22.3881	5.13098
2001	57	2.05837	0.83919	12	21.0526	5.44789
2002	61	1.69997	0.62686	13	21.3115	5.28673

Table 5.1.13. Neuston Fall Ichthyoplankton Survey Eastern Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1986	83	0.00000	0.00000	0	0.0000	0.00000
1987	74	0.20270	0.14524	2	2.7027	1.89796
1988	65	0.01538	0.01538	1	1.5385	1.53846
1989	63	0.00000	0.00000	0	0.0000	0.00000
1990	76	0.02632	0.02632	1	1.3158	1.31579
1991	63	0.01625	0.01625	1	1.5873	1.58730
1992	55	0.12562	0.06345	5	9.0909	3.91210
1993	62	0.04841	0.02749	3	4.8387	2.74745
1994	70	0.00000	0.00000	0	0.0000	0.00000
1995	68	0.04412	0.03269	2	2.9412	2.06415
1996	64	0.01563	0.01563	1	1.5625	1.56250
1997	68	0.11639	0.06775	4	5.8824	2.87458
1998	14	0.07143	0.07143	1	7.1429	7.14286
1999	74	0.29798	0.13991	8	10.8108	3.63433
2000	55	0.09091	0.06499	2	3.6364	2.54738
2001	73	0.05303	0.03274	3	4.1096	2.33949
2002	38	0.08015	0.08015	1	2.6316	2.63158

Table 5.1.14. Bongo Fall Ichthyoplankton Survey East.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1986	83	0.07756	0.06442	2	2.4096	1.69345
1987	74	0.11323	0.07973	2	2.7027	1.89796
1988	51	0.11099	0.11099	1	1.9608	1.96078
1989	52	0.08097	0.08097	1	1.9231	1.92308
1990	56	0.08449	0.08449	1	1.7857	1.78571
1991	46	0.22761	0.13010	3	6.5217	3.68070
1992	56	0.00000	0.00000	0	0.0000	0.00000
1993	62	0.00000	0.00000	0	0.0000	0.00000
1994	70	0.11775	0.08314	2	2.8571	2.00561
1995	68	0.20225	0.10417	4	5.8824	2.87458
1996	64	0.00000	0.00000	0	0.0000	0.00000
1997	68	0.11190	0.06483	3	4.4118	2.50883
1998	16	0.14085	0.14085	1	6.2500	6.25000
1999	72	0.34144	0.20198	4	5.5556	2.71846
2000	63	0.61523	0.26047	7	11.1111	3.99123
2001	70	0.29891	0.13865	5	7.1429	3.10041
2002	40	0.15774	0.11058	2	5.0000	3.48991

Table 5.1.15. Neuston Summer Bottomfish and Fall Ichthyoplankton Survey Combined Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	53	0.01887	0.01887	1	1.8868	1.88679
1983	39	0.17949	0.15530	2	5.1282	3.57816
1984	54	0.12963	0.07951	3	5.5556	3.14640
1985	62	0.06452	0.03896	3	4.8387	2.74745
1986	98	0.16327	0.07208	7	7.1429	2.61492
1987	106	0.13208	0.05205	8	7.5472	2.57785
1988	93	0.01031	0.01031	1	1.0753	1.07527
1989	94	0.26596	0.13027	5	5.3191	2.32708
1990	69	0.24133	0.11116	9	13.0435	4.08407
1991	105	0.17143	0.07469	8	7.6190	2.60151
1992	99	0.77026	0.24718	21	21.2121	4.12961
1993	107	0.40187	0.16256	14	13.0841	3.27543
1994	102	0.20262	0.09396	10	9.8039	2.95892
1995	84	1.86905	0.90510	10	11.9048	3.55466
1996	81	0.70865	0.24897	17	20.9877	4.55286
1997	105	0.58889	0.24683	11	10.4762	3.00299
1998	27	0.14766	0.10238	2	7.4074	5.13611
1999	107	0.64118	0.24292	15	14.0187	3.37212
2000	117	1.01636	0.39903	15	12.8205	3.10407
2001	102	0.67856	0.54526	9	8.8235	2.82229
2002	103	0.88837	0.30315	23	22.3301	4.12355

Table 5.1.16. Bongo Summer Bottomfish and Fall Ichthyoplankton Survey Combined Western Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	56	0.42747	0.14789	9	16.0714	4.95223
1983	39	0.51661	0.24993	4	10.2564	4.92161
1984	55	0.43465	0.17816	6	10.9091	4.24242
1985	81	0.50823	0.21748	7	8.6420	3.14148
1986	121	0.70672	0.19915	15	12.3967	3.00831
1987	129	0.83478	0.32685	13	10.0775	2.66076
1988	68	0.53339	0.24513	6	8.8235	3.46517
1989	67	0.97941	0.33461	9	13.4328	4.19748
1990	66	0.65492	0.25083	7	10.6061	3.81922
1991	79	0.64962	0.21539	10	12.6582	3.76487
1992	106	1.25886	0.41135	17	16.0377	3.58112
1993	108	0.63622	0.21729	11	10.1852	2.92393
1994	101	0.91657	0.46930	8	7.9208	2.70063
1995	83	1.50794	0.49401	15	18.0723	4.24928
1996	81	2.76869	1.00451	17	20.9877	4.55286
1997	105	1.77119	0.45606	23	21.9048	4.05569
1998	27	4.78339	3.21036	4	14.8148	6.96696
1999	109	0.94243	0.23721	19	17.4312	3.65056
2000	117	2.23520	0.48891	29	24.7863	4.00890
2001	101	1.82666	0.53314	20	19.8020	3.98507
2002	106	2.03169	0.47323	26	24.5283	4.19886

Table 5.1.17. Neuston Summer Bottomfish and Fall Ichthyoplankton Survey Combined Eastern Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	20	0.00000	0.00000	0	0.0000	0.00000
1983	18	0.00000	0.00000	0	0.0000	0.00000
1984	15	0.00000	0.00000	0	0.0000	0.00000
1985	9	0.00000	0.00000	0	0.0000	0.00000
1986	93	0.00000	0.00000	0	0.0000	0.00000
1987	86	0.19729	0.12679	3	3.4884	1.99018
1988	70	0.01429	0.01429	1	1.4286	1.42857
1989	72	0.00000	0.00000	0	0.0000	0.00000
1990	79	0.02532	0.02532	1	1.2658	1.26582
1991	67	0.01528	0.01528	1	1.4925	1.49254
1992	60	0.11515	0.05830	5	8.3333	3.59823
1993	67	0.05968	0.02915	4	5.9701	2.91644
1994	75	0.04000	0.02965	2	2.6667	1.87283
1995	70	0.04286	0.03176	2	2.8571	2.00561
1996	69	0.01449	0.01449	1	1.4493	1.44928
1997	74	0.10695	0.06233	4	5.4054	2.64659
1998	16	0.06250	0.06250	1	6.2500	6.25000
1999	79	0.29178	0.13152	9	11.3924	3.59746
2000	59	0.08475	0.06062	2	3.3898	2.37622
2001	76	0.05094	0.03147	3	3.9474	2.24842
2002	45	0.06768	0.06768	1	2.2222	2.22222

Table 5.1.18. Bongo Summer Bottomfish and Fall Ichthyoplankton Survey Combined Eastern Gulf.

YEAR	N	A	A-SE	FO	%FO	FO-SE
1982	20	0.00000	0.00000	0	0.0000	0.0000
1983	20	0.00000	0.00000	0	0.0000	0.0000
1984	15	0.00000	0.00000	0	0.0000	0.0000
1985	10	0.29775	0.29775	1	10.0000	10.0000
1986	93	0.06922	0.05751	2	2.1505	1.5124
1987	86	0.09743	0.06867	2	2.3256	1.6347
1988	57	0.09930	0.09930	1	1.7544	1.7544
1989	61	0.11957	0.08487	2	3.2787	2.2990
1990	62	0.07631	0.07631	1	1.6129	1.6129
1991	50	0.20940	0.11991	3	6.0000	3.3927
1992	61	0.00000	0.00000	0	0.0000	0.0000
1993	67	0.00000	0.00000	0	0.0000	0.0000
1994	75	0.16787	0.09600	3	4.0000	2.2780
1995	70	0.19647	0.10126	4	5.7143	2.7943
1996	69	0.00000	0.00000	0	0.0000	0.0000
1997	74	0.14883	0.07446	4	5.4054	2.6466
1998	18	0.12520	0.12520	1	5.5556	5.5556
1999	77	0.31927	0.18902	4	5.1948	2.5456
2000	67	0.67800	0.26154	8	11.9403	3.9914
2001	74	0.34958	0.14560	6	8.1081	3.1948
2002	46	0.34867	0.17670	4	8.6957	4.2004

Appendix 5.2.

Figures 5.1-4. Red snapper frequency of abundance categories for positive catch stations by year, for bongo and nueston net collections from the Summer Bottomfish and Fall Ichthyoplankton surveys.

