Center for Independent Experts (CIE) Independent Peer Review of the SEDAR 57 US Caribbean Spiny Lobster

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Executive Summary

A review of the SEDAR 57 assessment of the U.S. Caribbean Spiny Lobster was undertaken from 9th to 11th July 2019. The Review Panel was provided with the Working papers and Supplementary materials from the Data and Assessment Workshops and the Assessment Process Report. Summaries of the data and processes involved in assessing the fishery were presented at the start of the review period by the assessment team.

The U.S. Caribbean Fishery is a data limited/moderate fishery with two main data sources: catch and size frequency from the commercial fishery. To undertake this assessment other information (parameters) were imported from other lobster fisheries within the Caribbean region. A Stock Synthesis modelling platform was used and, with the exception of the chosen growth model and the way the unusual 2005 catch estimate for Puerto Rico (PR) was estimated, the model appeared to capture the supplied data well and thus outputs to overfishing and overfished would be considered as appropriate. During the workshop, a number of sensitivity tests and diagnostics of the available data and the input parameters were undertaken to ensure the robustness of model outputs. The growth parameters for the assessment were recommended to be changed to the Cuban estimates and the method of estimating the catch for the 2005 PR was altered to reflect an average of the expansion factors rather than the catch. This recommended model provided an improved fit to the data and provided similar outputs as to the status of the stocks as did the base model. This indicated that in 2016 none of the island fisheries were being over-fished and the fisheries were not in an overfished status.

A large unknown in the fishery is the recreational and IUU fishing catch and there are qualitative indications that this could be considerable. As no quantitative information was available the assessment did not account for addition exploitation of the resource from these sources. As such, the overfishing and over-fished status of the resource is optimistic, although the extent to which this is the case is unknown. For the PU and St Thomas/St John's fisheries, where the trend over the last four years is towards the maximum fishing mortality threshold, greater caution is required in claiming that these fisheries are not overfished or overfishing is occurring.

As such, research into understanding the magnitude of other forms of mortality on the resource (i.e., recreational, IUU and discards) is seen as a high priority followed by research to improve the data and parameters used in the assessment (size frequency, catch, selectivity, growth, recruitment).

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).

Further information on the CIE program may be obtained from www.ciereviews.org.

The SouthEast Data, Assessment, and Review (SEDAR) is the cooperative process by which stock assessment projects are conducted in NMFS' Southeast Region. SEDAR was initiated to improve planning and coordination of stock assessment activities and to improve the quality and reliability of assessments.

SEDAR 57 will be a compilation of data, an assessment of the stock, and CIE assessment review conducted for U.S. Caribbean spiny lobster. The review workshop provides an independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for ensuring that the best possible assessment is provided through the SEDAR process. The stock assessed through SEDAR 57 is within the jurisdiction of the Caribbean Fisheries Management Council and the territories of Puerto Rico and the U.S. Virgin Islands.

Description of the Individual Reviewers Role.

Professor Stewart Frusher brings over 45 years of research expertise in fisheries with nearly 30 years involvement in spiny lobster research. Recently he has led several teams of interdisciplinary researchers to ensure that research outcomes also capture the human dimension of resource use. He was the inaugural Director of the Centre for Marine Sociology, a joint Centre between the University of Tasmania and CSIRO.

My role in the SEDAR 57 review covered three main areas:

(a) Based on my expertise in lobster biology, I was to determine if model outputs are consistent with known lobster biology and behaviour.
(b) Based on my extensive lobster research background, I am able to provide details on future research programs
(c) Based on my knowledge of marine socioecology, I am able to provide comments on some of the human dimensions research that may be required.

Summary of finding for each Term of Reference

1. Evaluate the data used in the assessment, addressing the following:

a. Are data decisions made by the DW and AW sound and robust?

The data used in the assessment is limited and many parameters had to be borrowed from other regions which is acceptable for data limited fisheries.

However, there were three decisions made that could be improved upon. The first was the use of a single growth curve for both sexes. Male spiny lobsters are known to reach a larger size than females as females slow their growth as they reach sexual maturity and attain a smaller maximum size than males. The growth curves used in the base model had limited differentiation between male and female growth, and female maximum size appeared almost equivalent to male maximum size. Although limited in the number of recaptures and the size range over which tagging and recaptures occurred, the individual growth trajectories presented in Figure 1 indicate the majority of female trajectories to be at a lower slope than the mean of the projected growth curve. Similarly, male trajectories appear to be at a higher slope than the mean of the projected growth curve. The size frequency of all male and female lobsters measured (i.e., for all gears and all island fisheries for all years), indicate that there were very few females that were recorded above 150mmCL while male size frequency distribution did have a small number that reached 180mmCL. Given the observed size frequencies, the growth trajectories and knowledge of lobster biology, it was suggested that the Cuban estimates appeared a better match to the information available. Model runs using the Cuban estimates resulted in an improved model fit.

The second concern was the method used to calculate the 2005 landings data for PR. The 2005 estimated landings after applying the expansion factor was unusually large and most likely an erroneous value, and needed to be replaced by a more realistic estimate. While there are a number of ways to do this, it is better to average the expansion factors rather than the final estimated landings data. Of concern was the use of expansion factors across all species rather than just lobster.

The third was the lack of use of catch and effort data. This data is available from logbooks since 2011 for pots and traps and would have been of substantial benefit in assessing the fishery. The assessment team did mention that they were working on 'cleaning' the data and felt uncomfortable with its use without being cleaned. While the different configuration of traps and pots and targeting of different species at different times of the year does make the use of the data problematic, catch rate data is enormously valuable in fishery assessments as it enables abundance indices to be estimated and can provide improved clarification of changes in landings.

b. Are data uncertainties acknowledged, reported, and within normal or expected levels?

