Consolidated Caribbean SEDAR Research Recommendations

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The following is a consolidation of the Research Recommendations from the three previous SEDARs (SEDARs 4, 8, and 14) which have dealt with Caribbean species. Sections that were labeled "Research Recommendations" or "Recommendations" were extracted from the final SEDAR reports and consolidated herein. If additional recommendations were found within other sections of the text of the reports, they are not included here.

Data Report of SEDAR 4, Atlantic and Caribbean Deepwater Snapper-Grouper, Caribbean Species

6. Research Recommendations

6.1. Recommendations for the collection of landings statistics

6.1.1. Puerto Rico

In Puerto Rico it is important to determine the feasibility of expansion factors to estimate total catch. The information used to calculate expansion factors by year needs to be verified. Reporting of single trips, rather than multiple-trips per record in the catch report forms should be encouraged. This would greatly facilitate the estimation of effort and CPUE.

6.1.2. U.S. Virgin Islands

The collection of landings statistics in the U.S.V.I. should also aim at breaking down the reported catch into species, since analysis of the current species-groupings is not straightforward without additional information on species composition from TIP or alternative sampling programs.

The information used to calculate expansion factors by year (number of fishermen registered, reporting, etc.) needs to be corroborated, and the feasibility of these expansion factors for estimation of total catch needs to be determined.

Further examination and analysis of the data sets available to date would require an improved collaboration between local and SEFSC biologists. In particular, it is important to determine what species were commonly grouped within each gear-type classification in the 'Old Report Forms'. This information would help to break up the aggregated catch from years prior to the implementation of the Trip Interview Program.

Landings files for most years for the period 1974-2002 have now been compiled and provided to the SEFSC. However, some coding, typing and other errors, duplicates, as well as gaps in the

time series still persist. Action is required to verify, correct the errors and edit those data for future use. Significant effort should be geared toward the standardization of the landings series.

Finally, it would be important to encourage fishermen to submit all the monthly catch reports, to submit reports for months when they do not fish, and to complete all the fields in the reports, since critical information such as effort, gear, and location fished are often missing or incomplete.

6.2. Recommendations for the Trip Interview Program (TIP)

• Encourage the development of length-weight equations from the existing information in TIP

Specific recommendations for Puerto Rico TIP include:

• Record the total weight landed by species for each trip.
• Record the sampled fractions.
• Coding errors in length and weight units must be corrected.

Specific recommendations for U.S. Virgin Islands TIP include:

• Encourage/ aid the development of a commercial logbook system to enable estimation of reporting fractions.
• Increasing the fraction of interviewed trips (the sampling fraction needed to achieve specific objectives will depend on the objective and the variability of the observed species composition) to properly determine the species composition which is needed to break out the aggregated catches.
• Conduct regular interviews in St. Thomas and St. John, with the goal of increasing the sampling fraction.
• Encourage port samplers to complete all the fields in the sampling form. Often the trip effort information is missing, which is essential for the estimation of catch rates or relative indices of abundance.
• Continued and enhanced collaboration between the NMFS SEFSC scientists and the local USVI biologists and data collection agents.
• Correct coding errors, particularly in length and weight units.

Some questions that could be posed to local USVI biologists to improve the analyses of TIP data are:

1) How is the species in question landed, gutted or whole, etc.? How are length and weight typically recorded?
2) Is the species in question targeted or by-catch of another target species?
3) What species are often landed in association with a given species?
4) Is the species ever reported under a different name? For example, another species id, or a genus or family designation?
5) Are there environmental factors that might influence the abundance or catch rates of a given species?
6) Have management efforts, economic impacts, weather events, or other factors influenced fishing effort, catch rates or targeting?
7) Have fishery attributes changed (gear, boat type, technology, species targeted, skill of fishers etc.) changed during the period of monitoring. If so how?

8) Are interviewed trips chosen randomly? If not, what potential biases might exist in the dataset?

6.3. Recommendations for the estimation of catch rates

The following issues must be addressed to improve or construct catch rates for Puerto Rico and the U.S. Virgin Islands:

• In Puerto Rico the total catch by species for each trip in the TIP data is required. It has to be determined whether assumptions can be made regarding sampling fractions in TIP data to allow construction of Puerto Rico's CPUEs.

• The SEDAR Committee recommended that CPUEs for the U.S.V.I. be recalculated for a truncated time series (1984-1991), given that sample sizes for subsequent years are very limited.

• It is important to explore the availability of other fisheries-independent CPUE series.

• Standardization approaches for data-poor species, different from the delta-lognormal, need to be evaluated.

• The use of bootstrapping to estimate confidence intervals of the CPUE series should be investigated.

• The use of multivariate statistical analysis is recommended to identify the appropriate pool of gears to use when measuring effort.

6.4. Recommendations for the analysis of species composition

• In Puerto Rico, it is important to recommend increased interviews with an emphasis on representative sampling, and to record the sampling fraction.

• Eventually, if Puerto Rico moves toward reporting landings by species, it will be advisable to compare TIP and landings species composition.

• In the U.S.V.I., it is important to examine the species composition on handline and trolling trips separately, and to evaluate whether sampling is representative.

6.5. Recommendations for the Caribbean SEAMAP Survey

• Encourage continued annual surveys throughout the area.

• Determine the spatial/temporal coverage in fine detail.

• Data analysis and interpretation must address the temporal patterns observed in the size frequency distributions.

Regarding the shallow reef fish monitoring fishery-independent survey in Puerto Rico:

• Coordinate with NMFS to make this data readily available.

• Explore the CPUE and size-frequency data available from this data set.

• Compare with the other SEAMAP data set.

6.6. General Recommendations

• Continue and improve collaboration with scientists from Puerto Rico and the U.S. Virgin Islands. Advice is needed in terms of handling the data, interpreting it, correcting coding errors, duplicates, and other problems in the data collection, recording, and editing systems. Local scientists and staff can help to understand the sampling protocols, documenting the observed trends, and filling out persisting gaps in the time-series.

• Continued data exploration must be made with consultation of the local laboratories/agencies, including the biologists, field agents, and data-entry staff.

• There is a possibility that the data will have limited value for assessment in the near future; however, continued analysis and improved data collection may greatly increase the utility of the information. The fishery-dependent data from Puerto Rico in particular has a good potential for use in stock assessment.

• Emphasis should be placed on the improvement of the TIP sampling program, as catch rate standardization, catch composition and size-frequency analyses will continue to rely upon this information. However, fishery-independent surveys and the collection of other biological data are extremely important to develop alternative indices of abundance.
• It is recommended that early biological or biostatistical sample data for the U.S. V.I., from the early to mid 1970's be computerized and made available for future data workshops. It is strongly recommended that formal discussions between NMFS, SEFSC TIP program coordinator and the USVI DFW are held to ascertain what steps/procedures, etc. are needed to improve sampling in the U.S.V.I. fisheries. Similarly, discussions should be initiated between Puerto Rican biologists and NMFS assessment staff to identify any remaining historical data sets not yet available. It is noted that an effort to computerize Puerto Rico biostatistical samples from the mid 1980's is ongoing (N. Cummings personal communication).

• It is recommended that analytical efforts expended by the recent working group members be continued. First, some attention should be given towards identifying or selecting which species should be assessed more quantitatively. The Caribbean reef fish fisheries are complicated comprising a mix of many species that are harvested by a number of gears.

• It is recommended that additional workshops such as this one be implemented to further develop the information for assessment, especially for those species and fisheries for which extensive information exist.

• It is noted that that strong cooperation of all agencies and local scientists involved would be beneficial.

Stock Assessment Report of SEDAR 8
Caribbean Yellowtail Snapper

Data Workshop Recommendation

2.7 Life History Research Recommendations

During the SEDAR8 data workshop, the participants reviewed the available information on the biology of the yellowtail snapper in regards to its adequacy in support of stock assessment. The sub-group noted the scant information available on movement of this species, in particular, on adult individuals. Therefore, the group identified a need for scientific tagging studies of adult yellowtail snapper to obtain data on large-scale movements. The life history subgroup recommended that studies further evaluate maturation (size and spatial variation) and growth of this species in the Caribbean are needed. In particular, the group emphasized the need for fecundity information. The SEDAR8 life history sub-group suggested that such studies be conducted in conjunction with the fishing industry. Another research need identified by the working group was the preparation of general regional-wide GIS maps of landings of this species throughout the geographic range of the species in US Caribbean waters.

3.1 Commercial Fishery: US Virgin Islands

A recommendation was made that, a new data collection form and a new data entry program be developed in order to provide species-level information. Species level landings data would add more certainty to individual species based evaluations. Historically, the NMFS, SEFSC has provided guidance and data management help with bio-statistical field sampling forms (i.e., the NMFS, SEFSC, TIP data entry system) in the US Virgin Islands and with landings data entry programs in Puerto Rico. It was recommended that the US Virgin Islands DFW coordinate revision of landings data entry program with the NMFS, SEFSC.