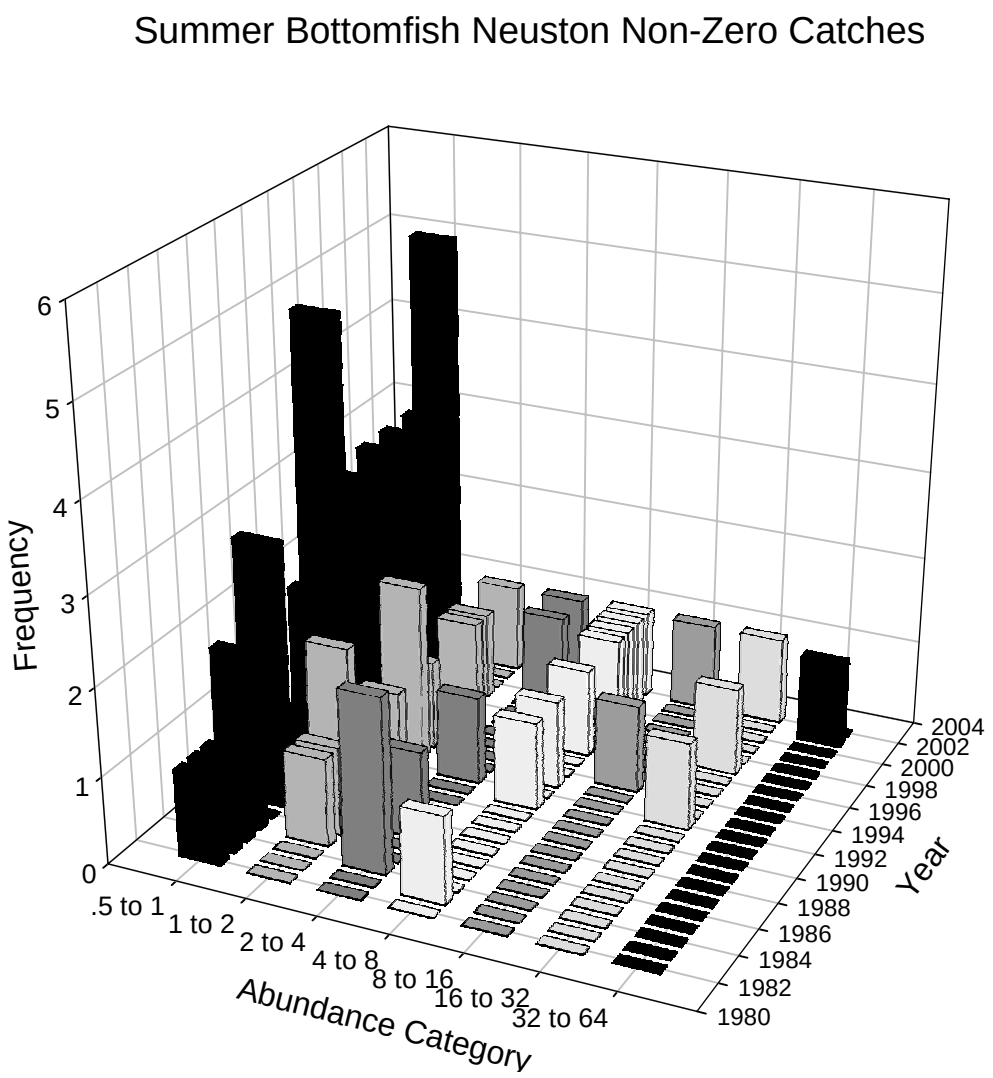

Figure 5.2.1. Frequency of standardized abundance categories for positive catch neuston stations by year for the SEAMAP Summer Bottomfish surveys. Abundance categories are in the number of larvae per 10 minute tow.

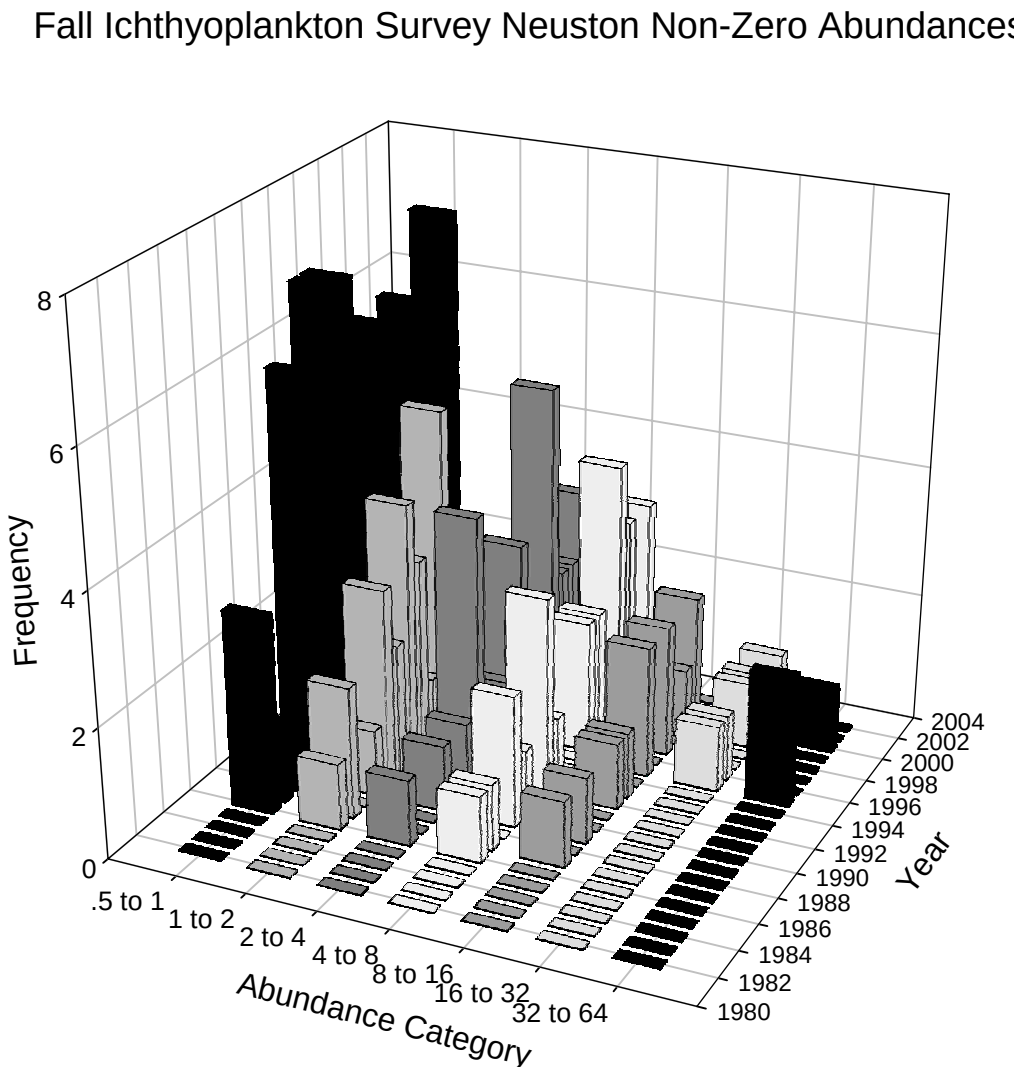

Figure 5.2.2. Frequency of standardized abundance categories for positive catch nueston stations by year for the SEAMAP Fall Ichthyoplankton surveys. Abundance categories are in the number of larvae per 10 minute tow.