The uncertainties in the data were acknowledged and reported.

Three areas that require further work are:

(i) As mentioned above, the use of expansion factors that are across a range of species in the fishery should be avoided and expansion factors based on the spiny lobster fishery be used where possible.

(ii) There are a range of other forms of mortality that are indicated from the literature provided (RD_11 and RD_23). These include recreational catch, illegal catch (IUU) and mortality of discarded lobsters. The assessment process report acknowledges that recreational catch may or may not make up a substantial fraction of the total landings. However, as very limited data existed, recreational catches were not represented in the assessment. While there is limited data, the only data point we know with any certainty is that each of these forms is not zero. The lack of accountability of these additional mortality values in the assessment results in an overly optimistic assessment of the fishery indicators when compared to the target reference points.

(iii) The lack of abundance indices may lead to under-estimating the uncertainty in this assessment.

c. Are data applied properly within the assessment model?

The data have been applied properly within the assessment model.

d. Are input data series reliable and sufficient to support the assessment approach and findings?

The input data series used are reliable in the context of a data moderate assessment (Tier 3).

For the life history parameters, the use of data from similar fisheries in the region (e.g., natural mortality) or previous assessments for which values are unlikely to altered (e.g., fecundity, size at maturity, length-weight) is appropriate. The growth estimate has been discussed above.

I agree that the fishery independent data described currently offer little information for this assessment. However, if time series of larval recruitment indices could be collected, these can provide beneficial inputs as recruitment is held constant in the model and lobster recruitment is known to be highly variable.

The annual removals by gear type from the self-reported log books appears reliable and while there are periods where sample size is small, the overall trends are sufficient for a Tier 3 assessment.

Only two of the three main data types were available. No abundance indices were available despite CPUE being available since 2011. As mentioned above, work on “cleaning” the data to enable CPUE trends to be added to the assessment is underway.

2. Evaluate the methods used to assess the stock, taking into account the available data.

a. Are methods scientifically sound and robust?

The model was fitted using Stock Synthesis version 3 (SS3.3), which is standard software from the NMFS toolbox and has been widely tested in many fisheries. SS3 provides a flexible platform for this type of analysis.

An issue with using this model is that it is age structured and requires size data to be converted to age. Lobsters have very plastic growth performance and age-size relationships can vary significantly between different water temperatures, food availability and stress (e.g., imposed by, for example, hurricanes). As such, global lobster models (and most invertebrates models) that have no fixed methods for estimating age from size (cf. otiliths in

fish) use size structured models. These allow for size transition matrices to represent growth, which is generally consider a more appropriate method than using estimates from von Bertalanffy growth curves that are based on continuous growth. Lobster growth is non-continuous as it occurs at fixed periods of molting. However, these models are relative data intensive and bespoke. While there is merit in using models available from a toolbox, future research (see later) should consider adapting some of the lobster models used elsewhere. While dome shaped selectivity was considered a reason for not considering size structured models, there still remains uncertainty as to the actual shape of the selectivity function. This is picked up further in the research recommendations and considered an issue for future research. As such, the current assessment using SS3 is scientifically sound and robust and appropriate for the data available. An advantage of SS3 is that as new forms of data become available, they can be added into the model whereas the bespoke size structured models often require development of software for the new model.

b. Are assessment models configured properly and used consistent with standard practices?

The assessment models were configured properly and used in accordance with standard practice. Parameters that could not be estimated were fixed at values based upon published estimates. These and other important assumptions were tested using sensitivity analyses.

Configurations are limited by data, but consistent with life history knowledge within these limits. So, for example, growth differences between the sexes is accounted for and island platforms are treated as separate stocks.

However, the possibility that the stock is shared between the US and British Virgin Islands has not been accounted for, because BVI data were not available. Similarly, there are uncertainties regarding connectivity in larval supply. The extent to which these three islands are dependent on self-recruitment or recruitment from other sources is unknown. Reference RD-14 estimated that Puerto Rico received larval imports primarily from the Dominican Republic and Venezuela (St Thomas/St John and St Croix were not estimated). As such, management in these other nations may have a greater impact on biomass than management within these islands. However, with such a protracted pelagic larval phase, uncertainties in larval supply are common in lobster fisheries and assessments focus on self-sustaining stocks.

The model has two critical features: sex-specific growth and domed shaped selectivity for the main gear-types. The larger male maximum carapace length has been widely observed, and can be accounted for in the model. Independent support for the dome-shaped selectivity was not available, but it does fit the data better. Dome shaped selectivity can be supported by both lobster life history characteristics and fisher behaviour. Lobsters are known to migrate away from fishing grounds during spawning periods. This can be as large migrations, such as documented in Florida and Papua New Guinea, or smaller migrations where lobsters move to deeper waters (e.g., Western Australia) or outer reef margins (e.g., Southern Australia and New Zealand). As lobster size can be reflected in market demand, targeting and retaining lobsters that receive premium prices (e.g., as paid by processors, retail outlets, hotels and restaurants, etc.) can be reflected in fisher behaviour. The size of the trap entrance can restrict the capture of larger lobsters and divers can leave lobsters that they perceive as being larger. Discussions with the fisher representatives from the

three island platforms indicated that their catch is dictated by market preferences. There are no export markets and the domestic market is strongly focused on the tourist market and thus during low tourism periods (including after storm and hurricane periods) demand for lobsters drives fishing intensity.

