Lessons Learned in the Application of the FPAT in Cabo Verde and Indonesia

Praia, Cabo Verde. 25th – 27th July, 2023.

Bali, Indonesia. 6th – 10th November, 2023.

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Meeting Activities

The primary focus of the meetings was to apply the FPAT app to one stock for each of the participating countries. The meeting consisted of an update on progress with regard to each stock, an introduction to the methods and concepts behind the FPAT app and then open-sessions where participants interacted with the app.

The format of the Indonesian meeting differed from Cabo Verde: the FPI scoring and FPAT application were carried out consecutively at a single 1-week meeting rather than in two dedicated meetings as in Cabo Verde. This did not appear to come at a significant cost and the longer meeting allowed working group members to work more closely together and with greater depth. Additionally, it appeared that in Cabo Verde many working group members had a relatively weak recollection of the former FPI scoring and that it might be in fact beneficial to maintain continuity in a single, longer one-week process. This suggests that the principal benefit of two individual meetings relates only to organization and preparation of data inputs for the FPAT app. This was not an issue in the single meeting format of Indonesia because fortunately two of the working group members were already familiar with the openMSE data input format.

In both meetings, the FPI concepts were explained via initial presentations by Dr Anderson (University of Washington). These included a breakdown of the FPI input and output scoring criteria and an explanation of the subjective decisions taken when assigning scores. This provides a very comprehensive agenda for the discussion of a wide range of topics relevant to industry, stakeholders and managers. While the FPIs appear to be relatively complex, when they are curated by an expert and used as the basis for eliciting feedback, they appear effective at engaging a wide range of working group members.

Since the FPAT application makes use of closed-loop simulation (the calculator behind management strategy evaluation, MSE) an introductory presentation was provided by Dr Carruthers (Blue Matter) on the problems addressed by MSE and the various benefits it can offer in informing the science and management of fisheries. The majority of working group members found the concepts easy to understand and could easily grasp the motivation behind simulation testing management approaches.

Before working with the app directly, Dr Carruthers presented overview slides describing app workflow and functionality including guidance on the interpretation of FPI outputs. Participants were shown how the FPI input worksheets could be uploaded to the app and where those inputs are presented graphically in radar plots and tables. Following the slides, Dr Carruthers provided a live demonstration of the app for a preliminary case study (garoupa in Cabo Verde, red snapper in Indonesia). Presenting the app in slides, then a live demonstration of a case study, then user-interaction, proved necessary for users to grasp the layout and functionality of the app and then use it while providing effective feedback.

FPAT can include fishery models fitted to data. Dr Carruthers provided a presentation showing the various data time series and model inputs that could be included to estimate stock size, stock status and exploitation rate. It is however not clear how beneficial such presentations are. The most effective way of understanding what data are available and for the working group members to understand its role in the app, is to work directly with the working group member one-on-one showing fits of the model to those data. It would appear that there is generally not a shared understanding of important concepts such as 'stock', 'population', 'fishery', 'fishing effort'. This suggests that work needs to be done to improve introductory materials on data preparation or there should be a requirement to read such documentation prior to the meeting. Failing that, a dedicated morning session on fishery concepts and terminology might be required prior to data inputs.

In order to better understand what management options were available to each case study, participants provided a summary of the current management system for each stock (e.g., size limits, spatial closures, catch limits) and alternatives were discussed. This proved very valuable, and this discussion was moved forward in the Indonesian meeting as it further brought participants into the discussions regarding fishery management. In future meetings, participants could be asked to arrive at the meeting with a presentation on the fishery, data and management approaches which might further improve engagement and productivity during the meeting.