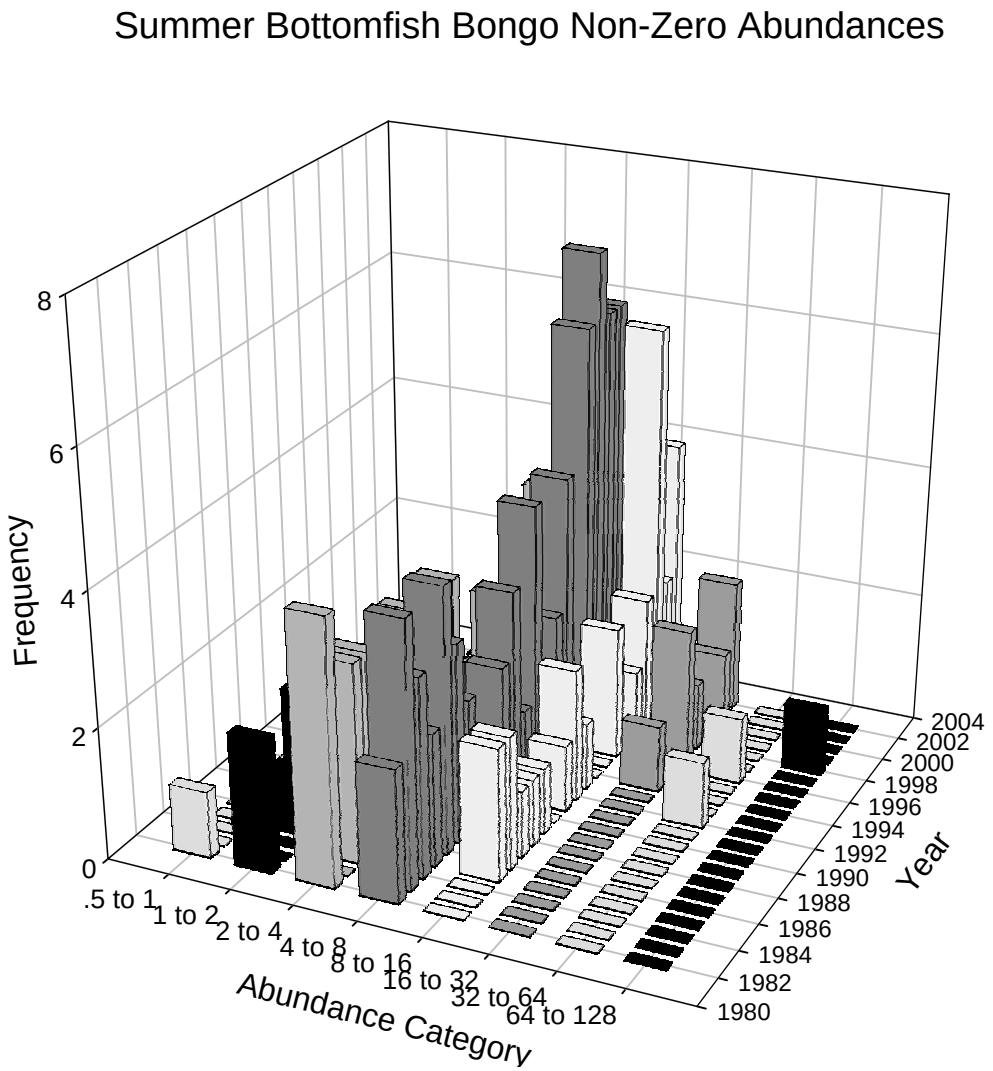

Figure 5.2.3. Frequency of standardized abundance categories for positive catch bongo stations by year for the SEAMAP Summer Bottomfish surveys. Abundance categories are in units of the number of larvae per 10 meters squared of sea surface.

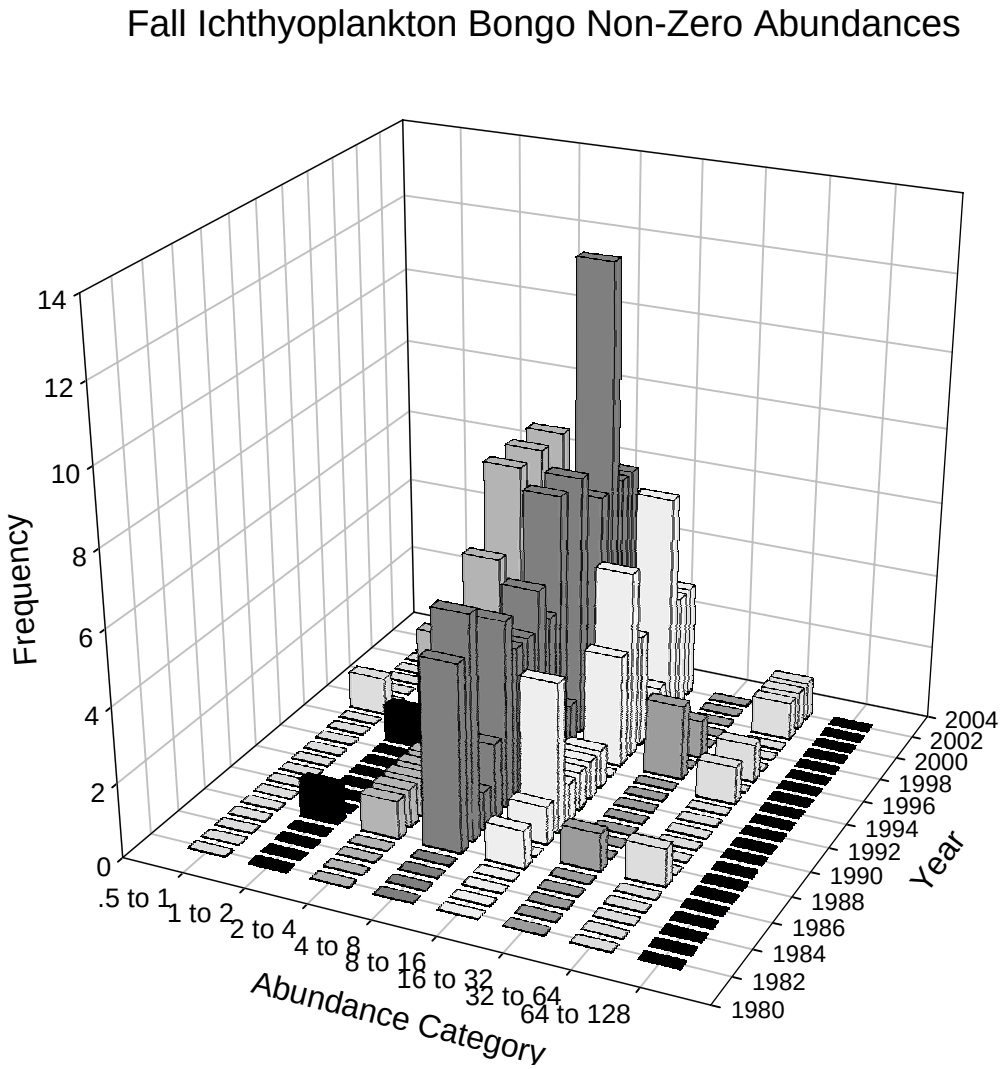

Figure 5.2.4. Frequency of standardized abundance categories for positive catch bongo stations by year for the SEAMAP Fall Ichthyoplankton surveys. Abundance categories are in units of the number of larvae per 10 meters squared of sea surface.

6. Release Mortality

6.1 Background

Gulf of Mexico red snapper are now protected from harvest by a size limit of 15 inches total length for the commercial fishery and 16 inches total length for the recreational fishery. The minimum size for recreational fisherman was increased to 18 inches for the last month of the recreational season in 1999. Anecdotal comments from fishermen attest to the consequence of this regulation i.e., significant numbers of undersize red snapper are caught and must be released. The mortality of released fish is an important consideration in evaluating the conservation effects of regulations that set minimum sizes and total allowable catch.

Data from some recent studies of the mortality of reef fishes after being caught and released were summarized by Parker (1991) who in an earlier report observed no immediate mortality of 30 red snapper (<16 in TL) caught from 30 m off the Texas coast and released at the surface (Parker 1985). That report also described experiments which found a mortality of 21% for red snapper that were caught from 22 m, returned to the capture depth and held in wire cages. A similar study at 30 m resulted in 11% mortality. Gitschlag and Renaud (1994) found that mortality of small (<32 cm) red snapper caught by hook and line off Texas and released at the surface was 1% at 21-24 m (n=138), 10% at 27-30 m (n=27), and 44% at 37-40 m (n=47). These authors also observed a mortality of 36% for red snapper that were caught from 50 m, returned to the capture depth and held in wire cages. Render and Wilson (1994) found mean mortality to be 20% for red snapper caught at 21 m and released at the surface into a 9-m-deep cage after 48 hours. Release mortality was higher in the fall than spring. Also, there was a nonsignificant increase in mortality with depth of capture.

Patterson et al. (2001) reported that of nearly 3,000 red snapper tagged and released in the north central Gulf, off Dauphin Island, 84% were released in "condition one," defined as fish that immediately returned to the bottom, showing no signs of stress. These were assumed to have survived capture and tagging. This survival assumption is strengthened by subsequent recapture of more than 500 fish, some of which had been judged to have been more stressed than condition one. Of the recaptured fish, thirty-five were recaptured twice, and one fish was recaptured three times. These data further suggest that red snapper can survive the catch-and-release experience. The study was based on release depths of 21m, 27m, and 32m. Release mortality was estimated at 9%, 14%, and 18%, respectively. Subsequent to the published study, an additional 3,000+ snapper were tagged and released, but the tagging process was streamlined. The release mortality, based on the "condition" assessment was reduced to about 12% (Shipp, pers. comm.).

Further tagging efforts are reported in Burns et al. (2004), at depths of 13m to 66 m. Of 5470 releases, 435 total recaptures have been made, primarily at 20 to 40 m (the same depth where most of them were tagged). Of those recaptures, 20 were captured twice and 5 were recaptured 3 times. This provides additional evidence of red snapper surviving the capture event.

C. Koenig conducted capture-release mortality studies off Apalachicola and Caribelle, Florida during the fall and spring of 1999, 2000, and 2001 (reported in Burns et al. 2002). Small red snapper (<50 cm) were caught using electric reels aboard chartered commercial vessels. Ascent rate varied 1-2 m/sec. Standard J hooks were replaced by circle hooks to eliminate gut and gill hooked fish. Fish were not vented. Cages remained on the bottom for 5 – 8 days. There was a direct, strong relationship between depth related mortality and surface interval. At a 40 m capture depth, mortality varied from 20 % at a 3 minute surface interval to 100% for an 18 minute surface interval (Fig. 6.1). These results indicate that the faster fish are released and returned to the bottom, the higher the survival. Burns et al. (2002) suggest that the higher internal pressure relative to ambient is a major factor in the relationship between surface interval and mortality.