Dome shaped selectivity implies that larger lobsters exist within the fishery but aren't selected by the gear. Conversations with the fisher representatives did indicate that potting gear would restrict the capture of larger lobsters although one fisher did have photos on his mobile phone of large lobsters that he had recently caught. While it is not inconceivable that larger lobsters are moving away from the fishing grounds, it is also plausible that the total effort, including recreational and IUU effort, is removing the majority of lobsters prior to reaching larger sizes.

While the fishing mortality due to legal fishing would suggest that fishing pressure is at a level that should see larger lobsters remaining in the fishery but not reflected in the size structure due to gear selectivity, non-reported mortality (recreational, IUU) may be considerably larger than assumed (i.e., zero in the assessment). S57_RD_23 reports that the owner of one fish market reported that about half of the fishers selling fish to his market do not have licences.

While there may be configurations that would, in the longer term, explain the observations better, current data were not available to support alternative configurations.

c. Are the methods appropriate given the available data?

As indicated, my skill set is not in modelling *per se* but the interpretation of model inputs and outputs given the biology of the species. The other reviewers (Cathy Dichmont and Paul Medley) provided the modelling expertise on the review panel.

The stock assessment was data limited for all three fished islands. No abundance index was available, and data were limited to total catches and length frequencies. The outputs from the model appear to be consistent with the data (i.e., fit to length frequencies). None of the outputs in my opinion provided cause for concern that the model was not capturing the dynamics of a data limited assessment.

3. Evaluate the assessment findings with respect to the following:

a. **Can the results be used to inform management in the U.S. Caribbean (i.e. develop annual catch recommendations)?**

The results of the model can be used to inform management of the fishery, especially trends in stock status. However, a degree of caution does need to be used as not all forms of mortality have been captured by the model. Given that these forms of mortality may be consistent over the last few years, the trends from the assessment are likely to be informative although the actual estimates are likely to over inflate stock status.

b. **Is it likely the stock is overfished? What information helps you reach this conclusion?**

Both the recommended base case and the original base case for all island fisheries show the stocks to not be overfished.

Furthermore, several tests were undertaken to examine model uncertainty:

- Sensitivity of the base models to assumptions such as natural mortality, growth, first year fishing mortality and selectivity options;
- Retrospective analyses on the effect of removing recent data; and
- Likelihood profiles to test components of the likelihood against different parameter values.

While uncertainties within the model structure were tested and these demonstrate that model outputs were robust to these uncertainties and thus maintain the original status of the stocks as to not be overfished, there still remains uncertainty about total mortality.

For St Croix, the 2016 value is well above the MSST and below the MFMT. The estimated values for the last four years are both showing improvements in these indicators, and thus it would be reasonable to conclude that even with other forms of mortality, the stock status of the St Croix resource is not overfished.

For St Thomas/St Johns, the 2016 value is also above the MSST and below the MFMT. However, since 1975, annual estimates have moved closer to the MSST and MFMT reference levels with the exception of the last 11 years. Thus, if other forms of mortality are substantial in comparison to estimated fishing mortality, the years around 2007 would be expected to be closer and possibly beyond the reference levels. Similarly, over the last four years, the trend has been towards the MFMT reference level and depending on the magnitude of other mortality, this could be moving close to or over the MFMT acceptable level and thus closer to undergoing overfishing.

For Puerto Rico, the 2016 value is also above the MSST and below the MFMT. Unlike St Croix and St Thomas/St Johns, this fishery was heavily exploited (overfished) at the beginning of the data periods in 1983. While the fishery has slowly moved away from both MSST and MFMT reference levels, the last four years has seen the estimated values move towards the MFMT reference level. If other forms of mortality are substantial for this fishery, then this fishery could have been in an overfished status on more occasions than estimated from the model projections and close to undergoing overfishing in recent years.

Thus, until other forms of mortality can be estimated and accounted for in the model, the model estimates remain the best information available and each of these shows the stocks not to be overfished.

c. Is it likely the stock is undergoing overfishing? What information helps you reach this conclusion?

As for the previous (overfished) question, the model indicates that none of the island fisheries are undergoing overfishing in 2016. However, as mentioned above, there is uncertainty in these point estimates as not all forms of mortality are accounted for in the model. Importantly, both St Thomas/St John and Puerto Rico have been trending over the last four years towards the MFMT reference point.

4. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods. Ensure that the implications of uncertainty in technical conclusions are clearly stated.

In the time allowed for the assessment, uncertainties in parameter estimates used in the model was the focus rather than uncertainty associated with information that is not known

(e.g., other forms of mortality). Both Paul Medley and Cathy Dichmont's reviews can provide greater detail for this criterion given their expertise. Uncertainty, in the context of a data limited fishery, was determined primarily by increasing and decreasing parameter estimates away from the chosen assessment estimate to understand the sensitivity on model outputs.

Correlation analysis to ensure that parameters were not over-correlated, profile likelihoods to determine parameter stability, jitter analysis to determine model stability and retrospective analysis to determine the influence of the terminal year were undertaken as model diagnostics.

The model diagnostics and sensitivity analyses undertaken before and during the Review Workshop provided adequate information on the uncertainty in the data and parameters used for the assessment to draw conclusions on stock status. The range of stock size and fishing mortality was clearly presented in graphs and other stock assessment output.

5. **Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring that could improve the reliability of, and information provided by future assessments.**

The recommendations provided by the Data and Assessment workshops are presented in Attachment 1 of this Report. Priorities are provided against each of the recommendations although several of the recommendations could be captured in a single research program. Below, I have identified three key research areas that I would prioritise. These have been selected from Review Panel Consensus Report and I have elaborated on these as required:

(i) A major uncertainty as to the stock status of the island fisheries is related to the magnitude of the total catch. As no quantitative information is available on catch beyond the commercial fishery, the assessment has assumed it to be negligible and thus unaccounted for in the assessment. However, Sedar57_RD_11 and RD_23 both indicate that recreational and IUU fishing could result in a substantial extraction from the resource.