Case studies

Cabo Verde Garoupa (*Chephalopholis taeniops*)

The Garoupa fishery provided an excellent case study for FPAT given that the species is moderately long-lived and shares biological and ecological properties with data-rich stocks in other regions. The stock has annual catch data and catch-at-length (market) data from 2000 and therefore, in theory it is possible to fit statistical catch at length models to more realistically characterize the fishery. There are a number of key challenges with regard to the Garoupa case study:

- there appear to be strong are regional differences in biomass depletion and fishery exploitation rate

- length data are available only for the marketed fish (above the size limit) but it may be the case that smaller fish are actually retained but not reported

- fishing is near-shore and not in deeper waters, and it is unknown whether there could be a large unexploited spawning biomass in those waters.

A statistical catch at length model was nonetheless fitted for Garoupa and various size limits and catch-rate (catch per unit effort) based management procedures were evaluated.

Based on the application of FPAT to each case study and the discussions about data, uncertainties and management options that arose from these applications, a number of research priorities were identified for the Garoupa fishery in Cabo Verde. These recommendations were intended to support a potential path forward for cost-effective sustainable management of Garoupa using tangible management procedures.

1. The Garoupa case study would benefit greatly from a fishery-independent survey that can map the offshore distribution and size structure of the population. At the two extremes, it is possible that the near shore fishing has been very low and there is a large productive spawning biomass available in the relatively underexploited deep water. On the other hand, it may be the case that near-shore fishing has been intensive and that cohorts have been over-exploited before they can move offshore in older age classes. Until data are collected on deep-water catch rates and size structure this fundamental uncertainty clouds the evaluation of management procedures.

2. A design-based fishery-independent survey could provide a reliable relative abundance index that could be used to calculate robust management advice using a management procedure.

3. The length data available for Garoupa are those from the market only. It is likely that these are not representative of the fishery selectivity and that smaller fish below the size limit are in fact retained on the boats but not sold at market. An observer program or similar is needed to collect retained fish lengths and fit the operating model to both these and the market size data.

Côte d'Ivoire Sardinelle (*Sardinella aurita*)

The dynamics of sardinelle were informed by a time series of catches and fishery effort since 2000. There was however some doubt over the continuity of these time series that ultimately undermined the process of fitting models to data. Instead, FPAT was run in its 'data poor' configuration where participants specified alternative stock depletion levels and using the historical effort trend, management procedures were evaluated for robustness to those alternative depletion levels.

Senegal white shrimp (*Penaeus notialis*)

Senegal white shrimp (aka Southern pink shrimp) proved a very challenging case study for application of FPAT. The stock is very short-lived (less than a year), is exploited by two fisheries (inland artisanal net, ocean commercial trawl) that target differing life stages (juvenile, mature, respectively). These dynamics are not easily implemented by FPAT without first fitting a more complex operating model that includes the two fleets and can approximate annual species dynamics. For demonstration purposes, white shrimp was replaced by Senegal white grouper in the final day and models for white grouper were fitted to data.

Senegal white grouper (*Epinephelus aeneus*)

White grouper operating models were fitted to catch and relative abundance data from 1990. The participants tested a range of management procedures including simple model-based approaches, those based on alternative minimum size limits and constant exploitation rates informed by catch-rate indices. Since white grouper was a last-minute addition, there was not much time to explore alternative model assumptions and management procedures.

Indonesia FMA 718, Red Snapper (*Lutjanus malabaricus*)

As is typically the case for data-moderate fisheries, the only data available were an incomplete recent catch time series and very recent length composition data. When fitting a statistical catch-at-length model to these data, the model found difficulty in identifying both depletion and scale, implying that longer-term fishery composition data or longer-term fishery catch per unit effort data could be valuable for scoping possible scenarios. A key research objective for red snapper was the construction of catch per unit effort standardization approaches for their commercial trip level data, potentially the use of more sophisticated spatial distribution models. Ultimately, the model was configured with an optional prior on the current level of stock depletion allowing the user to scope various scenarios.

There was considerable interest in the investigation of alternative gear configurations that could provide potentially provide yield and conservation benefits. Simultaneous gear experiments where, for example, alternative hook types and sizes were compared for the size of landings could be used to inform management procedures that specify gear type in response to relative abundance data.