3.1.7 Research and/or Analytical Recommendations for US Virgin Islands Commercial Landings and Biostatistical Data

• Complete data entry and clean-up task of fisher landings reports for reporting years 1986/1987 through reporting years 1992/1993) within 2-3 months, prior to the SEDAR8- Assessment Workshop. This task is currently being carried out by the US Virgin Islands, DFW

• Estimate landings based on complete catch report database after corrections to landings database are made and after reporting years 1986/1987 through 1992/1993 are entered

• Recalculate expanded landings based on new lists of licensed fishers

• Staff of the US Virgin Islands, DFW suggested that analyses of commercial bio-statistical data (size-frequency, catch-composition, CPUE) should be put on hold until all the field sampling data has been completely entered and checked for errors and both US, Virgin Island and NMFS, SEFSC staff have signed off on corrections

• Avoid repetitive analyses on incomplete information. Use only complete data sets in stock assessment analysis. A solid foundation will then be established for the analysis of other species to be included in future assessments

• If assessments proceed with incomplete databases, assumptions about the data should be clearly identified and formally documented;

• Immediate changes in the fisher landings report forms are not recommended. The fishing community in the U.S. Virgin Islands is reluctant to provide any additional information, unless they see their data of approximately 30 years reflected in the management decisions;

• Provide feedback to the fishing community after stock assessment analyses are performed, in order to reassure them that the information they provide is valuable and necessary to manage their resources

• CFMC and NMFS, SEFSC staff present at the SEDAR8 Data workshop, recommended to conduct stock assessments with the information currently available to support management decisions. Proper consideration of uncertainty and documentation of missing or possibly inaccurate data was emphasized.

3.2 Puerto Rico Commercial Fishery

For the future, it is recommended that an updated data entry program be written for Puerto Rico bio-statistical data. An additional recommendation was made that the data entry program consist of multiple-screen entry as opposed to the current one screen-entry system in use. It is recommended that the revised bio-statistical data entry program for Puerto Rico samples include a feature which screens the data for duplicate samples.

3.2.10 Research Recommendations for Puerto Rico Landings Data

• Puerto Rico commercial landings data are complete through 2003 however, preliminary estimates of yellowtail snapper landings will need to be updated prior to the SEDAR8 Stock Assessment Workshop to reflect changes made at the SEDAR8 Data Workshop

• Support the inclusion of coordinate locations in the Puerto Rico, DNER trip ticket forms.

• It is recommended that scientists from the Puerto Rico, DNER continue to work with federal scientists to carry out more updated analyses of the landings and bio-statistical data.

5. Fishery-Independent Survey Data

5.1 Southeast Area Monitoring Program (SEAMAP)

5.1.6 Overall Status of the NMFS, SEFSC, Caribbean SEAMAP Data and Future Recommendations

Evaluation of trends in catch rates and size composition was somewhat complicated for the current NMFS, Caribbean, SEAMAP data set for the reasons discussed above. In addition to various methodological changes that occurred during the surveys other major logistical problems are ongoing and in addition the dataset was limited temporally. At the SEDAR8 Data Workshop, scientists from the US Virgin Islands, DFW reported that approximately 60% of the data had not been entered into the database with paper copies in storage at the DFW, although funding for this task was previously awarded to DFW. Apparently, since the end of the workshop some progress

has been made towards entering this information. In addition, although sampling is annual, it does not occur during the same time each year, potentially introducing some confounding seasonal variability with CPUE variability. The sampling variation is mainly caused by inconsistencies in the timing of the annual availability of funds. One way of avoiding this problem would be to compute CPUE as grams (or numbers) per hour fished (g/hrs) over time. This method of calculating CPUE assumes that each sampling hour is uniform when compared to other sampling hours. It is recommended, that all future analyses related to catch rates consider appropriate analysis of variance standardization procedures to adjust for various logistical and methodological concerns discussed above. It is recommended, that such analyses consider the relevance of the entire dataset of catch observations as compared to excluding zero catches of yellowtail snapper in the calculation of abundance (CPUE) trends from these data.

It is strongly suggested that future SEDAR's' that consider CPUE analyses from these data form a small working group to discuss possible model types to pursue and important data stratifications to include prior to the Data Workshop. It is recommended that further analyses be explored with the NMFS, SEFSC Caribbean SEAMAP Survey data once the missing US Virgin Islands samples have been computerized and the corrections to the weight type have been made for all species in the dataset. In addition, analyses should be done separately for St. Thomas/St. John vs. St. Croix and separately by gear. It is known also that a more complete fishery independent data set for Puerto Rico is maintained by the Puerto Rico, DNER. The latter data set is discussed in detail in section 5.2. Until the NMFS, Caribbean SEAMAP data set is up-dated to contain all of the Puerto Rico samples the Puerto Rico, DNER data set should be used since it is more complete (see section 5.2). It is noted that the missing SEAMAP data for the US Virgin Islands, discussed above has been computerized since the SEDAR8 Data Workshop. Preliminary review of the data indicated that only 95 catch observations of yellowtail snapper occurred from 1992-2002 (US Virgin Islands only) supporting the thought that this survey does not encounter yellowtail snapper frequently. Although the analyses conducted for the SEDAR8 DW could be further updated, it is not likely the new information would add significantly to the current information base for this particular dataset. SEDAR8-DW-Tables 23c and 23d provide a brief summary breakdown of the total number of stations sampled for each gear from the revised SEAMAP dataset for the US Virgin Islands. About 15% of the total sampling effort included hook and line samples over the period of the surveys, 1992-2002.

7. Major Workshop Recommendations

• Continue the updating and data correction checks ongoing for the US Virgin Islands commercial landings and Biostatistical data bases.

• Continue the data correction checks ongoing with the Puerto Rico commercial landings and bio-statistical data bases.

• Continue the analyses related to partitioning of US Virgin Islands bulk landings data into species groupings after the missing bio-statistical samples have been entered, proofed and agreed on by both US Virgin Islands DFW staff and NMFS, TIP staff.

• Work toward developing a species specific commercial landings sales ticket in the US Virgin Islands commercial fisheries.

• Work towards research to obtain bio-statistical samples in the US Virgin Islands and especially to improve much needed sampling in St. Thomas/St. John Fisheries.

• Implement hard part biological sampling in US Virgin Islands and Puerto Rico.

• Work towards identifying the primary information needs regarding improving the ongoing fishery independent sampling initiatives for yellowtail snapper populations in the Caribbean.

ASSESSMENT WORKSHOP RECOMMENDATIONS

9 Research Recommendations

Various sources of fishery independent data have been collected about the Puerto Rico and US Virgin Islands reef fish fisheries through the NMFS SEAMAP Caribbean sampling program. The SEDAR 8 Data Workshop Panel concluded that the most complete fishery independent data set available for Puerto Rico was collected through the Puerto Rico DNER, while the most complete fishery independent data set available for the US Virgin Islands was collected by the Department of Fish and Wildlife through NOAA/NMFS/SEFSC's SEAMAP survey (SEDAR8-DW-Report).

During the SEDAR 8 assessment workshop, several issues regarding the fishery independent data were discussed, specifically whether these data and the analysis conducted should be considered in the assessment models pertaining to yellowtail snapper. One specific issue was whether a conflict exists between the fishery independent sampling procedures used and traditionally successful yellowtail snapper fishing technique. Sampling protocol for the surveys was designed to sample the greatest diversity of fish species during the day using a standard amount of time and gear type. Local knowledge of the yellowtail snapper fishery contributed by individuals in the St. Thomas/St. John and St. Croix Fisherman's Associations suggest that yellowtail can only be captured efficiently at night when certain fishing techniques are applied. Such methods of harvesting yellowtail snapper include the use of chumming in the evening, fishing with hook and line, and using thin line not easily detected by the yellowtail snapper. The majority of the yellowtail snapper caught during fishery independent sampling were caught using traps during daylight hours, suggesting that the hook and line sampling was not conducive to catching yellowtail snapper. A second issue is that the Puerto Rico DNER sampling only occurred on the west coast of Puerto Rico and some participants raised the concern that a region specific index may not adequately represent the total yellowtail population. In fact, some support for this exists from analyses of the commercial landings data which showed variability in landings between regions (Cummings and Matos-Caraballo, SEDAR8 DW-08).

Trap sampling captured the greatest number of yellowtail snapper off the West Coast of Puerto Rico. Though still a small sample size, sufficient proportion positive data was present to calculate standardized catch rates using the GLM model. The small sample size raised questions about whether or not the data ought to be used in the assessment of yellowtail. In January 2005, an updated version of the SEAMAP data was made available. This updated information contained additional SEAMAP data from the US Virgin Islands but no additional data from Puerto Rico. It was decided by the SEDAR 8 assessment panel that the additional fishery independent information did not contain enough yellowtail snapper data to yield an informative analysis for the US Virgin Islands.

The following recommendations were made to increase the utility of these data in the future:

• Increase the fishery independent sampling effort in the U.S. Caribbean. It is critical that the sampling effort be diversified across the region to include equal coverage of appropriate habitats/depths. Inquiry among the fishing community should provide appropriate information on the location, habitats and best fishing methods appropriate to acquire the most complete set of information on all species in the region. Cooperative sampling design and implementation between the fishermen and scientists is strongly encouraged. If every species captured cannot be completely sampled, then those species deemed to be important to the local fishing economy or those species considered representative of relevant habitat types should be given sampling priority. A list of commercially important species to the region can be obtained from the Caribbean Fishery Management Council.

• The ideal survey would utilize hook and line and traps as the primary sampling gears in order to maintain consistency with those surveys that have been completed in the past. The number of gear fished and the hours fished each sampling period should be standardized and strictly adhered to from one sampling period to the next. Sampling in the US Virgin Islands for reef fish has not been conducted on a consistent basis each year. Funding needs to be allocated to allow for consistent annual sampling (or at least bi-annual).