"Recreational activity was elusive or minimal compared to the larger incidence of unlicensed commercial fishing"

". . . current licensing system . . . unintentionally creating an incentive for unlicensed and, thus under- or unreported fishing activity"

"One owner of a fish market stated that about half of the fishers selling fish to his market do not have licenses"

Obtaining information on IUU and recreational activity is notoriously difficult, but I would suggest that a two-pronged approach be considered. The first component should be to gain an understanding of the magnitude of the problem as well as the trend - whether it is increasing or decreasing. This may best be achieved by a qualitative approach (i.e. preferably by an independent social scientist) and would hopefully build trust with recreational fishers, fish buyers, etc., which is essential. In addition to gauging the magnitude of the issue, it should also aim to establish where quantitative data might cost-effectively be obtained from for longer-term future monitoring (e.g., fish buyers/market owners, boat access points, etc.). The second component would be to follow up with a more quantitative study to begin to provide data for future assessments. . These programs should also include an education component to start to build an

improved understanding for why the data is need, how it is used and the longer-term advantages of having improved and more accurate data. Consideration should also be given to understanding the drivers and behaviors of fishers as to be able to predict future trends. For example, if recreational and/or IUU activity increases as lobster price increases, it is unreasonable to project future trends on the current level of activity.
Discards (identified in the logbooks) and their fate should also be investigated and incorporated.

(ii) An abundance index would take this assessment from a data limited to a data moderate assessment. It was indicated that catch rate data is available from the fishery since 2011 but requires considerable "cleaning". This data would provide a historic index and once the issues for cleaning have been identified and algorithms developed to use the data (e.g., possibly a GLM or GAM) this could then be applied to future logbook data. Because of the variety of gears used (fish traps, lobster pots, and various forms of diving) standardization of CPUE data will be complicated. Fishers at the Review Workshop indicated that, at least for traps and pots, the gear was being adapted continuously and photos (on their mobile phones) of different forms of trap entrances and size of traps were shown. Fishery independent surveys are possible, but these come at considerable costs depending on whether they are based on observers on vessels or using standardized vessels, catching gear and staff.

(iii) It was indicated that there are a number of Marine Protected Areas (MPAs) that have been established for a period of time and are policed for illegal activity. These MPAs may provide the closest approximation of an unfished resource. They have been used extensively in a number of regions in Australia and New Zealand to understand the effects of fishing and to understand changes in catch rates that are independent of fishing (e.g., due to environmental changes/impacts). Providing that permits can be obtained, research in MPAs provide opportunities to validate some of the key concerns in the assessment: dome-shaped selectivities; unfished size frequencies and an abundance index for an unexploited stock. Size frequency distributions would also assist in determining appropriate growth parameters and should be combined with tagging to improve the estimates of growth. Furthermore, by using gear that retains undersized lobsters, it may be possible to obtain pre-recruit information. Monitoring within MPAs would also provide fishery independent information on the impacts of hurricanes and other environmental impacts (e.g., climate change).

6. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

A key uncertainty in the status of the stock, especially when considering that PR and STT are trending towards the MFMT reference level, is the total extraction from the resource. Currently, the assessment has IUU and recreational fisheries extraction as 0. While the magnitude of IUU and recreational catch is unknown, reports are that it is not 0, as such an

IUU and recreational catch estimate should be built into the assessment and sensitivities around a “best estimate” be undertaken in the future.

Another key uncertainty in the assessment is its data limited/moderate nature. As a result, transitioning to an assessment incorporating more of the data would be greatly beneficial in addressing key uncertainties. In all the island fisheries, there was a reasonably large contrast between the stock status of the resource over the past decade. Even though the recording of effort in the logbook has changed over the whole time series, logbook formats have been reasonably consistent for the last ten years or so. Thus, CPUE could be useful to either a) help select between different sensitivity tests as a nominal index or, if standardised, be incorporated into the stock assessment as an index of abundance. A further uncertainty was in the selectivity and growth models. As per ToR 5, given that the Marine Protected Areas (MPAs) have been in place for some time, research within them would be very useful, most notably undertaking: a) selectivity studies to test for dome shaped selectivity and to provide the data to estimate selectivity within the model, and b) regularly collect unfished population size frequency information (preferably with gear that does not have such strong dome shaped selectivity) that can be used to compare with size frequency data from the fishery and potentially a recruitment index. These data should provide more information on parameters in the model and enable more accurate estimates of the assessment’s uncertainties.

The current model also holds annual recruitment as nearly constant through time (with just the magnitude varying between islands). Recruitment in spiny lobster fisheries is considered to be highly variable and also, due to the extensive oceanic larval phase of spiny lobsters, to be sensitive to changes in productivity and/or physics of ocean currents. The latter making it prone to climate change. As suggested in ToR 5 and above, an additional outcome from monitoring unfished population size frequency would be to obtain estimates of changes in abundance of smaller lobsters as an index of recruitment.

The current model and software, Stock Synthesis (SS3), would still provide an adequate framework for modelling with these data improvements.

However, as indicated in 2a, there are a number of bespoke lobsters assessment models based on size rather than age and these could also be considered for adaptation to this fishery as more data become available.

7. Provide recommendations on possible ways to improve the SEDAR process.

Make CIE reports available as quickly as possible to the SEDAR process. While the assessors report eventually receiving the reports, there appears to be considerable delay.