Dorf (2003) conducted a study of the recreational headboat discards at 3 ports in Texas (Galveston, Port Aransas, and Port Isabel) in August and September of 1999. Discard fate was determined for 3,851 fish (12.9% were kept and landed). Of those discarded, 60.6% were released alive and swam down, 22.8% were swimming erratically, 15.2% floating, and 1.4% were discarded dead. Fish released either dead or floating were caught at greater depths than fish which swam down or swam erratically on release. Depth ranged from 13.4 – 95.4 m. When snapper were discarded, 62.8% were released by hook removal without puncturing the swim bladder. The swim bladder was punctured along with hook removal for 36.2% of released snapper. Although hook type was not specifically documented, circle hooks are the predominant hook type on Texas headboats.

Burns et al. (2004) evaluated release mortality in 3 components: causes of acute mortality, hook related mortality with circle versus J hooks, and hyperbaric experiments to examine depth related mortality. Out of 266 undersized red snapper caught off Panama City, Daytona and St. Augustine, Florida, 171 (or 64.3%) suffered acute mortality (i.e., the fish were landed dead or died

on deck before they could be returned to the water). Of the 171 acute mortalities, 49.1% of them were killed from hook induced mortality. Another 13.5% were killed due to depth related trauma, and the remainder died of "other" causes. At all depth categories, hooking mortality was the largest proportion of identified mortality causes. In addition, several snapper brought back to MML died of latent hook injuries.

Burns et al. (2004) evaluated depth related mortality by placing fish in hyperbaric chambers. Red snapper suffered no mortality when exposed to simulated depths of 21 or 27.4 m, while 40% died at 43 m and 45% died at 61 m.

Diamond et al. (2004) are conducting a study of Texas release mortality and discards. Preliminary results from a control study to evaluate delayed mortality found significant differences in mortality for the main effects (depth, season). The control studies were conducted at BP Oil platforms, and used cages to assess mortality over a 4 day period.
All fish were vented. Circle hooks were used (>90% of fish were hooked in mouth).
Deeper depths and increased temperatures caused an increase in mortality. Overall mortality for the control project was 64%. By depth, observed mortality was: 53% at 30 m, 71% at 45 m, and 69% at 50 m. With respect to temperature, the proportion of released fish that were classified as dead (by month) was: 90% in July, 63% in September, and 44% in October.

Wilson and Nieland (2004) are conducting studies of the fate of undersized red snapper caught on commercial vessels off central Louisiana. Overall, 16 trips with 273 fishing events were observed at depths ranging from 30-90 m. Undersized fish were released and their condition of release was categorized as 1) swam down vigorously; 2) swam down slowly; 3) alive, but remained at surface; 4) unresponsive or dead. Over the 2 year study period, 65-74% of discards were classified in categories 3 and 4. Fish in category 2 accounted for 15% of total discards. Circle hooks and bandit reels were the principle gear.

Recent studies have evaluated hooking mortality for circle versus J hooks. Circle hooks have a different pattern of hooking location, typically around the maxilla for red snapper (Dorf 2004). It is believed that circle hooks reduce hooking related mortality because of reduced hook swallowing and subsequent damage to internal organs. During 2003, a comparison of release mortality of circle and "J" hooks was conducted as part of a long term tag-recapture study (Shipp, pers. comm.). Release mortality was reduced by approximately 50% by capture with circle hooks (Shipp, pers. com.). An evaluation of tagged fish in the Burns et al. (2004) study caught initially on either circle or J hooks revealed similar recapture rates for both hook types (5.5% for circle, 7.2% for J) in the headboat fishery. Circle hooks distributed by Burns et al. did not have the hook offset, however it is not known if fishers manually offset any hooks or if fishers used their own circle hooks with an offset angle. In practice, the commercial fishery uses circle hooks, and in the recreational fishery, the trend is moving towards increased use of circle hooks.

In addition to the hooking and handling mortality, predation of released fish may be important in areas with significant concentrations of large predators. Parker (1985) noted 19.5% mortality of reef fish caught and released in 20-30m depths off Daytona, Florida due to predation. In contrast, Gitschlag and Renaud (1994) noted that predation was not apparent in their study. Burns et al. (2004) directly observed dolphin predation on 2.9% - 6.5% of discards, and dolphins were seen to pursue another 20%-21.7% of released fish although the actual take was not witnessed. Wilson and Nieland (2004) also noted predation by pelicans and dolphins, and Shipp (pers. comm.) noted that bottlenose dolphins occasionally appeared during tagging operations and were seen to actively pursue red snapper.

Preliminary data from a study conducted at Mote Marine Laboratory (Burns and Porch *in preparation*, Figure 6.2) suggest that venting increases survival in red snapper caught in deep water. This is in contrast to earlier studies by Render and Wilson (1993) and Gitschlag and Renaud (1994), who found no increase in survival from venting. The work by Burns and Porch (*in progress*) updates the study by Burns and Restrepo (1999), which had concluded no significant difference between vented and non-vented fish. It is believed that venting, when properly executed, can increase survival of released fish. Most commercial fishermen are not thought to vent. The extent of venting in the recreational fishery is unknown. Florida SeaGrant is distributing pamphlets and producing videos that demonstrate proper venting techniques, and they are providing free venting kits. A survey is suggested as a way of determining the fraction of fishermen that vent.

Temperature related effects were reported by Render and Wilson (1994) and Diamond et al. (2004). Both studies found release mortality to be lower in the fall than in the summer months.

6.2 Derivation of estimates

To derive estimates of release mortality by region (West Gulf = Texas and Louisiana, East Gulf = Mississippi, Alabama, and West Florida), the effort at which fishing occurred in each fishery was determined and this was then matched with study estimates of release mortality by depth. Table 6.1 summarizes study estimates of release mortality by depth.

For Texas headboat and charterboat fisheries, Diamond et al. (2004) sampled depth ranges of 10 to 115 m with a median of 43 m. Dorf (2003) also sampled the Texas headboat fishery, and the depths fished ranged from 13-95 m with an average of about 40 m. Dorf (2003) found release mortality to be 40% at this depth (Table 6.1), and this value included Categories 2-4. The study by Diamond et al. (2004) found release mortalities of 71% at 45 m. While the Diamond et al. estimates made observations after 4 days to account for delayed mortality, the value of 71% includes survival of both control fish and fish from which blood was drawn. It is suspected that mortality may be inflated due to the increased stress and handling for the blood-drawn fish, but further analysis of this data is required to assess that. As this project is still being conducted, no further results are anticipated prior to the stock assessment.

Effort in Louisiana is believed to be focused at depths similar to Texas. Thus, a release mortality of 40% is assumed for the western Gulf recreational fisheries.

The recreational fishery in the northeastern and north central Gulf of Mexico is prosecuted in relatively shallow water, usually at depths of less than 40m (Patterson et al. 2001). The bulk of observations in the study by Burns et al. (2004) were concentrated in 20 to 40 m depths along the panhandle and west and southwest coast of Florida, and the east coast of Florida from Daytona to northeast Florida. Studies conducted in the eastern Gulf (Table 6.1) found release mortalities of 8.9%-22% at these depths. These estimates are based on observation methods that included Cage+SCUBA and surface observations that included Categories 2-4 as mortalities. Averaging over that range, we obtain a value of approximately 15% for the eastern Gulf recreational fisheries.

A Gulf-wide estimate of release mortality in the recreational fishery can be obtained by multiplying the proportion of landings in each region by the corresponding estimate of release mortality. The average landings by each region was close to 50-50 until 1997. For the period 1997-2002, the average by region is about 77% for the eastern region and 23% for the western region. Two possible explanations for the observed change were suggested. First, a strong year class in 1995 would have recruited to the fishery landings in the period 1997-2002. Second, management actions that changed the quota and that closed the winter season during this period may help explain the reduction in proportional and total western regional landings. A Gulf-wide estimate of release mortality for the recreational fishery is 27.5% the period 1981-1996, and 21% for the period 1997-2002.

The only available depth information for the commercial fishery is provided by TIP, which records the minimum and maximum depths fished on a given trip. The midpoint of the reported depth range was used to represent depth fished on that trip. Depth fished was examined following the same regional delineation in the Gulf as was used in the recreational analysis, namely an eastern region consisting of Florida, Alabama, and Mississippi, and a western region comprised of Texas and Louisiana. The regional analysis was summarized according to the open versus closed commercial fishing season, because it is believed that fishing during the closed season occurs in deeper waters where release mortality is expected to be higher. The median of the depths fished by region and by open/closed season was matched to a release mortality estimate by examining scientific studies in the regions, and self-reported dead discards from the logbook program.