• Visual surveys could be used in the Virgin Islands and in Puerto Rico to collect additional size and abundance information on the reef fish resource. This is the fastest way to obtain a large quantity of information, and data collected can be paired with efforts to link ages to lengths. Such data would provide abundance indices, particularly for shallow water species. Several potential sources of visual survey data were identified for the SEDAR8 Data Workshop but were not pursued at present because of the aggregate nature in which data were presented. Further work with the scientists who conducted these surveys is recommended.

• Mark recapture techniques could be used to estimate abundance and learn more about the movements and habitat preferences of yellowtail snapper. However, such studies should focus on movement patterns as well as recapture rates to avoid potential misinterpretation especially if fish show site fidelity. This project could be performed cooperatively between scientists and local fishers. Important components would include communicating and educating the fishermen such that they are encouraged to return the tags.

• Due to the lack of adequate and consistent historical data in the Caribbean, it is difficult to determine stock status using many of the traditional quantitative methods. However, the relatively good knowledge of habitat distributions and of habitat usage by various species/life stages provides a valuable opportunity to explore the power of habitat based spatial models in this region.

REVIEW WORKSHOP RECOMMENDATIONS

The Review Panel offers the following comments regarding research needs and the data and assessment of yellowtail snapper.

1. Well-designed, systematic research programs are essential to providing the data necessary for effective management. Much of the research reviewed lacked the necessary sample sizes and regular (ongoing) data collection needed to construct an adequate time-series of catch and abundance indices.

2. The yellowtail snapper fishery is unique among Caribbean fisheries with regard to fishing methods and timing, and the needed research designs. It is an important fishery in the U.S. Caribbean. The design of data collection must take into account the unique aspects of the fishery, and therefore sampling effort will need to be either added or redirected to target yellowtail snapper more effectively.

3. A commitment to long-term research and data collection is essential for effective management. Short-term research and data collection are not the solution to the data problems identified in this assessment. Long-term research and monitoring are necessary in the Caribbean, as in any other managed fishery. Based on the studies and data available, it is clear that the resources necessary to collect essential data are not currently available to support scientifically based management of yellowtail snapper in the region.

4. Throughout the region, data quality control independent of the data collection process has not been effectively realized. Validation of historical and future collections is needed for the data to be used appropriately for any type of assessment. Documentation of changes in data collection and management methods must be maintained and provided to those charged with conducting the assessments and reviews.

5. The Panel recognizes the significant effort that has been put into data collection in the region and emphasizes that, although the resulting data are insufficient for an assessment at this time, they will be useful for assessment in future when combined with additional data identified elsewhere in this report. Past efforts are not wasted, but rather their data will play an important role, providing the temporal contrast needed by assessment models. The recommendations below are offered as improvements to the current data collection, not as replacements.

6. The Panel strongly endorses the need to develop partnerships with local fishermen to conduct research and to collect needed data. Partnerships with the fishing community and other stakeholders are a cost-effective way to collect components of the data necessary for the assessment process. Currently, it is clear that there is a high level of interest in the fishing community to cooperate with management agencies in collecting data, and this partnership should be encouraged and strengthened. This would also facilitate ongoing cooperation and participation by fishermen in the management process, benefiting all involved.

7. Monitoring and assessment of yellowtail snapper should be undertaken with due consideration given to the species' importance in the overall species assemblage and community. Future ecosystem management will likely dictate such a course of action.

Recommendations for future data collection and research

Fishery-independent data

• A new independent sampling regime to target yellowtail snapper more effectively should be created, because current methods do not allow temporal or spatial coverage.

• Visual surveys can provide useful fishery-independent data. The methods would, however, vary, based on the depth of the insular shelf.

• The output of other existing studies (NOAA and non-NOAA) should be examined to see if alternative fishery-independent sampling already exists.

Life history data

• Fecundity data should be collected
• Maturity data should be collected
• Growth information should be collected
• The parameter natural mortality needs investigation on the basis of better data

Catch data

• Recreational catches need to be sampled and quantified better
• Information on trip species targeting is needed
• Information on the location of catches is sometimes not good, and should be improved
• Identification of species in the snapper complex in the US Virgin Islands is crucial to future assessments • Historical data from the US Virgin Islands need to be collected from fishermen, if they exist
• Port samplers need to modify their schedules to target yellowtail snapper landings, and to sample sizes of the species need to increase
• TIP sampling in the US Virgin Islands needs to be revitalized

Age and length frequency data

• These are needed from all commercial catches
• These are urgently required from recreational catches
• Fishery-independent surveys can provide these crucial data

Genetic / otolith microchemistry studies

• Stock structure is important in assessments, and genetics and otolith microchemistry offer hope to unravel it in future

Spatially explicit studies

• Identification of spawning areas and the source of recruits is important
• Construction of habitat maps will help identify stratification for research designs
• Combination of habitat maps with fish counts and habitat models will aid in providing population estimates
• Development of a GIS map of yellowtail snapper landings throughout the species' geographical range could help in the production of a distribution map of catches

Mark-recapture studies

- This could help identify movements and migrations
- Fishing mortality estimates could be derived
- Population estimates would be enhanced with such studies
- Such studies could help solve the perplexing question of stock structure

Of the above, the Panel places the highest priority on the following, understanding the need to maximize the likelihood of generating an acceptable assessment of the stock in the near future:

- The carrying out of fishery-independent surveys
- Collection of more catch data, including specifically the recreational fishery
- The collection of age and length data from commercial and recreational catches and from fishery-independent surveys

Stock Assessment Report of SEDAR 8
Caribbean Spiny Lobster

DATA WORKSHOP RECOMMENDATIONS

3.2 Commercial Fishery US Virgin Islands

3.2.8 Research and Analytical Recommendations

Complete data entry and clean-up task of landings (catch) reports (reporting years 1986/1987 to reporting years 1992/1993) within 2-3 months, prior to the SEDAR8-Assessment Workshop. This task is currently being carried out by the US Virgin Islands, DFW.

• Estimate landings based on complete catch report database after corrections to landings database are made and after reporting years 1986/1987 to 1992/1993 are entered.
• Recalculate expanded landings based on new lists of licensed fishers.
• Table final analyses of commercial bio-statistical data (size-frequency, catch composition, CPUE) until all the field sampling data has been completely entered and checked for errors and both US, Virgin Island and NMFS, SEFSC staff have signed off on corrections.
• Avoid repetitive analyses on incomplete information. Use only complete data sets in stock assessment analysis. A solid foundation will then be established for the analysis of other species to be included in future assessments.
• If the assessment proceeds, assumptions about the data should be clearly identified.
• Immediate changes in the catch report forms are not recommended. The fishing community in the U.S.Virgin Island is reluctant to provide any additional information, unless they see their data of approximately 30 years reflected in the management decisions.
• Provide feedback to the fishing community after stock assessment analyses are performed, in order to reassure them that the information they provide is valuable and necessary to manage their resources.
• Caribbean Fishery Management Council staff present at the SEDAR8 Data workshop, recommended to conduct stock assessments with the information available at the moment to support management decisions. Proper consideration of uncertainty and acknowledgment of missing data was recommended.

5. Overall Data Workshop Research Recommendations for Spiny Lobster

None were provided

ASSESSMENT WORKSHOP RECOMMENDATIONS

9 Research Recommendations

Various sources of fishery independent data have been collected through the NMFS SEAMAP Caribbean sampling program for the Puerto Rico and US Virgin Islands reef fish fishery. It was established at the SEDAR 8 Data workshop that at the time, the most complete data set available for Puerto Rico was collected through the Puerto Rico Department of Natural and Environmental

Resources, while the most complete data set available for the US Virgin Islands was collected by data.

The following recommendations were made regarding fishery-independent sampling in general:

• Increase the fishery independent sampling effort in the US Caribbean. Further diversify the regions that are sampled to include equal coverage of areas frequently fished. Inquiry among the fishing community should provide appropriate information on the location, habitats and best fishing methods appropriate to acquire the most complete set of information on all species in the region. Cooperative sampling design and implementation between the fishermen and scientists is strongly encouraged. If every species captured cannot be completely sampled, then those species deemed to be or to have been important to the local fishing economy should be given sampling priority. A list of commercially important species to the region can be obtained from the Caribbean Fishery Management Council.

• The ideal survey would utilize hook and line and traps as the primary sampling gears in order to maintain consistency with those surveys that have been completed in the past. The number of gear fished and the hours fished each sampling period should be standardized and strictly adhered to from one sampling period to the next. When determining the appropriate amount and allocation of standard effort, one should consider how fishery independent effort was employed in previous years so that consistency can be achieved over a substantial time period. Sampling should be done such that it is temporally distributed in an even manner with the same number of hours fished from season to season, and within a season.

• Due to the lack of adequate and consistent historical data in the Caribbean, it is difficult to determine stock status using many of the traditional quantitative methods. However, the relatively good knowledge of habitat distributions and of habitat usage by various species/life stages provides a valuable opportunity to explore the power of habitat-based spatial models in this region.

Recommendations were also made specific to fishery-independent monitoring of spiny lobster:

• Development and implementation of a fishery independent sampling program specific to Caribbean spiny lobster. One of the challenges was the inability to determine a reliable and robust measure of abundance and size for the population, using fishery dependent or fishery independent data. Consequently, a program is needed to go beyond the present attempts to determine larval dispersal and should attempt to sample lobsters in the same capacity that the SEAMAP Caribbean sampling program samples reef fish or queen conch. These improvements would also provide a better understanding of directed versus incidental fishing effort on spiny lobster, of gear selectivity, and of the fishing process as a whole. Local fisherman participation (cooperative research) should be used to assist in the sampling and information gathering process. The SEAMAP Caribbean sampling group is aware that the puerulus sampling program is insufficient and is presently considering alternatives.