8. Prepare a Peer Review Summary summarizing the Panel’s overall conclusions and recommendations.

A peer Review Summary has been completed and provide separately by the Chair.

Attachment 1: Combined Data Workshop and Assessment Workshop Recommendations

Please note that a low priority does not indicate that the project is not important but rather that there are other projects of higher priority. Given that funding is generally limited, the high priority areas have been targeted either to a few activities or to important activities that can be undertaken as part of other projects.

Life History

1. Research on stock structure is needed, particularly as it relates to connectivity caused by larval dispersal.
   Low: There are other researchers undertaking this work and they should be encouraged.

2. Encountering the right habitat is important for survival of juvenile lobster recruits. Research should be conducted to explore effects of sargassum, water quality, coastal development, and mangrove root communities on the availability and quality of habitat for juvenile spiny lobsters.
   Low: Unless there are any indications of major changes in these habitats on an island scale.

3. Explore plausibility of cause and effect mechanisms that may lead to temporal growth variation.
   Low: Gaining improved growth estimates is of higher priority.

4. Investigate potentially unaccounted for discards in the self-reported commercial logbook data to be able to quantify the number of lobster discarded dead, as well as the number of lobster discarded alive.
   Medium: This has been identified as a component of the unreported catch but is likely to be smaller than some of the other IUU/recreational catch that is currently unaccounted for in the assessment.

5. Research aimed at quantifying post-release mortality (including post-release predation) of spiny lobster to better understand and propose mechanisms that could potentially mitigate mortality among lobsters that are discarded.
   Low: Could be built into other fishery or fishery dependent studies.

Fishery Dependent

9. General data improvements are recommended, including continued reporting of specific gear categories (e.g., different types of diving).
   High – needs to also include different trap and pot configurations to enable CPUE estimations.

10. Investigate the sensitivity of stock assessment results to landings data associated with high uncertainty.

High: There are a range of recommendations that should be grouped with this recommendations). Uncertainty in landings needs to reflect both the uncertainty is the reported catch landings as well as the unreported catch landings.

11. Investigate improvements or alternatives to past correction factors in Puerto Rico (2005 in particular).
    Medium (combine with 10 above)

12. Continue SEFSC funded commercial landings validation studies in Puerto Rico and begin similar surveys in the US Virgin Islands.
    High: This needs to also consider recreational and IUU landings

13. General data improvements are recommended, including encouraging complete reporting of discards.
    High (as 4 and incorporated in 12)

14. Further explore TIP data for possible data entry and/or measurement errors, particularly regarding the number of individuals associated with a given length entry and associated with potentially miscoded species.
    Low: Initial focus needs to be on data quality

15. Permanent programs that quantify the recreational effort and landings in the US Caribbean are needed. The results of recent pilot studies (Valle-Esquivel and Trumble 2016 and Goedeke et al. 2016) should be used to develop future surveys.
    High: This needs to also include IUU and should be incorporated with 10 and 12 above and 16 below. Please note that while the two projects lists above provide valuable information, the development of programs that include (and potentially led by) social scientists often provide greater insights into these activities. As suggested in ToR 5, a two-pronged approach is needed which should begin with a qualitative approach to gain an understanding of the magnitude of these events. These programs should also include an education component to start to build an improved understanding for why the data is needed, how it is used and the longer-term advantages of having improved and more accurate data. Consideration should also be given to understanding the drivers and behaviors of fishers as to be able to predict future trends. For example, if recreational and/or activity increases as lobster price increases, it is unreasonable to project future trends on the current level of activity. Along with the above two studies, the study by Seara et al. (RD_23) should also be considered in the development of future programs in this recommendation.

16. Continue comprehensive bio-socio-economic database of events, compile references and time series of quantitative data as available.
    High: It is important that this database not only be maintained, but also used to understand the dynamics of the fishery. Linking impacts such as hurricanes, population and unemployment trends, annual and intra-annual market prices and demand (for lobsters and alternatives) either qualitatively or quantitatively to fisher behavior in commercial, recreational and IUU sectors would assist in interpreting model outputs including stock status.

17. Identify significant EBM quantitative socioeconomic indicators (ex. gravity of the market, network market analyses, population growth, tourism, poaching).
    Medium: This should be linked with 15 & 16 above. While there is an emphasis on quantitative indicators, qualitative indicators and statements should not be ignored. They can provide significant insights for interpretation of model outputs. For example, the statement "One owner of a fish market stated that about half of fishers selling to his market do not have licenses" immediately makes it clear that (a) this needs to be investigated in more detail; and (b) the outputs from a model that does not include IUU estimates will be overly optimistic about stock status (and potentially substantially so).

18. A Caribbean-specific staff for data statistics and assessments was recommended to aid in establishing and maintaining high technical expertise.
    High; although this needs to be put in context of the need for technical expertise elsewhere. There is only limited funds and the lobster fishery is a relatively small fishery with a few operators. Increased priority may be afforded to this position because of the impact of the fishery on the local economy.

Fishery-Independent

19. Development of fishery-independent surveys that are specifically designed for spiny lobster, which would require considerable planning regarding data priorities (e.g., relative abundance versus length), the life stage to target (e.g., adult, juveniles, or larvae), type of gear, sampling design, temporal and spatial resolution, and the availability of funds. In addition to discussing field sampling, planning of how best to record and store data would be beneficial to future analyses and stock assessments.
    Low-High: Fishery-independent studies are costly and often combinations of fishery dependent and independent can reduce costs (e.g., chartering fishers gear and vessel, allowing parts of catch to be retained, offsetting costs through additional allocation to fisher, etc.). As indicated above and in ToR 5, establishing a program within an MPA is likely to provide substantial benefits and would be preferred over a study within the fishery.