During the open season, the median depth for trips that landed red snapper was 55 m in the eastern Gulf and 58 m in the western Gulf. Because the commercial and recreational fisheries operate very differently, release mortality estimates were restricted to studies that sampled the commercial fishery. In the eastern Gulf, a study by Burns et al. (2002) fit a logit regression to estimate release mortality at depth. At 55m, the estimate from their equation predicts a release mortality of about 70%. In the western Gulf, the work by Wilson and Nieland (2004) found a release mortality of 85% (categories 2,3,4) for depths between 50 and 60 m. From self-reported discard records in the logbook program (Poffenberger and McCarthy, SEDAR7-DW-22), fish were classified into one of the following categories: All dead, Mostly dead, Mostly alive, All alive, Kept but not sold, Unable to determine. Although these categories do not match those of other studies, a reasonable approximation was to treat the sum of categories “All dead + Mostly dead + Mostly alive” as similar to categories 2-4 in the surface observation studies. Using this criterion, an estimate of release mortality from the logbook program is 72% in the east and 78% in the west. Averaging the estimates from the logbook program with regional estimates from scientific studies, the release mortalities assigned to the commercial fishery during the open season are 71% in the east and 82% in the west.

In the closed season, there are no red snapper trips recorded in the TIP database. Rather than look at depths for all trips in the closed season, it was decided that only trips that were likely to catch red snapper should be examined. To identify these trips, discard records from the logbook program that reported red snapper discard in the closed season were matched to landings of other

species caught on those trips. The list of all species associated with trips discarding red snapper was reduced to those species that accounted for a substantial portion of total regional red snapper discards. The species in each region that were associated with trips likely to catch red snapper are reported in Table 6.3; in the western Gulf, the top two species were mackerel (king and cero) and vermilion snapper, while in the eastern Gulf, red and gag grouper were associated with the greatest amount of red snapper discard.

Trips that landed any of the species identified in Table 6.3 during the closed red snapper season were extracted from the TIP database. The median depth fished on these trips in the eastern Gulf was 55 m (the same as in the open season) and 83 m in the western Gulf. The list of species associates was evaluated to determine how sensitive the median estimate of depth fished was to the inclusion/exclusion of some species. In the east, only yellowtail snapper had a lower median depth fished of 23 m; all of the remaining fish were associated with depths of 42-68 m. In the west, only king and cero mackerel were caught at shallower depths (median 38 m), while the remaining species on the list were caught in the range of 83-101 m. From this, it was concluded that the median depth assigned to each region in the closed season was not sensitive to the species included in the analysis.

Release mortality in the eastern Gulf during the closed season is the same estimate as during the open season (71%) because the median depth fished was the same. In the western Gulf, Wilson and Nieland (2004) estimated release mortality to be about 97% for trips that fished at depths of 80-85 m. For the sake of comparison, the logit model of Burns et al. (2002) predicts a release mortality of 91% at 80m. Averaging the estimates in the western Gulf from the logbook program (78%) and from the study by Wilson and Nieland (97%), the release mortalities assigned to the commercial fishery during the closed season are 71% in the east and 88% in the west.

A Gulf-wide estimate of release mortality in the commercial fishery could be obtained by weighting the regional estimates according to regional proportional landings (total weight). Table 6.4 shows the proportional landings by region in the commercial fishery from 1962-2003. The average split in total landings by weight is 86% for the eastern Gulf and 14% for the western Gulf for the period 1962-1983, whereas the last ten years (1993-2003) show the opposite split (15% for the eastern Gulf and 85% for the western Gulf). For the intervening period, the landings by the eastern region declined steadily from a high of 68% to a low of 25%. A Gulf-wide estimate of release mortality is 73% for the period 1962-1983, and 80% for the period 1993-2003. For the period 1984-1992, the average split between the east and west is 43% for the east and 57% for the west. Applying these proportions, a weighted average for Gulf-wide release mortality is 77% for 1984-1992.

In the recreational fishery, the depths of fishing assigned to each region were derived from recent studies. The group discussed whether these depths could have varied over time. Because recreational effort directed towards red snapper is concentrated on structures (wrecks, reefs, rigs, etc.), it is not believed that fishing depth has changed over time. For the commercial fishery, reported depths from the TIP database were examined for a temporal trend in both the open and the closed season. No temporal trend was observed. In the east, the range was 50-60 m in the closed season and 41-64 meters in the open season. In the west, the range was 73-100 during the closed season and 34-79 during the open season.

As noted in several recent studies, predation on discarded fish by dolphins and pelicans is occurring in both the recreational and commercial fisheries. It is also being reported to occur on fish before they are landed. At present, there is no way of quantifying the mortality caused by predation, and the group does not recommend including an additional component of mortality due to predation. Estimates reported in the studies by surface observation method, which counted categories 2-4 as mortalities, would already account for predation on fish in these categories. It is felt that the estimates derived for regional, fishery specific release mortality represent a compromise on potential biases, both high and low. Two tagging studies (Burns et al. 2004, Bob Shipp *pers. comm.*) report recoveries of fish released in categories 2-4; there is no measure of delayed mortality or predation on category 1 fish; and underwater predation prior to landing fish cannot be quantified.

Point estimates of release mortalities assigned to each sector (recreational and commercial) and region, and the associated depths fished, are summarized in Table 6.5. Uncertainty associated with these estimates comes from having no depth observations in the recreational fishery and only very limited depth information for the commercial fishery, no estimates of variability for the release mortality values in the studies summarized in Table 6.1, no way of quantifying the distribution of handling time for each fishery, little or no information about venting practices by each fishery, as well as the aforementioned uncertainty in fish fate (based on surface observations) and unquantifiable predation. For these reasons, no attempt was made to provide a distribution for these point estimates. If sensitivity runs are desired, one might consider using the minimum and maximum observed estimates in Table 6.1 that are associated with each category in Table 6.5.

6.3 References

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Table 6.1. Summary of release mortality estimates by study, observation method, and area. (R&W refers to Render and Wilson; G&R refers to Gitschlag and Renaud).

Depth range (5 meter intervals)	Release Mortality	Method of Observation	Study	Area
<20 m	0%	Hyperbaric	Burns	Panama City, FL
	22%	Cage+SCUBA	Parker	Daytona,FL and Galveston
	21%	Cage	R&W	LA gas platforms
	1%	Cage	G&R	Galveston, TX
	8.9%	Surface Obs	Patterson	AL coast
	0%	Hyperbaric	Burns	Panama City, FL
25	41%	Surface Obs	Dorf	Texas ports
	11%	Cage+SCUBA	Parker	Daytona, FL and Galveston
	10%	Cage	G&R	Galveston, TX
	8.9%	Surface Obs	Patterson	AL coast
	0%	Hyperbaric	Burns	Panama City, FL
	53%	Cage	Diamond	Port Aransas, TX
30	47%	Surface Obs	Dorf	Texas ports
	13%	Surface Obs	Patterson	AL Coast
35	15%	Surface Obs	Dorf	Texas ports
	44%	Cage	G&R	Galveston, TX
40	40%	Surface Obs	Dorf	Texas ports
	40%	Hyperbaric	Burns	Panama City, FL
	71%	Cage	Diamond	Port Aransas, TX
45	63%	Surface Obs	Dorf	Texas ports
	36%	Cage	G&R	Galveston, TX
	69%	Cage	Diamond	Port Aransas, TX
50	61%	Surface Obs	Dorf	Texas ports
55	58%	Surface Obs	Dorf	Texas ports
	45%	Hyperbaric	Burns	Panama City, FL
60	38%	Surface Obs	Dorf	Texas ports
65	37%	Surface Obs	Dorf	Texas ports
70	33%	Surface Obs	Dorf	Texas ports
75	23%	Surface Obs	Dorf	Texas ports
80	47%	Surface Obs	Dorf	Texas ports
85				
90				
95	56%	Surface Obs	Dorf	Texas ports
100				

Table 6.2. Proportional landings by region in the Gulf of Mexico recreational fishery. Proportions were calculated from MRFSS (1981-2003), Headboat (1986-2002), and Texas Parks and Wildlife Division (1983-2002) data sets, which are summarized in SEDAR7-DW-58.

Year	FL+MS+AL	TX+LA
1981	0.40	0.60
1982	0.55	0.45
1983	0.38	0.62
1984	0.21	0.79
1985	0.50	0.50
1986	0.51	0.49
1987	0.60	0.40
1988	0.42	0.58
1989	0.45	0.55
1990	0.52	0.48
1991	0.52	0.48
1992	0.52	0.48
1993	0.53	0.47
1994	0.46	0.54
1995	0.41	0.59
1996	0.50	0.50
1997	0.64	0.36
1998	0.73	0.27
1999	0.84	0.16
2000	0.78	0.22
2001	0.82	0.18
2002	0.84	0.16

Table 6.3. Species associated with trips that reported red snapper discards during the closed season.