• Visual surveys could be used in the Virgin Islands and in Puerto Rico to collect additional size and abundance information on the spiny lobster resource. This may be the fastest way to obtain a

large quantity of information (although targeted lobster fishing may prove more efficient), and data collected can be paired with size distributions. Lobsters can be temporarily captured and carapace length measured while in the water. Such data would be useful in calculating yield per recruit.

• Mark recapture techniques could be attempted to estimate abundance and learn more about the movements and habitat preferences of spiny lobster. One problem with this is that for lobsters, growth is achieved through molting. Each time a lobster molts, the tag is removed from the individual along with the molt. New tagging technologies however may enable more success with spiny lobster. This is a good opportunity to do cooperative research between scientists and the local fishing association. Important components would include communicating and educating the fishermen such that they are encouraged to return the tags.

REVIEW WORKSHOP RECOMMENDATIONS

The Review Panel offers the following comments regarding research needs and the data and assessment of spiny lobster.

1. With the available data, an interesting story becomes evident. The data series can seemingly be split into two components, before and after about 1992. In the first part of the time-series, the abundance indices decline. The models were able to recreate the decline in nominal CPUE on Puerto Rico / St Thomas / St John. This is a common pattern found in exploited fish populations, biomass steadily decreasing, and fishing mortality steadily increasing. The second part of the time-series shows the abundance index remaining steady while the catch increases, a trend inconsistent with our expectation of a fishery in a closed system. As catch increases above the level that was causing a population decline in the first portion of the time-series, we would expect the abundance index either to continue to decline or for the decline potentially to accelerate. Instead, the abundance index levels off as the catch increases. Because of this situation, standard production model approaches do not fit the entire time series, because they do not have the ability to recreate the observed behavior.

The Panel therefore suggests that additional factors be considered in an attempt to understand better the dynamics of the population. One possibility is that recruitment may have increased during the second half of the time-series, allowing for increased catch without reducing population size. Another possibility is that fishermen may have moved into new areas, accessing a previously unexploited portion of the population, so allowing for increased catches. Other possible hypotheses involve changes in the gear used, or in post-settlement survival, and/or changes in post-larval settlement rates.

It should be possible to modify the modelling approach to produce a model that would support the observed data. One way to do this would be to allow the recruitment parameter r to increase over the second part of the time-series. This would require refining a model unique to the system, perhaps moving beyond the standard modelling software currently used. Once a model can recreate the behavior observed in the data, it should be possible better to identify hypotheses for the cause of the behavior.

Clearly, understanding the dynamics of recruitment in this fishery is crucial. There is therefore a great need to create a standardized annual recruitment index to support any assessment of this stock.

2. The Panel strongly endorses the development of partnerships with local fishermen, to conduct research and to collect the data needed for assessments. Partnership with the fishing community is a cost-effective way to collect components of the needed data. Currently, there is a high level of interest in the fishing community to cooperate with management agencies in collecting data, so the partnership should be encouraged and strengthened. This would also facilitate ongoing cooperation and participation by fishermen in the management process, benefiting all involved.

Recommendations for future data collection and research:

Improve and complete historical data on relative abundance indices and catch

- For the commercial fishery
  - Recover pre-1983 data for Puerto Rico
  - Create/recover pre-1975 data for the US Virgin Islands by working with the fishermen's associations
  - Use the newly available US Virgin Islands data for the period 1987–1992
  - Use structured interviews with fishermen to assess gear changes
- For the recreational fishery
  - Estimate historical and current levels

Fishery–independent monitoring

- The Panel identified an apparent inconsistency between the assessment model assumptions of recruitment as a direct function of spawning stock. This appeared to be important enough to warrant two recommendations: 1) to build additional flexibility into the models to allow time-varying recruitment (or at least recruitment dynamics); and 2) to seek to establish a fishery-independent index of recruitment, which is deemed to be crucial. Based on presentations made during the review, there appears to be a tested method for conducting such a survey, and these types of data are currently being used in the SA-GOM lobster assessment. The method consists of placing a series of post-larval collectors in appropriate areas and consistent sampling their catch. This approach appears to be conducive to cooperative research, utilizing fishermen's knowledge of the area as well as their frequent visits to sampling areas. The Panel strongly endorses the need for such a survey to provide a data series for use in the Caribbean spiny lobster assessment, preferably with a sampling design covering both platforms, given the uncertainty about the spatial coupling of recruitment dynamics

- It is necessary to develop and implement sampling program(s) specific to both pre-recruit and adult Caribbean spiny lobsters
- It is crucial to increase sampling effort in the US Caribbean.
- There will be benefit in further diversifying the regions sampled to include equal coverage of areas frequently fished
- Visual surveys for size structure, abundance, and YPR could provide useful time-series of data

Revise the trip interview program (TIP) database exhaustively

- Completing the historical data set would be valuable
- Revitalizing TIP sampling in the US Virgin Islands would have many benefits, not just for the Caribbean spiny lobster stock
- Effort should be directed at key species, generating trip-target information, and obtaining needed detail

Length distribution of the catch

• For the commercial fishery
    Complete incorporation of non-digitized data for the US Virgin Islands (TIP)
    Recover historical length data for Puerto Rico and the US Virgin Islands from other studies prior to the TIP
• For the recreational fishery
    Determine length distributions

Conduct studies to understand the ecology of early juveniles (25 mm carapace length)

• Habitat use needs to be understood better
• More needs to be known about settlement habitat
• Information on movements and migrations needs to be sought
• Clarity of the mortality rates needs to be sought

Spatially explicit studies

• Identify spawning areas and sources of recruits
• Build/acquire habitat maps to identify stratification for research designs
• Combine habitat maps with density counts and habitat models to provide population estimates
• Develop a GIS map of spiny lobster landings throughout the geographic range of the stock, producing catch distributions

Mark-recapture techniques

• Such studies could hone knowledge of abundance
• The techniques could provide additional information on movements and migrations
• Habitat preferences would be better understood

Stock structure

• Stock structure is important in assessments, and genetics offers hope to improve knowledge

Future assessments

• These should explore further use of length structure and density from closed areas as reference points
• Assessments need to be repeated when significant quantities of previously unavailable historical data have become available
• Alternative stock assumptions need to be considered during assessment
    That of a wider Caribbean stock
    That of the stock of the US Caribbean and neighboring islands
• The use of nominal CPUE should be considered in future assessments
• The modelling approach needs to be modified to produce a model that would support the observed data. Within the model, the recruitment parameter r should be allowed to increase over the second part of the time-series, perhaps moving beyond the standard modelling software currently used.

Of the above, the Panel places the highest priority on the following, understanding the need to maximize the likelihood of generating an acceptable assessment of the stock in the near future:

• Develop/strengthen fishery-independent data collection
• Incorporate historical data into existing data sets
• Utilize refined models (better to identify viable hypotheses)

Stock Assessment Report of SEDAR 14
Caribbean Yellowfin Grouper

DATA WORKSHOP RECOMMENDATIONS

2. Life History Group

2.13. Research Recommendations

The life history subgroup made several research recommendations pertaining to Yellowfin grouper. These are prioritized below.

2.13.1. Early life history

1) Conduct studies on temporal (intra- and inter-annual) variability of oceanographic processes in relation to larval dispersal to quantify the degree of connectivity between platforms of the currently managed stock units.

2) Examine early larval dispersal patterns (post fertilization to pre-flexion) using genetic markers.

3) Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.

2.13.2. Adult Populations

4) Identify additional past and present spawning aggregation sites and characterize migration corridors.

5) Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies.

6) Evaluate the potential to use visual census data obtained from spawning aggregations as fisheries independent data for assessing stock status (i.e. sex ratio, average size, density) and for monitoring populations.

2.13.3. Stock Identification

7) Investigate population genetic structure of yellowfin grouper “stocks” within the US Caribbean and in relation to the wider Caribbean.

8) Examine ontogenetic shifts in habitat usage and diel foraging patterns

3. Commercial Statistics

3.8. Research Recommendations

Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

Eliminate the need for expansion factors by obtaining information on all landings.

4. Recreational Fishery

4.3. Research Recommendations

Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.

Include conch and lobster in the MRFSS for Puerto Rico.

To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be needed

5. Indices of Abundance

5.4. Research Recommendations:

1) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.

2) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.

3) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.

4) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.

5) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).

6) The group recommends that efforts be made to monitor spawning aggregations of finfish to improve measures of population abundance. Collection of historical indicators of spawner abundance (e.g., directed visual census, analysis of catch statistics for spawning peaks, etc).

7) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

ASSESSMENT WORKSHOP RECOMMENDATIONS

1.2.8. Research Recommendations
The AWP recommends collecting species level information on commercial and recreational harvest in the US Virgin Islands.

The AWP recommends collecting biological samples to characterize commercial and recreational catches in the US Virgin Islands and Puerto Rico.

The AWP recommends continuation of the survey efforts directed at the Grammanik Bank spawning aggregation as a potential source of yellowfin grouper trends that reflect a potentially important population component.

The AWP recommends developing specific surveys to evaluate species such as yellowfin grouper which rarely occur in general surveys but are known to seasonally aggregate.

The AWP recommends developing research and monitoring programs that enable quantitatively evaluating management actions such as seasonal and area closures, especially as such actions can significantly alter fishery operations and limit traditional data collection approaches.

The AWP recommends pursuing alternative assessment methods for evaluating the status of stocks such as yellowfin grouper that are not commonly encountered by either fishery-dependent or fishery-independent sampling and monitoring programs.