20. Research aimed at identifying correlations between larval and juvenile abundance from the SEAMAP-C surveys and lobster landings could assist in determining the relationship between juvenile abundance and adult abundance (e.g., Butler et al. 2010).
    Low: Underwater visual census surveys for post-larval and juvenile lobsters have had limited success. The results from the projects to date have indicated that few lobsters are recorded. Most success in understanding pre-recruits comes from either purpose built larval (puerulus) collectors or sampling the undersized portion of the catch. The later can be done through supporting fishers (through permits) to close escape vents in selected traps and record (measure/photograph) undersized lobsters or, as suggested above, it can also be incorporated into an MPA sampling project.

Overall

21. Where possible, the research recommended above should consider ecosystem linkages toward developing capacity in the region for ecosystem-based fisheries management.

    While agreeing with this recommendation, I would emphasise that the “ecosystem” represents both biological and human components and that while the emphasis in the projects above has been towards the biological component of ecosystems, the social, economic and legal components of the ecosystem should also be given priority attention. This is especially the case in this fishery where data is limited, and the outputs of this assessment may not be reliable given the potential for large amounts of unreported catch.

Appendix 1: Bibliography of materials provided for review

Document #	Title	Authors	Date Submitted
Documents Prepared for the Data Workshop			
SEDAR57-DW-01	Inventory of Fishery-Independent Programs and Survey Data Available for Stock Assessment of Caribbean Spiny Lobster in the US Caribbean	Skyler Sagarese, William Harford, Aida Rosario, Matt Johnson and Jay Grove	1 June 2018 Updated: 26 July 2018
SEDAR57-DW-02	Summary of Life History Information of Spiny Lobster for SEDAR 57	William Harford and Adyan Rios	6 June 2018 Updated: 18 Sept 2018
SEDAR57-DW-03	Building a Timeline of Major Socioeconomic Events Affecting Lobster Fisheries in Puerto Rico	Adyan Rios and Juan Agar	6 June 2018
SEDAR57-DW-04	Building a Timeline of Major Socioeconomic Events Affecting Lobster Fisheries in St. Croix USVI	Adyan Rios and Juan Agar	6 June 2018
SEDAR57-DW-05	Building a Timeline of Major Socioeconomic Events Affecting Lobster Fisheries in St. Thomas and St. John USVI	Adyan Rios and Juan Agar	6 June 2018
SEDAR57-DW-06	Summary of the Trip Interview Program data for Spiny Lobster from the US Caribbean	Adyan Rios, Skyler Sagarese, and William Harford	15 June 2018
Documents Prepared for the Assessment Process			
SEDAR57-AP-01	Efficacy of TIP length composition for use in length-based mortality estimation	William Harford and Adyan Rios	24 September 2018 Updated: 16 April 2019
SEDAR57-AP-02	Reliability testing of non-equilibrium mean length mortality estimation routines	Victoria P. Simmons, Quang C. Huynh, Elizabeth A. Babcock, and	3 November 2018

		William J. Harford	
Final Stock Assessment Reports			
SEDAR57-SAR1	U.S. Caribbean Spiny Lobster	SEDAR 57 Panels	
Reference Documents			
SEDAR57-RD01	Line Point-Intercept (LPI) Survey Protocol for the U.S. Caribbean and Flower Garden Banks National Marine Sanctuary	National Coral Reef Monitoring Program (NCRMP), Coral Reef Conservation Program (CRCP), National Oceanic and Atmospheric Administration	
SEDAR57-RD02	Report of the US Caribbean Fishery-Independent Survey Workshop	Shannon L. Cass-Calay, William S. Arnold, Meaghan D. Bryan, Jennifer Schull	
SEDAR57-RD03	Working Towards a Framework for Stock Evaluations in Data-Limited Fisheries	Skyler R. Sagarese, Adyan B. Rios, Shannon L. Cass-Calay, Nancie J. Cummings, Meaghan D. Bryan, Molly H. Stevens, William J. Harford, Kevin J. McCarthy, and Vivian M. Matter	
SEDAR57-RD04	The United States Virgin Islands 2015 Comprehensive Economic Development Strategy		
SEDAR57-RD05	Report on the FAO/Danida/CFRAMP/WECAFC Regional Workshops on the assessment of the Caribbean Spiny Lobster (*Panulirus argus*)	Western Central Atlantic Fishery Commission	
SEDAR57-RD06	Population dynamics, ecology and behavior of spiny lobsters, *Panulirus argus*, of St. John, USVI: II Growth and Mortality	David A. Olsen and Ian G. Koblic	
SEDAR57-RD07	A review of the literature and life history study of Caribbean spiny lobster, *Panulirus argus*	Steven Saul	
SEDAR57-RD08	Maturity of spiny lobsters in the US Caribbean	David Die	
SEDAR57-RD09	A Collaborative Assessment of the Virgin Islands Spiny Lobster Fishery	David Olsen, Josh Nowlis, and Daryl Bryan	