Eastern Gulf	**Proportion of total red snapper discard associated with trips catching species**
GROUPER,RED	0.141
GROUPER,GAG	0.101
SNAPPER,MANGROVE	0.084
SCAMP	0.058
GROUPER,BLACK	0.049
SNAPPER,YELLOWTAIL	0.046
SNAPPER,VERMILION	0.040
TRIGGERFISH,GRAY	0.038
Western Gulf	
MACKEREL,KING AND CERO	0.147
SNAPPER,VERMILION	0.073
SCAMP	0.049
TRIGGERFISH,GRAY	0.048
GREATER AMBERJACK	0.046
GROUPER,WARSAW	0.044

Table 6.4. Proportional landings (total weight) by region in the Gulf of Mexico commercial fishery. Proportions were calculated from Table 1 in SEDAR7-DW-23.

Year	FL+MS+AL	TX+LA
1962	0.80	0.20
1963	0.81	0.19
1964	0.82	0.18
1965	0.83	0.17
1966	0.86	0.14
1967	0.86	0.14
1968	0.87	0.13
1969	0.89	0.11
1970	0.87	0.13
1971	0.86	0.14
1972	0.83	0.17
1973	0.87	0.13
1974	0.88	0.12
1975	0.91	0.09
1976	0.93	0.07
1977	0.90	0.10
1978	0.91	0.09
1979	0.92	0.08
1980	0.89	0.11
1981	0.83	0.17
1982	0.83	0.17
1983	0.81	0.19
1984	0.68	0.32
1985	0.60	0.40
1986	0.43	0.57
1987	0.41	0.59
1988	0.34	0.66
1989	0.35	0.65
1990	0.41	0.59
1991	0.35	0.65
1992	0.25	0.75
1993	0.18	0.82
1994	0.20	0.80
1995	0.12	0.88
1996	0.11	0.89
1997	0.10	0.90
1998	0.10	0.90
1999	0.12	0.88
2000	0.16	0.84
2001	0.18	0.82
2002	0.24	0.76
2003	0.16	0.84
2003	0.16	0.84

Table 6.5. Summary of depths fished by fishery and by region in the Gulf of Mexico, and the estimate of release mortality assigned. Release mortality is expressed as the percent of discarded fish that were assumed to suffer mortality.

Recreational Fishery	**Depth**	**% Release Mortality**
Eastern Gulf	20-40 m	15%
Western Gulf	40 m	40%
Gulf-wide (1981-1996)		27.5 %
Gulf-wide (1997-2002)		21%
Commercial Fishery—Open Season		
Eastern Gulf	55 m	71%
Western Gulf	58 m	82%
Gulf-wide (1962-1983)		73%
Gulf-wide (1984-1992)		77%
Gulf-wide (1993-2003)		80%
Commercial Fishery—Closed Season		
Eastern Gulf	55 m	71%
Western Gulf	83 m	88%

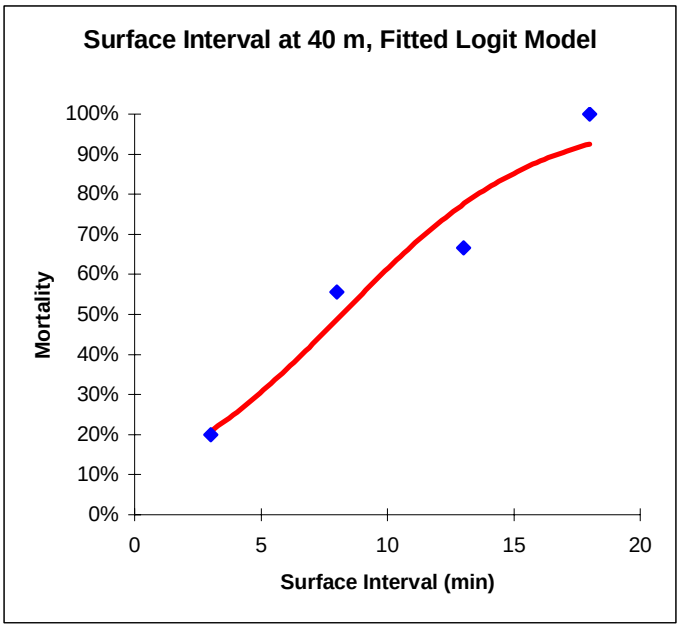

Figure 6.1. The relationship between surface interval of captured red grouper, red snapper, and gag and mortality at 40 m capture depth. (From Burns et al. 2002)

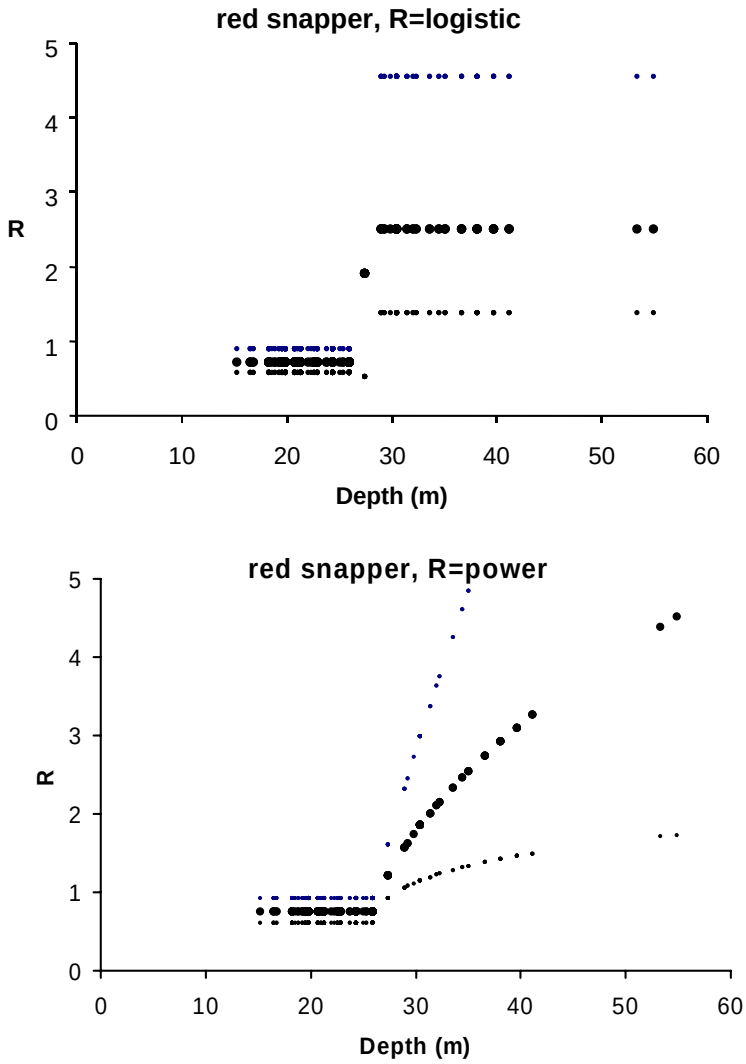

Figure 6.2. Estimated survival of vented red snapper relative to un-vented red snapper (R) as a function of depth with 80% confidence limits. A value of 1.0 would imply that venting has no effect on survival whereas a value less than 1.0 would imply that venting decreases survival. The logistic and power function expressions of R explain the data equally well (i.e., they have similar AIC values). (From *Burns and Porch, in progress*)

7. Shrimp Fleet Bycatch

7.1 Shrimp Effort Calculations

Allocation of Landing and CPUE

Allocation of landings and CPUE has been a concern relative to the estimation of shrimp effort in the Gulf of Mexico. Current shrimp effort estimations involve the assignment of shrimp landings and effort to one or more of 231 location cells by month. The allocations are based on information obtained through dockside interviews conducted by port agents. The current method (SEDAR7-DW-24) involves allocation to 21 statistical areas subdivided by 10 depth zones on a monthly basis. In location cells where no interview data are available, a General Linear Model (GLM) based on historical data, is used to estimate effort. For the 2004 assessment, this method will be used as a comparative or baseline run for the new assessment as described below.

Because of a reduction and possible misallocation to proper cells in dockside interviews over the past decade, alternative pooling methods will be used for the 2004 assessment. A determination was made by the group to pool data in a manner most applicable to the shrimp fishery as opposed to pooling for bycatch species (e.g., red snapper, king mackerel).

The consensus of the group was to pool location cells into larger units by collapsing interview and landings data into four statistical area groups (1-9; 10-12; 13-17; 18-21); two depth zones ($\leq$10, >10); and three-four month seasons (Jan-April; May-Aug; Sept-Dec). This "pooling scheme" is denoted as model SN (SEDAR7-DW-24).

Interview Representation

Concern related to interview data as being non-representative with respect to vessel size was addressed (SEDAR7-DW-6). The common consensus proposed to correct for this potential problem is to apply an alternative model where effort is estimated for non-interviewed vessels (Model 4, SEDAR7-DW-6). The effort estimates from this model will be used as an alternative scenario in the 2004 assessment.

By expanding or pooling, we reduce any allocation error made by port agents.
The selected or any other "pooling scheme" based upon the current data will not, however, address the underestimation of effort in nearshore and deep-water areas. Higher effort in deep-water has been reported recently; however the majority of effort still occurs in the 20-35 fathom zone, typically off statistical area 19. A recommendation was made to continue to partition by state (e.g. 18-21- TX) due to the radically different regulatory measures of each Gulf state. Differences in statistical areas 18 and 19 relative to habitat and fishery operations were explored. The uniqueness of statistical zones 1-3 when compared to zones 4-9 off Florida was discussed.