The AWP recommends devoting effort to characterizing basic catch, biological, and survey data availability before recommending SEDAR assessments of stocks that have never been quantitatively assessed. Such work should be considered between scheduled SEDAR assessment projects or perhaps in lieu of a project dedicated to a particular species.

The AWP recommends a complete review of the potential data collection programs, including commercial and recreational catch, biostatistical sampling and fishery-independent surveys for Puerto Rico and US Virgin Islands with the purpose of identifying what relevant information could be obtained and modifying sampling procedures accordingly, including the identification of key economic and ecological indicator species.

The efforts to analyze the available data were greatly enhanced by the presence of local fishers and agency representatives. However, there was no local representative from the USVI Division of Fish and Wildlife assigned to the AWP and the sole Puerto Rico representative could not

attend the full term of the meeting. There must be greater buy-in from the local agencies such that knowledgeable representatives are present for the full term of the meeting. Furthermore, greater efforts should be made to attract and secure participation of local fishers.

REVIEW WORKSHOP RECOMMENDATIONS

The Review Panel agrees with the points put forward by the Data Workshop and Assessment Workshop.

In addition it was the opinion of the RP that:

1. Tagging data should also be considered in relation to obtaining information on growth rates of yellowfin grouper. In addition to be of general life history interest this will also be of importance in relation to validation of otolith age determination. Because yellowfin grouper is a quite rare species it might be considered to use some kind of Data Storage Tags in order to obtain as much information from each individual fish tagged as possible. If sufficient number of yellowfin grouper can be caught and tagged (with ordinary tags), annual tagging programs to reveal stock size and fishing mortality could be considered for yellowfin grouper. Because yellowfin grouper is quite rare to catch it might be practical to tag several species (with similar lack of life history knowledge for which tagging studies are potential appropriate) at the same time.

2. An internet setup could be explored, where anglers and maybe divers report their catches of yellowfin grouper (and other relevant species) as well as additional information directly on forms on the internet. Such internet systems are used with success in other places in the world to report fish catches, especially for large and rare species like yellowfin grouper. Such an approach should be accompanied with various test and checks to estimate reporting rates by segments of anglers and divers, proper way. The internet is also an effective tool for communicating with the data suppliers, for instance about how to report, the results of the reports and ongoing tagging experiments.

Of all these recommendations including those of Data Workshop and Assessment Workshop, the Panel regards the following to be of the highest priority:

- the improvements of sampling from the fishery (both commercial and recreational) including biological measurement;
- tagging studies to reveal stock structure, population size, annual fishing mortality and life history parameters;
- improving fisheries-independent surveys;
- resolving the problems in the commercial landings data base.

Stock Assessment Report of SEDAR 14
Caribbean Mutton Snapper

DATA WORKSHOP RECOMMENDATIONS

2. Life History Group

2.11. Research Recommendations

2.11.1. Early life history

1) Conduct studies on temporal (intra- and inter-annual) variability of oceanographic processes in relation to larval dispersal to quantify the degree of connectivity between platforms of the currently managed stock units.

2) Examine early larval dispersal patterns (post fertilization to pre-flexion) using genetic markers and otolith microchemistry where possible.

3) Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.

2.11.2. Adult Populations

4) Identify additional past and present spawning aggregation sites and characterize migration corridors.

5) Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies.

6) Evaluate the potential to use census data obtained from spawning aggregations as fisheries independent data for assessing stock status (i.e. sex ratio, average size, density) and for monitoring populations.

2.11.3. Stock Identification

7) Investigate population genetic structure of mutton snapper “stocks” within the U.S. Caribbean and in relation to the wider Caribbean.

8) Examine ontogenetic shifts in habitat usage and diel foraging patterns.

3. Commercial Statistics

3.8. Research Recommendations

Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

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4. Recreational Fishery

4.3. Research Recommendations
Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.

Include conch and lobster in the MRFSS for Puerto Rico.

To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be needed

5. Indices of Abundance
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1) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.

2) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.

3) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.

4) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.

5) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).

6) The group recommends that efforts be made to monitor spawning aggregations of finfish to improve measures of population abundance. Collection of historical indicators of spawner abundance (e.g., directed visual census, analysis of catch statistics for spawning peaks, etc).

7) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

ASSESSMENT WORKSHOP RECOMMENDATIONS

2.12. Research Recommendation

Table 12 provides a comprehensive overview of the availability of information for U.S. Caribbean mutton snapper populations, This table in addition to the following discussion provides a synthesis of the groups thoughts regarding sufficiency and quality of the data available for use in evaluating the stock status of the mutton snapper population in this region. Due to the current categorization of mutton snapper as undergoing overfishing, this species should be prioritized in all data collection efforts in the US Caribbean both in dependent and fishery independent programs. Obtaining information required to assess the impact of regulations on management measures is needed. Targeted research efforts are needed to determine relative abundance, CPUE, length and age structure of catch for all commercial and recreational gears used to harvest mutton snapper. The group noted the need to monitor population densities at seasonal closed areas to open areas to determine effects of management and to monitor compliance. The only area closure for mutton snapper is off St. Croix and the closure has been in place since 1993. There has been no monitoring in this area since the closure took effect. In addition there is no current mechanism of enforcing the spawning seasonal closure.

2.12.1. Dependent Data Collections

At the SEDAR14 AW the group discussed the importance of accurate and reliable information regarding the catch. Fishery dependent data collection (i.e., commercial fishery) should be continued and improved with emphasis on priority species (in this case mutton snapper). The group noted that a review of the field methods and protocols of the fishery data collection systems in the U.S. Caribbean needs to be conducted to evaluate what relevant attributes need to be collected to characterized trip specific catch. Such a review should be conducted in collaboration with all the primary agencies responsible for management of these species to assess appropriate sampling levels and priority species (or groups of species) and prioritize fisheries. Species landings information should be collected at a resolution so CPUE can be determined for each gear used to harvest this species. Accurate information must be recorded to identify each individual fisher, location and date of catch and where possible depth of catch. For all primary harvest gears, optimum CPUE should be in terms of number of individuals, biomass, and the amount of effort in hook-hours (i.e., time hooks are in the water) or trap soak-time in hours. The group also emphasized the need to review the catch sampling intensity protocols prescribed by the NMFS, SEFSC, Trip Interview Program for sampling catches as a guideline for setting catch length frequency sampling needs. As a starting point the current TIP target of taking 25-30 individual lengths and weights per trip should be considered as a guideline for sampling of

individual catches. When sub-sampling occurs the sampling fraction must be recorded. In addition, information should be collected to determine whether fish were captured in a spawning aggregation or otherwise. Where appropriate, information on directed fishery discards should be collected and, the fate (i.e., dead, alive) and size of individuals of the discards characterized. The group also noted the importance of monitoring the fishery accurately as relates to the intra-day variability. The group emphasized that the MRFSS sampling program should add additional survey attributes to draw out information on mutton snapper throughout the U.S. Caribbean. The group emphasized the need to continuous recreational fishery data collection in the US. VI. In addition, the sampling effort of the MRFSS intercepts should be increased to a level that would result in adequate sample sizes for biological characterization. The use of research initiatives such as CRP, MARFIN and Sea Grant were encouraged as funding mechanisms for the collection of such critically needed data.

2.12.2. Fishery Independent

The group emphasized the need to continue and enhance the current fishery independent program(s) to better evaluate abundance indices for mutton snapper populations cross insular platforms in habitats where these fish are known to occur as well as for known spawning aggregations. During such monitoring length of individuals, location, depth, time of day of sample collection, and habitat should be noted. Visual counts or directed gear sampling (i.e., hook-and-line, traps, spear fishing, nets, etc.) are possible monitoring gear as well as possible camera devices. Life history information to determine age, size, growth, reproduction (size of maturity, fecundity, spawning behavior, stock identification) is needed. The group encouraged the use of already existing research funding opportunities including CRP, MARFIN, and Dingell Johnson (Johnson) programs for the collection of such critically needed data. The group emphasized the need to coordinate life history studies between key agencies to collect and assemble time series of information on life history attributes including age, growth, and maturation. In addition, individuals conducting basic life history studies are encouraged to collaborate with other external groups including NMFS, SEFSC Panama City and Beaufort Laboratories, with existing protocols and methods for similar species.

The group encouraged reference to supporting efforts by SEAMAP-C committee and also the other ongoing fishery independent sampling initiatives. The group noted that the SEDAR14 DW discussed a recent proposal submitted to the SEAMAP-C committee, the objective which was to evaluate the current reef fish sampling methods and protocols of the SEAMAP-C and to develop pilot studies for enhancing the spatial and temporal coverage of the study. The group noted that the SEMAP-C committee has recently submitted a letter of support regarding that study (SEDAR14 AW RW-49). Research efforts such as these are encouraged.

A research need exists for evaluating impacts from management measures. In particular monitoring of closed areas should be conducted through carefully conducted scientific experiments in such no take areas. Researchers are encouraged to collaborate with fishers in the areas to utilize their knowledge in planning these experiments and to seek funding through such initiatives as NOAA, CRP process.

REVIEW WORKSHOP RECOMMENDATIONS

2.3.2. Review Panel research recommendations:

The DW and AW reports provided a wide range of research recommendations related to biology, fishery data, fishery-independent data and assessment methods for mutton snapper. The recommendations were scattered throughout the reports, but without any prioritization according to short-term and longer-term needs or any indication of the extent to which the results could improve the assessment and management of the stocks. The RP recommends that future DW and AW reports provide a single section collating all recommendations, with priorities and expected contribution of the results clearly identified.