SEDAR57-RD10	A study of the Virgin Islands Spiny Lobster Fishery: Growth, Population Size and Mortality	David Olsen, Josh Nowlis, and Daryl Bryan
SEDAR57-RD11	Pilot Study of the Recreational Queen Conch (*Strombus gigas*) and Spiny Lobster (*Panulirus argus*) Fishery in Puerto Rico	Monica Valle-Esquivel and Robert J. Trumble
SEDAR57-RD12	Patterns of Spiny Lobster (*Panulirus argus*) Postlarval Recruitment in the Caribbean: A CRTR Project	MARK J. BUTLER, ANGELA M. MOJICA, ELOY SOSA-CORDERO, MARINES MILLET, PAUL SANCHEZ-NAVARRO, MIGUEL A. MALDONADO, JUAN POSADA, BLADIMIR RODRIGUEZ, CARLOS M. RIVAS, ADRIAN OVIEDO, MARCIO ARRONE, MARTHA PRADA, NICK BACH, NILDA JIMENEZ, MARIA DEL CARMEN GARCIA-RIVAS, KIRAH FORMAN, DONALD C. BEHRINGER, JR., THOMAS MATTHEWS, CLAIRE PARIS, and ROBERT COWEN
SEDAR57-RD13	Dependence of recruitment on parent stock of the spiny lobster, Panulirus argus, in Florida	NELSON M. EHRHARDT* AND MARK D. FITCHETT
SEDAR57-RD14	Larval Connectivity and the International Management of Fisheries	Andrew S. Kough, Claire B. Paris, Mark J. Butler IV
SEDAR57-RD15	Implications of the ecosystem approach to fisheries management in large ecosystems: The Caribbean spiny lobster, *Panulirus argus*, fisheries as a case	Nelson Ehrhardt, Rafael Puga and Mark Butler IV
SEDAR57-RD16	A pilot, cooperative fishery-independent trap survey of Saint Croix, United States Virgin Islands	Meaghan D. Bryan, Todd Gedamke, and John F. Walter
SEDAR57-RD17	USVI Caribbean Spiny Lobster Assessment	Shenell Gordon & Jason Vasques
SEDAR57-RD18	Activity and harvest patterns in the U.S. Virgin Islands recreational fisheries	Ivan Mateo, Ruth Gomez, K.Roger Uwate, Barbara Kojis, Dean C. Plaskett
SEDAR57-RD19	Recreational Fisheries Habitat Assessment for St. Thomas/St. John	Barry VoIson, Shenell Gordon, Ginger Chapman, Gene Brin, George Green, Arthur Adams, and Joseph Barbel
SEDAR57-RD20	Environmental Impact Statement/Fishery Management Plan and Regulatory Impact Review for	CFMC/NMFS

	the Spiny Lobster Fishery of Puerto Rico and the U.S. Virgin Islands	
SEDAR57-RD21	Portrait of the Spiny Lobster (*Panulirus argus*) Fishery in Puerto Rico during 1998 - 2013	Daniel Matos Caraballo, Martha Ricaute Chica, Jesus León, and Luis A. Rivera
SEDAR57-RD22	Census of licensed fishers of the U.S. Virgin Islands (2016)	Barbara Kojis, Norman Quinn, and Juan J. Agar
SEDAR57-RD23	Assessing socioeconomic impacts of climate change on Puerto Rico's coral reef fisheries through a participatory approach	Tarsila Seara, Karin Jakubowski, Richard Pollnac, and Thomas Webler

Appendix 2: A copy of this Performance Work Statement

Performance Work Statement (PWS)
National Oceanic and Atmospheric Administration (NOAA)
National Marine Fisheries Service (NMFS)
Center for Independent Experts (CIE) Program
External Independent Peer Review

SEDAR 57 U.S. Caribbean Spiny Lobster Benchmark Assessment Review

Background

The National Marine Fisheries Service (NMFS) is mandated by the Magnuson-Stevens Fishery Conservation and Management Act, Endangered Species Act, and Marine Mammal Protection Act to conserve, protect, and manage our nation's marine living resources based upon the best scientific information available (BSIA). NMFS science products, including scientific advice, are often controversial and may require timely scientific peer reviews that are strictly independent of all outside influences. A formal external process for independent expert reviews of the agency's scientific products and programs ensures their credibility. Therefore, external scientific peer reviews have been and continue to be essential to strengthening scientific quality assurance for fishery conservation and management actions.

Scientific peer review is defined as the organized review process where one or more qualified experts review scientific information to ensure quality and credibility. These expert(s) must conduct their peer review impartially, objectively, and without conflicts of interest. Each reviewer must also be independent from the development of the science, without influence from any position that the agency or constituent groups may have. Furthermore, the Office of Management and Budget (OMB), authorized by the Information Quality Act, requires all federal agencies to conduct peer reviews of highly influential and controversial science before dissemination, and that peer reviewers must be deemed qualified based on the OMB Peer Review Bulletin standards. (http://www.cio.noaa.gov/services_programs/pdfs/OMB_Peer_Review_Bulletin_m05-03.pdf).

Further information on the CIE program may be obtained from www.ciereviews.org.

Scope

The **SouthEast Data, Assessment, and Review (SEDAR)** is the cooperative process by which stock assessment projects are conducted in NMFS' Southeast Region. SEDAR was initiated to improve planning and coordination of stock assessment activities and to improve the quality and reliability of assessments.

SEDAR 57 will be a compilation of data, an assessment of the stock, and CIE assessment review conducted for U.S. Caribbean spiny lobster. The review workshop provides an

independent peer review of SEDAR stock assessments. The term review is applied broadly, as the review panel may request additional analyses, error corrections and sensitivity runs of the assessment models provided by the assessment panel. The review panel is ultimately responsible for ensuring that the best possible assessment is provided through the SEDAR process. The stock assessed through SEDAR 57 is within the jurisdiction of the Caribbean Fisheries Management Council and the territories of Puerto Rico and the U.S. Virgin Islands.

The specified format and contents of the individual peer review reports are found in **Annex 1**. The Terms of Reference (TORs) of the peer review are listed in **Annex 2**. Lastly, the tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements

NMFS requires three (3) reviewers to conduct an impartial and independent peer review in accordance with the PWS, OMB guidelines, and the TORs below. The reviewers shall have a working knowledge in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the primary task of providing peer-review advice in compliance with the workshop Terms of Reference fisheries stock assessment. Expertise in data-limited methods would be preferred.