7.2 Red Snapper CPUE

Data Inputs

Data inputs for bycatch were discussed by the group. From group consensus, there were no issues of concern relative to SEAMAP (SEDAR7-DW-2) or to observer data (SEDAR7-DW-5).

Average Number of Nets

Methods of estimating bycatch have historically assumed an average of 2 nets was representative of the shrimp fishery. SEDAR7-DW-54 describes a functional-distribution approach (with variance estimates) to address the increase in total nets pulled on a per-tow basis from 1 to 4 over time. The group agreed to include a function describing the increase in the number of nets per vessel in the estimates of red snapper bycatch, as outlined in SEDAR7-DW-54.

Bycatch Models

In past stock assessments, a general linear model (GLM) has been used to estimate red snapper bycatch. However, this linear modeling technique did not generate a credible estimate of variance for these effort values. Because of the lack of the ability to estimate variance for the central tendencies of the data and the unbalanced nature of the data sets, this approach has been criticized during previous peer reviews. Therefore, a Bayesian model using Markov Chain Monte Carlo procedures was developed to estimate red snapper bycatch (SEDAR7-DW-3 and 54). This type of model provides for the ability to calculate variance for these estimates, while simultaneously addressing the lack of data in some of the cells

Two papers were submitted following up on suggestions to consider Small Area Estimation (SAE) from the Congressionally-mandated review in 1997. The original SAE suggestions were found to require too many ad hoc procedures to produce complete bycatch estimates (SEDAR7-DW-31). A spatial model that attempted to incorporate the spirit of the SAE suggestions was found to be beyond the current state of knowledge with respect to numerical analysis, and was unsuccessful.

Following detailed discussions of the Bayesian approach a consensus by the group was reached. Because of the ability of the Bayesian model to calculate variance terms while dealing with observations of zero, it was agreed to adopt this model (model 02 of SEDAR7-DW-3, as updated by 54) to generate estimates of bycatch for the red snapper stock assessment.

The current Bayesian model developed assumed a negative binomial error-distribution. It was proposed by the group that a comparative Bayesian model should be developed using the delta lognormal error-distribution. This additional model run will be compared to the negative binomial model.

Red Snapper Age Partitioning and Size Distributions

The group agreed to partition red snapper age distributions by trimester by year for all years. It was also agreed that for those cells not having data by trimester available, the average size distribution for that trimester during that year will be calculated for the entire Gulf and be used in lieu of those empty data cells.

It was agreed that all red snapper under 300 mm that are not age zero will be counted as age one. Further analysis of the data set will be conducted to determine at what size age zero and age one fish start to appear as bycatch, as well as the cut off size for age zero fish.

7.3 BRD Performance Projections

The status of Bycatch Reduction Device (BRD) performance in the north-central western Gulf of Mexico is presented in SEDAR7–DW-38 (see also SEDAR7-DW-57 for an update of the Foundation's efforts). The results of the Red Snapper Initiative program 2001-2003 indicate a decline in performance since 1998. Several changes in fishing gear characteristics and practices in the fishery may be reducing fisheye performance. Fisheye performance appears to be highly variable over the range of vessels and gear configurations, but poor performance is most likely due to changes in fishing practices to minimize shrimp loss. A NOAA Fisheries/Industry meeting sponsored by the Gulf and South Atlantic Fisheries Foundation will be held on May 4-5, 2004, to present the status of fisheye performance and to elicit recommendations from the industry on means to improve BRD performance. The red snapper shrimp trawl bycatch reduction projection for the stock assessment model will be derived based on the results of the meeting.

7.4 Future Research Recommendations

Future recommendations for improved data collection methods related to shrimp effort estimation include implementation of the Electronic Logbook Program (ELB) for 3-5 years (SEDAR7-REF-1; SEDAR7-REF-2) in conjunction with the current (or some form of) port agent interview system. Amendment 13 to the Shrimp Fishery Management Plan will address vessel monitoring systems (VMS) or ELB approaches for the shrimp fishery to obtain better effort data. Considerations of who will pay and own units (VMS or ELB) were discussed. VMS units are approximately $1200 (+ monthly fee + maintenance) vs. ELB ($500).

The group strongly recommended a fully-funded shrimp trawl observer program to collect bycatch data as related to bycatch reporting requirements. This program would cost approximately $2.5 KK annually.

Work will continue on the new BRD designs using infrared observation technology (SEDAR7-DW-30). With this approach, we must encourage industry innovation by providing information to fishers for cooperative research to solve operational problems and maximize shrimp retention. The key to development of effective designs is getting new designs into the fleet, but this will result in innovation only if the industry has incentive to develop new technology. Consideration must also be given to the present certification protocol. BRD performance requirements will have to be re-examined based on performance projections of current BRD designs. BRD development should be focused on BRD designs which induce continuous and consistent bycatch escapement during variable environmental and commercial applications.

Appendix 1. List of Participants.

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Appendix 2. List of Working Documents.

Submitted Working Papers

Document #	Title	Authors
SEDAR7-DW-1	Derivation of Red Snapper Time Series from SEAMAP and Groundfish Trawl Surveys	Nichols, S.
SEDAR7-DW-2	Calibration Among the Separate Trawl Survey Programs to Extend the Time Series for Juvenile Snapper Indexes	Nichols, S.
SEDAR7-DW-3	Some Bayesian Approaches to Estimation of Shrimp Fleet Bycatch	Nichols, S.
SEDAR7-DW-4	Behavior and Swimming Performance of red Snapper: Its Application to Shrimp Trawl Bycatch Reduction	Parsons, G.
SEDAR7-DW-5	Observer Coverage of the US Gulf of Mexico and Southeastern Atlantic Shrimp Fishery, February 1992-December 2003 - Methods	Scott-Denton, E.
SEDAR7-DW-6	Discussion of Days Fished Expansion in the Gulf of Mexico Shrimp Fishery	Griffin, W.
SEDAR7-DW-7	Bioeconomic Simulation Analysis of Alternative Bycatch, Commercial, and Recreation Policies for the Recovery of Gulf of Mexico Red Snapper	Griffin, W.
SEDAR7-DW-8	Shark/Snapper/Grouper Longline Surveys	Henwood, T., W. Ingram, and M. Grace
SEDAR7-DW-9	Distribution, Abundance, and Age Structure of Red Snapper (Lutjanus campechanus) Caught on Research Longlines in U.S. Gulf of Mexico	Mitchell, K., T. Henwood, G. Fitzhugh, and R. Allman
SEDAR7-DW-10	Data Summary of Red Snapper (Lutjanus campechanus) Collected During Small Pelagic Trawl Surveys, 1988-1996	Ingram, W.
SEDAR7-DW-11	Assessment of the Distribution and Abundance of Coastal Sharks in the U.S. Gulf of Mexico and Eastern Seaboard, 1995 and 1996	Grace, M. and T. Henwood
SEDAR7-DW-12	Estimation of Prey Biomass Necessary to Maintain the Equilibrium Standing Stock Biomass of Red Snapper (Lutjanus campechanus), at Various Levels, in the Gulf of Mexico	Driggers, W.
SEDAR7-DW-13	The Steepness Stock-Recruit Parameter for Red Snapper in the Gulf of Mexico (Lutjanus campechanus): What Can Be Learned From Other Fish Stocks?	McAllister, M.
SEDAR7-DW-14	The Potential for Incorporating a Larval Index of Abundance for Stock Assessment of Red Snapper, Lutjanus Campechanus	Lyczkowski-Shultz, J., D. Hanisko, and W. Ingram
SEDAR7-DW-15	SEAMAP Reef Fish Survey of Offshore Banks	Gledhill, C. and W Ingram
SEDAR7-DW-16	Retrospective Coding of Dual Size Classes of Size Frequency Data for Red Snapper Collected During SEAMAP Shrimp/BottomFish Surveys	Pellegrin, G., N. Sanders, K. Johnson, and A. DeBose