On the final day of the meeting, the live VMS monitoring system was demonstrated by the representative from the Indonesian Ministry of Fisheries. The system tracks the several thousand vessels that are equipped with VMS that are over a gross registered tonnage of 30. Additional a large number of Automatic Identification System equipped vessels are also tracked live. A new requirement for 2024 is that all vessels over a GRT of 9 will be equipped with VMS. These data provided a significant rethink of potential management options for Indonesian fisheries. While there is a directive from the ministry to move to total allowable catch control, the scale of the resources is largely unknown and would be required. On the other hand, their

effort is extremely well monitored and can be enforced, and is likely to be much more robust to uncertainties in a data moderate context that is typical across Indonesia.

Limitations of FPAT with regard to Fishery Types

FPAT is not well suited to case studies where species live for less than 3 years. In these cases, the performance differences of alternative management procedures (providing annual advice) are masked by natural variability. For this reason, short-lived species such as shrimp and squid require more bespoke operating models and management procedures, for example, those based on in-season data and management advice.

If fisheries have more complex fleet dynamics (e.g., white shrimp) they can be accommodated by FPAT but it still requires data to support the fitting of operating models outside of FPAT. This is a case of a more generic problem – the operating models of FPAT can accommodate a large range of fishery and population dynamics (e.g., spatial complexity, hermaphroditism etc.) but only if data are available to inform these dynamics.

Data Preparation, Management and Availability.

In settings where fishery assessment modelling is not routine, gathering data may require an iterative approach where data are presented, models fitted that in turn instigates further data gathering and exploration. This was the case for every case study of this FPAT meeting. In all cases, additional data were provided during the meeting as participants gained greater understand of how these data could be used.

In all case studies there were more data than expected (e.g., length compositions and indices for CV Garoupa and Senegal White Garoupa). As has been found in other data-poor and data-limited fisheries elsewhere (e.g., Mexico, Indonesia, Argentina), processed data may be limited, but there are often a lot of raw data that could be processed to inform models.

A better process of data description and explanation is required prior to the meeting; emphasizing effort and relative abundance (catch rate data, for example).

It is necessary to understand better the origins of age or length composition data. In the case of garoupa and red snapper these are from the market and may not be indicative of the size selectivity of retained catches which may strongly affect the evaluation of fishery sustainability.

In general, a high degree of organization is required ahead of the meeting to ensure participants have fully investigated and formatted data – in both the Cabo Verde and Indonesian workshops, participants were busy with their daily jobs and came to the meeting largely empty handed. Pre-workshop time commitments should be properly communicated and that time should be set aside.

Robustness testing

As has been found widely elsewhere, robustness testing allowed scientific uncertainties to be distinguished from management uncertainties. For example, there was considerable doubt about the reliability of the historical catch data for Indonesian red snapper and a high degree of uncertainty over the resilience of the stock. A valuable set of robustness tests showed that reconstructing substantially higher historical catches provided a more optimistic view of future stock trends and productivity. Similarly, testing management procedure sensitivity to lower stock resilience levels (lower steepness) also provided a more optimistic assessment of the various management options illustrating that both of these would not necessarily behave as a pinch point for the selection of a suitable management procedure.

FPAT App Design and User Experience

The application could use some other example management procedures. For example, a commonly applied approach is to set catch advice as a constant fraction of a relative abundance index. These could be a suite of custom MPs that are accessible in the app. In the case of Indonesian red snapper, users requested a great range of effort control MPs and retention (size limit) versus selectivity (gear type) controls.

The online app absolutely requires a reliable internet connection. It is possible to create offline USB memory sticks but configuring these is time-intensive. In addition, these memory sticks will not work for all users depending on their security settings and the speed of their computers.

Before a workshop including ~20 participants, the FPAT server should be expanded to multiple 'workers' and the expense of this should be budgeted for.