Tasks for Reviewers

1) Review the following background materials and reports prior to the review meeting:

Working papers, reference documents, and the Data Workshop and Assessment Process Reports will be available on the SEDAR website: http://sedarweb.org/sedar-57

2) Attend and participate in the panel review meeting. The meeting will consist of presentations by NOAA and other scientists, stock assessment authors and others to facilitate the review, to answer any questions from the reviewers, and to provide any additional information required by the reviewers.

3) After the review meeting, reviewers shall conduct an independent peer review report in accordance with the requirements specified in this PWS, OMB guidelines, and TORs, in adherence with the required formatting and content guidelines; reviewers are not required to reach a consensus.

4) Each reviewer should assist the Chair of the meeting with contributions to the summary report.

5) Deliver their reports to the Government according to the specified milestones dates.

Foreign National Security Clearance

When reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance

approval for reviewers who are non-US citizens. For this reason, the reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: http://deemedexports.noaa.gov/ and http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration- system.html. The contractor is required to use all appropriate methods to safeguard Personally Identifiable Information (PII).

Place of Performance

The place of performance shall be at the contractor's facilities, and in Miami, FL.

Period of Performance

The period of performance shall be from the time of award through September 2019. The CIE reviewers' duties shall not exceed 14 days to complete all required tasks.

Schedule of Milestones and Deliverables: The contractor shall complete the tasks and deliverables in accordance with the following schedule.

Within two weeks of award	Contractor selects and confirms reviewers
Approximately 2 weeks later	Contractor provides the pre-review documents to the reviewers
July 9-11, 2019	Panel review meeting
Approximately 3 weeks later	Contractor receives draft reports
Within 2 weeks of receiving draft reports	Contractor submits final reports to the Government

Applicable Performance Standards

The acceptance of the contract deliverables shall be based on three performance standards: (1) The reports shall be completed in accordance with the required formatting and content; (2) The reports shall address each TOR as specified; and (3) The reports shall be delivered as specified in the schedule of milestones and deliverables.

Travel

All travel expenses shall be reimbursable in accordance with Federal Travel Regulations (http://www.gsa.gov/portal/content/104790). International travel is authorized for this contract. Travel is not to exceed $7,000.

Restricted or Limited Use of Data

The contractors may be required to sign and adhere to a non-disclosure agreement.

Project Contacts:

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Annex 1: Peer Review Report Requirements

1. The report must be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The report must contain a background section, description of the individual reviewers' roles in the review activities, summary of findings for each TOR in which the weaknesses and strengths are described, and conclusions and recommendations in accordance with the TORs.

   a. Reviewers must describe in their own words the review activities completed during the panel review meeting, including a brief summary of findings, of the science, conclusions, and recommendations.

   b. Reviewers should discuss their independent views on each TOR even if these were consistent with those of other panelists, but especially where there were divergent views.

   c. Reviewers should elaborate on any points raised in the summary report that they believe might require further clarification.

   d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The report shall represent the peer review of each TOR, and shall not simply repeat the contents of the summary report.

3. The report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review

   Appendix 2: A copy of this Performance Work Statement

   Appendix 3: Panel membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

SEDAR 57 U.S. Caribbean Spiny Lobster Benchmark Assessment Review

1. Evaluate the data used in the assessment, addressing the following:
    a. Are data decisions made by the DW and AW sound and robust?
    b. Are data uncertainties acknowledged, reported, and within normal or expected levels?
    c. Are data applied properly within the assessment model?
    d. Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
    a. Are methods scientifically sound and robust?
    b. Are assessment models configured properly and used consistent with standard practices?
    c. Are the methods appropriate given the available data?
3. Evaluate the assessment findings with respect to the following:
    a. Can the results be used to inform management in the U.S. Caribbean (i.e. develop annual catch recommendations)?
    b. Is it likely the stock is overfished? What information helps you reach this conclusion?
    c. Is it likely the stock is undergoing overfishing? What information helps you reach this conclusion?
4. Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods. Ensure that the implications of uncertainty in technical conclusions are clearly stated.
5. Consider the research recommendations provided by the Data and Assessment workshops and make any additional recommendations or prioritizations warranted. Clearly denote research and monitoring that could improve the reliability of, and information provided by future assessments.
6. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.
7. Provide recommendations on possible ways to improve the SEDAR process.
8. Prepare a Peer Review Summary summarizing the Panel's overall conclusions and recommendations.

Appendix 3: Panel membership or other pertinent information from the panel review meeting

Panelists

Adyan Rios (Co-Lead analyst) ..... NMFS Miami
Bill Harford (Co-Lead analyst) ..... Univ. of Miami
Cathy Dichmont ..... CIE
Stewart Frusher ..... CIE
Doug Gregory (Chair) ..... SSC
Paul Medley ..... CIE
Tarsila Seara ..... SSC

Appointed Observers

Julian Magras ..... STT/STJ Fisherman
Gerson N. Martinez ..... STX Fisherman
Carlos J. Velazquez ..... P.R. Fisherman

Attendees

Nicole Carmouze ..... NMFS Miami (Intern)
Kevin McCarthy ..... NMFS Miami
Matthew Nuttell ..... NMFS Miami
Skylar Sagerase ..... NMFS Miami
Nathan Vaughn ..... NMFS Miami

Staff

Julie Neer ..... SEDAR
Graciela Garcia-Moliner ..... CFMC
Kathleen Howington ..... SEDAR