SEDAR7-DW-17	Partitioning release mortality in the undersized red snapper bycatch: comparison of depth vs. hooking effects	Burns, K.M., N. F. Parnell, and R. R. Wilson
SEDAR7-DW-18	Red snapper movements based on tag recovery data.	Burns, K. M et al.
SEDAR7-DW-19	Estimating Catches and Fishing Effort of the Southeast United States Headboat Fleet, 1972-1982.	Dixon, R.L. and G.R. Huntsman
SEDAR7-DW-20	Overview of State Trip Ticket Programs in the Gulf of Mexico	Donaldson, D.
SEDAR7-DW-21	Fishery independent estimation of abundance, age frequency, growth rates, and mortality of red snapper *Lutjanus campechanus,* in the northeast Gulf of Mexico.	Szedlmayer, S., D. Moss, and M. Maceina.
SEDAR7-DW-22	Estimates of Red Snapper Discards by Vessels with a Federal Permit in the Gulf of Mexico	Poffenberger, J.
SEDAR7-DW-23	Commercial Landings Statistics –Red Snapper in the Gulf of Mexico	Poffenberger, J.
SEDAR7-DW-24	Estimation of Effort in the Offshore Shrimp Trawl Fishery of the Gulf of Mexico	Nance, J.
SEDAR7-DW-25	Using scenario-based population dynamics modeling to prioritize those parameters in Gulf of Mexico red snapper stock assessment where uncertainty should be taken into account	McAllister, M. K.
SEDAR7-DW-26	Using demographic analysis to evaluate the stock resilience implications and plausibility of life history parameter values assumed for Gulf of Mexico red snapper.	McAllister, M. K.
SEDAR7-DW-27	MARINE RECREATIONAL FISHING STATISTICAL SURVEY (MRFSS): One Constituent's Analysis	Zales, R. F. II.
SEDAR7-DW-28	Summary of Fishing Mortality for the Red Snapper Research Project off Alabama	Shipp, R. L.
SEDAR7-DW-29	NOT USED	
SEDAR7-DW-30	NOT USED	
SEDAR7-DW-31	EBLUP Small Area Estimation for Red Snapper Bycatch from the Gulf of Mexico Shrimp Fleet	Jones, B.
SEDAR7-DW-32	Spatial Modeling of Red Snapper Shrimp Fleet Bycatch in the Gulf of Mexico	Jones, B.
SEDAR7-DW-33	Red snapper (*Lutjanus campechanus*) otolith aging summary 1980 & 1991-2002. NOAA, NMFS, Panama City Laboratory. Contribution Series: 04-03.	Allman, R.J., G.R. Fitzhugh, W.A. Fable, L.A. Lombardi-Carlson and B.K. Barnett

SEDAR7-DW-33add	Addendum to Document 33.	
SEDAR7-DW-34	Precision of age estimation in red snapper (*Lutjanus campechanus*). NOAA, NMFS, Panama City Laboratory Contribution Series: 04-04.	Allman, R.J., G.R. Fitzhugh, K.J. Starzinger and R.A. Farsky
SEDAR7-DW-35	Characterization of red snapper (*Lutjanus campechanus)* reproduction: for the 2004 Gulf of Mexico SEDAR. NOAA, NMFS, Panama City Laboratory. Contribution Series: 04-01.	Fitzhugh, G.R., M.S. Duncan, L.A. Collins, W. T. Walling Jr., D.W. Oliver.
SEDAR7-DW-35add	Addendum to Document 35.	
SEDAR7-DW-36	Red snapper otoliths selected for aging at NMFS Panama City Laboratory and discussion of future sampling targets. NOAA, NMFS, Panama City Laboratory. Contribution Series: 04-02	Fitzhugh, G.R., L.A. Lombardi-Carlson, R.J. Allman and B. K. Barnett.
SEDAR7-DW-37	Analysis of Total Fishing Mortality for Gulf of Mexico Red Snapper Contributed by Shrimp Trawl Bycatch and Commercial and Recreational Fisheries (Including Discards)	McAllister, M. K.
SEDAR7-DW-38	Status of bycatch reduction device performance and research in Norh-Central and Western Gulf of Mexico	Foster, D. G. and Scott-Denton, E.
SEDAR7-DW-39	Florida Fishery Dependent Monitoring	Brown, S. E.
SEDAR7-DW-40	History of red snapper management in federal waters of the US Gulf of Mexico, 1984-2004.	Hood, P. and Steele, P.
SEDAR7-DW-41	Alternative catch rate indices for red snapper (Lutjanus campechanus) landed during 1981-2003 by the U.S. recreational fishery in the Gulf of Mexico using MRFSS and Texas Parks and Wildlife Department data sets.	Cass-Calay, S. L.
SEDAR7-DW-42	Standardized catch rates of red snapper (Lutjanus campechanus) from the United States headboat fishery in the Gulf of Mexico during 1986-2002	Brown, C. A. and S. L. Cass-Calay
SEDAR7-DW-43	Some problems with sampling commercial red snapper fisheries in the Gulf of Mexico.	Chih, C-P.
SEDAR7-DW-44	Estimation of species misidentification in the commercial landing data of red snappers in the Gulf of Mexico.	Chih, C-P.
SEDAR7-DW-45	Size frequency distribution of red snapper from dockside sampling of commercial landings in the Gulf of Mexico 1984-2003 (TIP size data)	Diaz, G.A., S. C. Turner, and C-P Chih.
SEDAR7-DW-46	Size frequency distribution of red snapper from dockside sampling of recreational landings in the Gulf of Mexico 1984-2003 (TXPW, MRFSS, and headboats size data)	Diaz, G. A.
SEDAR7-DW-47	Standardized catch rates of red snapper (Lutjanus campechanus) from the United States commercial handline fishery in the Gulf of Mexico during 1996-2003	McCarthy, K. J. and S. L. Cass-Calay
SEDAR7-DW-48	NOT USED	
SEDAR7-DW-49	A priori estimates of natural mortality rates and stock-recruitment curve steepness for Gulf of	Sladek Nowlis, J.

	Mexico red snapper	
SEDAR7-DW-50	An age-structured assessment model for red snapper that allows for multiple stocks, fleets, and habitats.	Porch, C. E.
SEDAR7-DW-51	MSY, Bycatch and Minimization to the "Extent Practicable"	Powers, J. E.
SEDAR7-DW-52	Length and weight conversions for Florida's recreationally important finfish species	Sauls, B., R. Beaver, and J. O'Hop
SEDAR7-DW-53	Comparisons of Relative Fishing Powers of Selected SEAMAP Survey Vessels	Pellegrin, G. Jr N. Sanders Jr; J. Hanifen; R. Waller; M. VanHoose
SEDAR7-DW-54	Update for the Bayesian estimation of shrimp fleet bycatch	Nichols, S.
SEDAR7-DW-55	An evaulation of the first annulus for red snapper off Alabama	Mareska, J.
SEDAR7-DW-56	Some methods of calculating catch at age of the directed fisheries for red snapper in the Gulf of Mexico, 1984-2002	Turner, S. C.
SEDAR7-DW-57	An Update of Shrimp Trawl Bycatch Reduction Efforts in the Gulf of Mexico	Graham, G.
Reference Documents Provided for Data Workshop		
NAJFM 2003 23:581-589 SEDAR7-REF1	Description of a simple electronic logbook designed to measure effort in the Gulf of Mexico shrimp fishery.	Gallaway, B. J., J. G. Cole, L. R. Martin, J. M. Nance, and M. Longnecker
NAJFM 2003 23:7987-809 SEDAR7-REF2	An evaluation of an electronic logbook (ELB) as a more accurate method of estimating spatial patterns of trawling effort and bycatch in the Gulf of Mexico shrimp fishery.	Gallaway, B. J., J. G. Cole, L. R. Martin, J. M. Nance, and M. Longnecker
GoM Science 1998(1):92-104 SEDAR1-REF3	Movement of red snapper, *Lutjanus campechanus*, in the North central Gulf of Mexico: Potential effects of hurricanes	Watterson, J. C., W. F. Patterson III, R. L. Shipp, and J. H. Cowan
TAFS 2001 130:533-545 SEDAR7-REF4	Movement of tagged red snapper in the Northern Gulf of Mexico	Patterson, W. F. III, J. C. Watterson, R. L. Shipp, and J. H. Cowan
MRAG Americas Inc. 1997 SEDAR7-REF5	Consolidated Report of the Peer Review of Red Snapper (*Lutjanus campechanus*) Research and Management in the Gulf of Mexico	anon.

MARFIN Final Report NA87FF0424 SEDAR7-REF6	Stock Structure of red snapper in the Northern Gulf of Mexico: Is there management as a single stock justified based on spatial and temporal patters of genetic variation, otolith microchemistry,and growth rates?	Gold, J. R.
AFS Symp. 36. 2003 SEDAR7-REF7	Red snapper discards in Texas coastal waters—a fishery dependent onboard survey of recreational headboat discards and landings. In:Stanley, D.R., Scarborough-Bull, A. (Eds.), Fisheries, reefs, and offshoredevelopment. American Fisheries Society, Symposium 36, Bethesda, Maryland, pp.155-166	Dorf, B.A.
Fish Bull 2001 99:617-621 SEDAR7-REF8	Age and growth of red snapper, *Lutjanus campechanus*, from an artificial reef area off Alabama in northern Gulf of Mexico	Patterson, W. F. III; J. H. Cowan, Jr; C. A. Wilson, R. L. Shipp
53 GFCI SEDAR7-REF9	Indirect estimatio of red snapper (*Lutjanus campechanus)* and gray triggerfish (*Balistes capriscus*) release mortality	Patterson, W. F. III; G. W. Ingram, Jr.; R. L. Shipp, J. H. Cowan, Jr.
AFS Symp. 2003 36:181-193 SEDAR7-REF10	Site fidelity and dispersion of red snapper associated with artificial reefs in the northern Gulf of Mexico	Patersonm, W. F. III; and J. H. Cowan