The following sections give the combined DW and AW recommendations for different research areas. In each case these are followed by RP evaluations and consolidated recommendations for data collection and research that is needed to address the deficiencies in data and understanding that are impeding the evaluation of stock status and development of appropriate management measures. In some cases similar recommendations appear in different guises in different parts of the DW and AW reports and the RP has taken the liberty of merging and rewording these as appropriate, and summarizing some of the other recommendations.

2.3.2.1. DW & AW Workshop recommendations on fishery-dependent data

- Biological sampling at USVI to characterize size and age composition.
- Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.
- Eliminate the need for expansion factors by obtaining information on all landings; resolve other problems with data through extensive meetings with port samplers and others familiar with US Caribbean fisheries.
- Targeted research efforts to determine relative abundance, CPUE, length and age structure of catch for all commercial and recreational gears;
- Collection of species landings data at resolution to allow CPUE data for each gear; need to identify each individual fisher, location/date of catch, and depth where possible.
- Estimate CPUE in terms of numbers and biomass; estimate effort as hook-hours and trap soak times;
- Where appropriate, collection of discards data and fate (dead or alive) of discards;
- Review of field methods and protocols for fishery data collection throughout Caribbean;
- Review catch sampling intensity protocols;
- Evaluate impacts of management measures, particularly closed areas

The RP considers the improvement in the accuracy and coverage of fishery data to be of very high priority for the fisheries of Puerto Rico and the U.S. Virgin Islands, and endorses the DW and AW recommendations. The RP makes the following consolidated recommendations:

i) Ensure accurate recording of data by species in all areas.

ii) Development of a random fishery sampling scheme, stratified by appropriate areas/gears/seasons, to provide valid statistical estimates of catches and size compositions by species, and fishing effort, with high spatial and temporal resolution.

iii) Continued improvement of log-book reporting schemes and improvements in methods for expanding reported landings to the total fishery, for example by stratifying by port.

iv) Evaluation of the representativeness of the reported fishery data, for example by interviewing fishermen who have submitted log sheets in recent years but did not before.

v) Identification of fishing effort units (e.g. soak time for traps; hook-hours) that are most likely to provide a linear relationship between CPUE and population abundance, and the capturing of historical TIP data on landing weight per trip for trips with soak time or other effort data

vi) Collection of covariates (e.g. depth) to help explain variability in CPUE data.

vii) Accurate documentation of changes over time in fishing effort, fishing gears and their deployment, species targeting and fish-location technology (e.g. GPS), to help interpret CPUE data and identify periods when catchability may have changed.

viii) The Panel agrees that standardized sampling protocols and systems for Quality Assurance / Quality Control of data are needed for data collection throughout the Caribbean.

ix) Involvement of fishers in data collection schemes, including investigating the potential for web-based systems for capturing fisher's data and other information.

2.3.2.2. DW & AW Workshop recommendations on the recreational fishery

- Conduct surveys to estimate magnitude of USVI recreational landings for all species (use a USVI contractor) (To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be required.)

- MRFSS program should add additional survey attributes to draw out information on mutton snapper throughout US Caribbean; increase MRFSS intercepts to improve sample sizes.

The RP endorses recommendations to collect relevant data on recreational fishing. Data on recreational fishery catches of mutton snapper are limited to the recent period of the MRFSS survey (2000 onwards for Puerto Rico, 2000 only for USVI). Although the precision of estimates of fish catches is quite low (CV's = 30-50%), recreational fishing appears to be an important source of mortality (6,000 – 25,000 fish killed per year off Puerto Rico), and shore fishermen appear to target mainly juvenile mutton snapper. Improvements in the coverage and intensity of the Puerto Rico sampling scheme and restarting the USVI scheme would contribute significantly to the accuracy of removals estimates from the stocks. Shore-angling catch rates may indicate

recruitment trends. As with the commercial fishery, involvement of the angling community in data collection schemes would be beneficial, potentially making use of web-based systems.

2.3.2.3. DW & AW Workshop recommendations on fishery independent data

- Initiate surveys in deeper water, the preferred habitat of adult mutton snapper.
- Identify essential habitats according to life history stage, including critical recruitment and post-settlement (nursery) habitats.
- Monitor spawning aggregations for density (abundance indices), and collection of population parameters such as sex ratio and size of fish.
- Collection and documentation of historical information for qualitative and/or quantitative comparisons of current conditions; collation of historical indicators of spawner abundance
- Continue and enhance fishery independent programs including spawning aggregations and collection of data on size of individuals, depth, time of day, habitat; use of visual counts or directed gear sampling;

The RP encourages the development of fishery independent surveys using fishing gears or direct observation, provided the surveys adequately cover the range of the target species and are capable of providing abundance indices or raised abundance estimates with acceptable accuracy. The RP recognizes that such surveys require substantial investment to achieve the necessary spatial coverage, and will benefit from existing studies and fisher's knowledge to identify strata for visual or fishing surveys of spawning fish.

The DW listed 14 different sources of fishery independent data from different areas around Puerto Rico and the U.S. Virgin Islands, but only five appear to provide data on mutton snapper, mainly in the U.S. Virgin Islands. In general the surveys tend to be localized and observations of mutton snapper can be low. Diver surveys using volunteer divers on the REEF program indicate (other than in 2006) an increase in abundance of mutton snappers at inshore sites off the U.S. Virgin Islands, showing a similar general pattern to the Puerto Rico commercial trap fishery CPUE. The existing surveys should be reviewed to establish areas that could be targeted for systematic dive surveys, and to determine the survey effort required to achieve specified precision levels. Discussions at the Review meeting indicated that surveys at times of year when the fish are more dispersed may provide more precise abundance indices than surveys of spawning aggregations. Occupancy of spawning sites will also be strongly affected by spawning behavior and the environmental triggers for spawning. On the other hand, surveys designed to collect data on parameters such as relative size composition of mature fish, may benefit from taking place on known spawning sites at spawning time. The design of surveys therefore needs to be linked clearly to their objectives.

The RP recommends investigation of other methods for fishery-independent stock monitoring, for example beach-seine surveys to provide recruitment indices for mutton snapper and other species and tag-release programs to estimate mortality rates as well as fish movements. Desk studies are however required to establish the requirements for design, intensity and sampling to deliver the required accuracy of estimates from any such surveys.

2.3.2.4. DW & AW Workshop recommendations on biological studies

- Collect life history information (growth, maturity, fecundity etc.); coordinate between key agencies;
- Tag recapture studies to determine habitat utilization and movement.
- Identify additional past and present spawning aggregation sites and characterize migration corridors;
- Define the spatial scale of migrations by individuals participating in spawning aggregations through tag and release studies;
- Conduct studies on temporal variability of oceanographic processes in relation to larval dispersal and connectivity of platforms of currently managed stock units;
- Examine early larval dispersal patterns using genetic markers and otolith microchemistry;
- Investigate population genetic structure of mutton snapper "stocks" within US Caribbean and in relation to the wider Caribbean.
- Examine ontogenetic shifts in habitat usage and diel foraging patterns.

The RP endorses the need for estimates of biological parameters determining productivity (growth, maturity, fecundity). Growth estimates by sex are needed for length-based models, and growth and maturity data are needed for development of biological reference points for exploitation.

The RP endorses the need for better information on distribution and seasonal/ontogenetic migrations and dispersal of mutton snapper. Whilst such information may not necessarily feed directly into stock assessment models, it is important for interpreting CPUE data, evaluating the impact of effort redistribution during closures, and establishing the possibility for over-fishing of localized populations with limited dispersal and mixing.

Modeling of egg and larval drift provides further information on connections between spawning and recruitment sites and the linkages between mutton snapper populations around Puerto Rico and the US Virgin Islands, and is an important long-term area of research rather than for assessing local stock status.

2.3.2.5. DW & AW Workshop recommendations on modeling approaches

The AW did not make any specific recommendations regarding future development of assessment models for mutton snapper. The RP makes the following recommendations:

i) Simulation testing of the length-based mortality estimator and any subsequent developments of it to examine its performance under different conditions of recruitment variability; use of a bootstrapping procedure to estimate variance; testing of the method on a wide range of stocks with age-based indices and associated length frequencies.

ii) Further exploration of GLM models for CPUE; regional application of the Stephens and McCall method to identify trips that could have caught mutton snapper; comparative model runs for all co-occurring species taken by each gear.

iii) Development of community-based indicators of fishery impacts in different areas or habitats, and evaluation of how these could be used to inform management of the fisheries.

iv) Investigate future use of PARFISH (Participatory Fishery stock assessment; MRAG) to integrate fishery data and information from fisher interviews.

v) Collection of the necessary information to carry out simple yield-per-recruit and spawner-per-recruit models to evaluate reference points for fishing mortality and the potential benefits of improving the selectivity characteristics of the commercial and recreational fisheries.

Stock Assessment Report of SEDAR 14
Caribbean Queen Conch

DATA WORKSHOP RECOMMENDATIONS

3. Commercial Statistics

3.8. Research Recommendations

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Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

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4. Recreational Fishery

4.3. Research Recommendations

Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.

Include conch and lobster in the MRFSS for Puerto Rico.

To adequately characterize catch rates and sizes of mutton snapper caught by recreational anglers in Puerto Rico, very substantial increases in dockside sampling will be needed.

5. Indices of Abundance

5.4. Research Recommendations:

1) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.

2) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.

3) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.

4) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.

5) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).

6) The group recommends that efforts be made to monitor spawning aggregations of finfish to improve measures of population abundance. Collection of historical indicators of spawner abundance (e.g., directed visual census, analysis of catch statistics for spawning peaks, etc).

7) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

ASSESSMENT WORKSHOP RECOMMENDATIONS

2.8. Research Recommendations

1. The efforts to analyze the available data were greatly enhanced by the presence of local fishers and agency representatives. However, there was no local representative from the USVI Division of Fish and Wildlife assigned to the meeting, while the Puerto Rico representative could not attend the full term of the meeting. There must be greater buy-in from the local agencies such that knowledgeable representatives are present for the full term of the meeting. Greater efforts should be made to attract the participation of local fishers.

2. Data from past density surveys should be re-analyzed so that values can be expanded on the basis of both habitat and depth, including confidence limits. Habitats should be matched to those available for existing/planned habitat maps. As a subportion of this, the data for the Puerto Rico 1986 survey should be entered into electronic and GIS formats. This could be done using NOAA's Data Rescue funds.

3. Expansion factors for both Puerto Rico and the USVI should be calculated for conch fishers only.

4. Assessment of the spatial and temporal variations and dynamics of the resource, fishery, habitat and species interactions would be greatly enhanced if traditional ecological knowledge were obtained from fishers. Efforts should be made to incorporate fishers into the process, particularly using NOAA's CRP funds.

5. The impact of the recreational fishery is unknown and must be quantified.

6. Considering the established and potential value of resource surveys, mechanisms should be identified to increase their aerial coverage.

7. More detailed spatial expansions of survey densities should be planned in preparation of the 2010 Conch Update. For this, significant improvements in available data and analyses are required, including but not limited to the following:

A. Detailed bathymetry data for PR and USVI

B. Analysis of the impact of closed areas

C. Inclusion of more detailed habitat maps for the PR western platform currently in progress

D. Quantified size/age structure of the exploitable stock.

8. The only estimate to date of fishing mortality came from a tagging study in the 1980's. New tagging studies should be initiated to quantify rates of exploitation. This would allow existing SPR models for conch to be used in assessments.

9. Another issue remaining is to investigate the potential impact of very old conch in deep refuges, especially with respect to reproduction, coupled with studies to age very old conch. Such refuges may be substation off St. Thomas/St. John, in patches in Puerto Rico and potentially in protected areas on all three platforms.

10. Intersessional data evaluation workshops for CFMC managed species or species complexes should be conducted by the Council so that SEDAR level analyses are limited to those where data are sufficient to warrant such an analysis.

11. There needs to be a complete review of the potential data collection programs, including commercial and recreational catch, biostatistical sampling and fishery independent surveys for Puerto Rico and US Virgin Islands with the purpose of identifying what relevant information could be obtained and modifying sampling procedures accordingly, including the identification of key economic and ecological indicator species.

REVIEW WORKSHOP RECOMMENDATIONS

The DW and AW have made a number of recommendations for future research and monitoring which are reviewed below alongside further recommendations of the RP.

Recommendations of the Data Workshop

Life history

The DW made no recommendations for future research into queen conch life history. Biological parameters for queen conch are generally well characterized from the literature, although variations in growth and maturation over small spatial scales mean that there is uncertainty about area-specific parameters. This is not presently a limiting factor for stock assessment, principally because there are neither data nor model structures available for analytical assessment of conch stocks, but use of yield or spawner per recruit analyses to develop biological reference points would need to account for this fine scale variation. In common with many other species,

empirical information is lacking on natural mortality after early life stages, but assumed values and their relationship with age appear to be adequate at present.

The RP made no specific recommendations for high priority research into conch life history parameters, but there was a general view that more information is needed on stock identity and the spatial scale of population processes at each life stage. Genetic studies indicate population connectivity between different areas of the Caribbean, but this does not preclude the existence of stock units that are effectively self-contained at time scales relevant to stock assessment and fishery management. Modeling of conch larvae dispersal by surface currents may shed some light on this issue.

Commercial statistics
The DW recommended that Puerto Rico conch landings for recent years should be corrected for the change from reporting uncleaned to reporting cleaned meat weights and that this should be done on a port-by-port basis. Landings included in the DW report were not corrected, but approximate corrections at the scale of the entire Puerto Rico fishery were applied in figures presented in the AW report and during the RW meeting. The RP agreed that it was a high priority to apply such corrections in presenting time-series of conch landings data.

The DW also made the following recommendations regarding the collection of statistics on the commercial fisheries for the three species considered by SEDAR 14:

DW1) Continuous biological sampling in the Virgin Islands at sufficient levels to adequately characterize size and age composition.

DW2) Link biostatistical data for a fishing trip from Puerto Rico to all of the landings records for that trip.

DW3) Ensure that the catch and effort data of individual fishers in Puerto Rico can be identified over time.

DW4) Eliminate the need for expansion factors by obtaining information on all landings.

The first recommendation relates mostly to finfish, but it is also true that future assessments may benefit from more information on the composition of conch catches. Ideally, continuous sampling should be maintained at sufficient levels to allow calculation of required indicator statistics, but occasional intensive sampling may provide a viable alternative. The definitions of ‘sufficient’ and ‘occasional’ can only be judged in a risk assessment context, the relevant question being what precision around indicator statistics is required for management purposes. In the absence of information on which indicator statistics might be desirable the RP is unable to provide more specific recommendations on sampling of conch catch composition.

Recommendations DW2-4 reflect the urgent need for accurate gear-specific total landings and effort data across the whole of the assessed area, and for comprehensive qualifying data to be matched with individual catch records such that meaningful and properly standardized CPUE estimates can be calculated. The RP regards these recommendations as being of the highest

possible priority. Future progress in developing stock assessments and population benchmarks for queen conch depends critically on the availability of comprehensive, quantitative information on fishery removals and the associated fishing effort. This will remain true even if, as seems likely, fishery independent indices are used as the primary source of information on stock abundance. ABCs and related statistics will always need to be calculated with reference to complete landings data. The RP further recommends investigation of uncertainty around estimated expansion factors and hence around estimated total landings. This might be achieved by bootstrap sampling of the reported landings data, preferably on a species-specific basis. There also needs to be some evaluation of the assumption that available landings declarations are representative of all license holders. One possible approach would be to examine fishery returns from long-term license holders who have only recently submitted logbook records. If this subset of records is representative of the whole it would be reasonable to suppose that the calculated expansion factors are not biased.

The RP also recommends exploration of alternative approaches to estimating total landings and fishing effort directed at queen conch. These might include randomized sampling of catches at landing sites, aimed at statistical estimation of landings quantities that might circumvent the possible biases involved in expanding incomplete log-book records. Another approach that could be considered is the use of internet forms to allow fishers to enter catch and effort data directly. In this context it is worth emphasizing the desirability of developing partnerships with local fishers to collect data and to conduct research.

Recreational fishing

In common with other species, the recreational catch of queen conch may be considerable. Recreational fish catch estimates for Puerto Rico are available for 2000 onwards, but unfortunately conch and other invertebrates were not included in the MRFSS. Based on a one-off survey in 2000, recreational catches of conch were estimated to be at a level of about a third of the commercial landings by Puerto Rico in 2000-2001[1], i.e. around a quarter of the total landings. Clearly, the recreational catch of queen conch is an important omission from the Puerto Rico total landings data for other years and from the USVI total landings data in all years[2]. Furthermore, it is difficult to interpret even relative trends without more information on the variability of recreational effort between years[3]. The DW made the following recommendations relevant to recreational fishing for queen conch:

DW5) Conduct surveys to estimate the magnitude of the U. S. Virgin Islands recreational landings for all species including conch and lobster. It is possible that using a Virgin Islands contractor would improve the likelihood of success of the survey.

DW6) Include conch and lobster in the MRFSS for Puerto Rico.

1 The figures appear to be derived from the observation that recreational catches during a 3 month period were at around 50% of the *reported* landings over the same period. No adjustment seems to have been made for differences in commercial reporting rates between years.

2 Tentative estimates for the USVI have been made for the same years, assuming that the same relationship exists with commercial landings (SFA Amendment, 2005).

3 The AW report also mentions a similar proportion of recreational landings (35% of commercial landings) for Puerto Rico in 1986, but this would be a slender basis from which to infer a constant proportional contribution over time.

The RP strongly endorses these two recommendations for both Puerto Rico and USVI and considers that they should be given high priority in the immediate term. Information on total landings is crucial for calculation of ABCs and associated benchmark statistics. The RP further recommends that, in common with the expansion factors for commercial landings statistics (see above), the uncertainty around the current and future recreational landings estimates be investigated. The current figures for Puerto Rico can be regarded as indicative rather than definitive estimates, and the application of the same expansion factor to USVI is somewhat tenuous. Unlike the commercial landings, it would be unrealistic to suppose that 100% coverage of recreational landings could ever be achieved. This makes it important to characterize the uncertainty around all recreational landings estimates.

Indices of abundance

Both fishery-dependent and fishery-independent indices were examined by the DW. A number of recommendations were made on the analysis of CPUE, mainly concerning filtering of trip records and adjustment for reporting cleaned or uncleaned meat weights. These recommendations were taken on board by the AW, but owing to the lack of relationship between conch density and the ability of commercial divers to catch their daily quotas the resulting indices were considered not to be informative of stock abundance. The RP agrees that under current fishing practices it is unlikely to be feasible to measure diver effort in any way that would allow calculation of CPUE values that are responsive to abundance changes. The RP considers that low priority should be given to further analyses of queen conch CPUE data, given the likelihood that fishery-independent stock indices will be used as the main source of information on stock status in the near future, but the situation might change if alternative effort measures could be devised and recorded. This does not, of course, mean that reduced emphasis should be placed on collecting reliable records on fishing effort. Examination of effort trends is an important component of monitoring for overall fishery 'health', and trends in effort directed at queen conch may in themselves be indicative of changes in abundance.