Although the excel input format is flexible (figures, notes) and relatively accessible to participants, it is highly fragile and it is impossible to anticipate all the ways that the user could 'break' it as an input file. For example, in the various case studies, the sheet names were renamed or even just reordered which broke the loading of the input file into the app. It may be necessary to fix cells and add more checks but this will not completely solve the issue.

The app could benefit from better in-line help and further fleshing out of the help tab.

Advanced controls for the simulations should be placed somewhere (e.g., the number of simulations or projected years)

Several users asked for greater control of graphing outputs (e.g., year ranges for plotted projections).

There may be a bug in the implementation of user-defined size limit MPs that requires further investigation.

Participation and Engagement

In the final day of the Cabo Verde workshop, participants were asked to describe the possible management procedures for their fisheries. This devolved into a very useful description of their fishery which provoked discussion that was often relevant to all case studies. Future workshops should include this participant-led description of the fishery in the first day. A more demanding suggestion would be to have participants arrive at the meeting with a full presentation of their fishery, its management and data sources.

In both workshops, very little feedback was provided on the app. It may be advisable to have a more formal process for receiving participant feedback such as a form with fields for 'app layout', 'app features', 'results presentation' etc.

Documentation

In order to reduce the necessary expertise required to use the app, it would be useful to develop guidance on particular inputs to the model such as steepness, maturity and natural mortality rate.

It would be very valuable to modify the Excel input worksheet to highlight those inputs to the model that are necessary (e.g., color-code these in the spreadsheet).

Ideal meeting schedule and structure

Based on experiences in this workshop and those of a similar process MERA the following meeting schedule would be ideal and would allow for multiple iterations on case studies and data:

1. *At least 4 weeks prior to the in-person meeting*. 45minute online review of data inputs
2. *1 week later*. 45 minute online check-in about progress in obtaining data
3. *1 week later*. FPAT instructors present on the data provided and any gaps remaining
4. *prior to the meeting*. FPAT instructor and participants interact over email on data
5. *first agenda item after introductions and recap.* Data review

The meeting would benefit from asking each case study to present on their fishery, its management, potential management and current research priorities, near the beginning of the meeting.

The technical MSE aspects of the app require workshop instructors to interact with the participants particularly in the interpretation of results. It is advisable to have multiple MSE instructors for large meetings (20+ participants).

Delivery of the workshop would benefit with clearly identifying instructor roles (e.g., facilitator, meeting chair, FPI, FPAT app) such that tasks are distributed – the technical burden of emails

regarding data and the app can become overwhelming, leaving little time to focus on the schedule of the meeting (a dedicated chair would help).

User participation might be improved by asking specific questions or identifying structured tasks such as: which type of management options performed best/worst? Where fishery uncertainties important in management option selection?

Technical Capacity

In general, participants had a much higher than expected technical capacity. There was capacity to do more advanced R coding and analysis in the teams from both Côte d'Ivoire and Senegal

Having the flexibility in the modelling to extend the approaches to more complex analyses means that the meeting holds the interest of more advanced participants. The workshop has produced an ongoing collaboration to model the two-life stage, two spatial area, two fleet annual white shrimp fishery in Senegal.

In the Indonesian workshop, two participants had previously trained in similar software MERA (Carruthers et al. 2023) and were sufficiently conversant in concepts and the types of data that could be included to come to the meeting fully prepared to specify operating models. This illustrates that while an initial meeting may be challenging, subsequent case studies could be developed much more quickly and efficiently.

The fundamental concepts behind simulation testing and MSE were not challenging and relatively clear to most participants.

On the other hand, MP design was opaque to most participants.

Appendix A. Supporting Materials

Coastal Fisheries Initiative (2018-2022; http://www.fao.org/in-action/coastal-fisheries-initiative/en/).

FPAT app: https://shiny.bluematterscience.com/app/fpat

Fishery Performance Indicators (FPIs): https://fpilab.org/