The DW provided additional recommendations on indices of abundance for species considered by SEDAR 14, of which the following are relevant to queen conch:

DW7) Fisheries-independent survey efforts currently rarely include stations in deep water, the preferred habitat of adult mutton snapper and adult yellowfin grouper. In addition, large aggregations of queen conch have been reported in deep water by commercial fishers. The group highly recommends the initiation and continued funding of such surveys. As trends can be regional in nature, the group highly recommends that such surveys be conducted throughout Puerto Rico and the US Virgin Islands.

DW8) The commercial landings data from Puerto Rico and the US Virgin Islands have been incompletely entered and a variety of problems are known to exist in those data. The group strongly recommends that every effort be made to resolve the problems with those data. This should include extensive meetings with port samplers and others familiar with the US Caribbean fisheries.

DW9) The group recommends that tag-recapture studies of mutton snapper, yellowfin grouper, and queen conch be conducted in Puerto Rico and the US Virgin Islands to determine habitat utilization and movement of those species.

DW10) Ongoing long-term monitoring studies should be expanded spatially and include data useful for stock assessment, e.g. size-frequency and density information.

DW11) It is suggested that areas exploited by fishermen be compared to those areas where monitoring has been ongoing to further knowledge of essential habitat for these species and improve the design of monitoring efforts (i.e., ensure that monitoring is reflective of fished conditions).

DW12) The group encourages the collection and documentation, for this and future Caribbean assessments, of historical information for qualitative and/or quantitative comparisons of current conditions.

The RP agreed that all of these recommendations are valid for queen conch, with varying degrees of urgency, but more specific information is required on precisely what is needed and on the proposed methods of addressing them. Recommendation DW8 regarding commercial landings data should be clarified. The high priority that should be given to attempts to improve compliance with reporting requirements has already been noted above. However, the completeness of commercial fishing records is less of an issue in the context of abundance indices, principally because commercial CPUE is not informative as an index. It is nonetheless desirable to ensure that qualifying data for landings records are as comprehensive as possible, for example allowing the efforts of individual fishers to be followed. Significant progress with identifying improved measures of effort may change the priority of this recommendation.

Recommendations DW7, DW10 and DW11 are relevant to fishery-independent surveys, specifically visual surveys that generate habitat-specific queen conch density estimates that can be expanded to domain-wide stock abundance estimates. This assessment method is the most promising for queen conch stock assessments in the near future; the RP took the view that high priority should be given to expanding the spatial coverage and habitat coverage of the fishery-independent surveys with a view to improving the precision of stock abundance estimates. This type of assessment might also benefit from the inclusion of information on how fishing effort is distributed between areas of similar habitat, so that, for example, fishing intensity as well as habitat classification could be used to stratify the density estimates.

The RP agreed that tagging studies of queen conch should be conducted in both Puerto Rico and USVI. Recommendation DW9 relates to the use of tagging to determine patterns of movement and habitat utilization. The RP endorses this recommendation as a medium- to long-term priority, and further recommends that serious consideration should be given to tagging sufficient numbers of conch to allow conclusions to be drawn about population dynamics as well as movement patterns. Modeling of recaptures potentially allows estimation of, among other parameters, rates of both fishing and natural mortality. Even if large-scale, long-term tagging studies prove not to be feasible, short-term, intensive tagging experiments conducted alongside

the fishery can be extremely informative, particularly if both commercial and experimental operations are used to generate recaptures and recoveries.

Recommendation DW12 relates to the collation of conch density estimates from different areas of the Caribbean experiencing varying levels of exploitation. Preliminary results of such an exercise constructed by the AW show considerable promise as an innovative approach to placing survey findings in the context of potential population benchmarks. The RP considered that progress with this approach is a high, short-term priority, and recommended that further attention be paid to the influence of habitat type and stock structure (juveniles and adults) on the comparisons. The RP also took the view that the establishment of Marine Protected Areas in the waters of Puerto Rico and USVI holds potential for shedding light on unfished conch densities in the area. This might provide an improved basis for calculating a Bmsy proxy than comparisons with quasi-unexploited densities in other areas of the Caribbean. The AW suggested that conch densities measured around Puerto Rico are below the 'Allee effect limit', this being the threshold below which reduced reproductive output may be expected based on studies in the Bahamas. The RP recommends examination of whether the mean conch densities reported are representative of effective local densities that may exist in patches, hence whether Puerto Rico conch stocks are in fact reproductively compromised to the extent shown. This would need to be addressed before precautionary advice could be offered on the basis of such evidence.

Recommendations of the Assessment Workshop

The AW rejected the use of production (biomass dynamic) models for assessing Puerto Rico queen conch stocks, on the grounds that landings data are incomplete, lacking particularly the recreational component, and that CPUE data do not effectively index stock abundance. Similarly, for reasons stated above, diver CPUE data alone cannot be used to infer trends in stock abundance. The RP agreed with these conclusions and with the decision of the AW to concentrate primarily on fishery-independent surveys. The RP further recommended that stock assessments based on primarily on fishery-dependent data should not be attempted until it can be demonstrated that landings data are complete and that there are informative indices of stock abundance.

The AW compiled the following list of research recommendations for queen conch:

AW1) The efforts to analyze the available data were greatly enhanced by the presence of local fishers and agency representatives. However, there was no local representative from the USVI Division of Fish and Wildlife assigned to the meeting, while the Puerto Rico representative could not attend the full term of the meeting. There must be greater buy-in from the local agencies such that knowledgeable representatives are present for the full term of the meeting. Greater efforts should be made to attract the participation of local fishers.

AW2) Data from past density surveys should be re-analyzed so that values can be expanded on the basis of both habitat and depth, including confidence limits. Habitats should be matched to those available for existing/planned habitat maps. As a subportion of this, the data for the Puerto Rico 1986 survey should be entered into electronic and GIS formats. This could be done using NOAA's Data Rescue funds.

AW3) Expansion factors for both Puerto Rico and the USVI should be calculated for conch fishers only.

AW4) Assessment of the spatial and temporal variations and dynamics of the resource, fishery, habitat and species interactions would be greatly enhanced if traditional ecological knowledge were obtained from fishers. Efforts should be made to incorporate fishers into the process, particularly using NOAA's CRP funds.

AW5) The impact of the recreational fishery is unknown and must be quantified.

AW6) Considering the established and potential value of resource surveys, mechanisms should be identified to increase their aerial coverage.

AW7) More detailed spatial expansions of survey densities should be planned in preparation of the 2010 Conch Update. For this, significant improvements in available data and analyses are required, including but not limited to the following:

A Detailed bathymetry data for PR and USVI

B Analysis of the impact of closed areas

C Inclusion of more detailed habitat maps for the PR western platform currently in progress

D Quantified size/age structure of the exploitable stock.

AW8) The only estimate to date of fishing mortality came from a tagging study in the 1980s. New tagging studies should be initiated to quantify rates of exploitation. This would allow existing SPR models for conch to be used in assessments.

AW9) Another issue remaining is to investigate the potential impact of very old conch in deep refuges, especially with respect to reproduction, coupled with studies to age very old conch. Such refuges may be substation off St. Thomas/St. John, in patches in Puerto Rico and potentially in protected areas on all three platforms.

AW10) Intersessional data evaluation workshops for CFMC managed species or species complexes should be conducted by the Council so that SEDAR level analyses are limited to those where data are sufficient to warrant such an analysis.

AW11) There needs to be a complete review of the potential data collection programs, including commercial and recreational catch, biostatistical sampling and fishery independent surveys for Puerto Rico and US Virgin Islands with the purpose of identifying what relevant information could be obtained and modifying sampling procedures accordingly, including the identification of key economic and ecological indicator species.

The RP was supportive of all recommendations in this comprehensive list, several of which re-iterate suggestions by the DW. The RP draws particular attention to recommendations AW2, AW6 and AW7 which provide specific comments on improving and extending the existing fishery-independent surveys and their analyses. Recommendations AW3, AW5 and AW11 relate to improved collection of commercial and recreational fishery statistics, the importance of which has already been emphasized above. The DW suggested tagging studies to examine patterns of

movement and habitat utilization; recommendation AW8 suggests extending tagging studies to examine exploitation rates. The RP endorses this recommendation as a priority for the medium- to long-term, with the suggestion that the feasibility of small-scale intensive tagging experiments be examined in addition to more extensive experiments.

Recommendation AW9 is for investigation of the reproductive contribution of very old conch in deep water refuges. Given the implications for spatial management of the resource, and the context this would supply for interpretation of assessment outcomes in relation to potential population benchmarks, this recommendation should be prioritized for the mediumterm.

The AW made two recommendations (AW1 and AW10) relevant to future queen conch stock assessment meetings. The RP notes recommendation AW10 to conduct intersessional data evaluation workshops. Given the current lack of a definitive stock assessment for conch the RP considers data evaluation workshops to be a high priority and recommends that the next workshop be held within the next 3 years to maintain impetus particularly on improvements to fishery monitoring and resource surveys. The time-scale for future stock assessments would be dictated by the progress demonstrated at these intersessional workshops.