Commission for the Conservation and Management of
Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

Northern Committee
Sixth Regular Session
WORKSHOP ON BIONLOGICAL REFERENCE POINTS

Fukuoka, Japan
6 September 2009

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Northern Committee
Sixth Regular Session

Nagasaki, Japan
6–10 September 2009

WORKSHOP ON BIOLOGICAL REFERENCE POINTS SUMMARY REPORT SUMMARY REPORT

AGENDA ITEM 1. OPENING OF MEETING

1. The First Workshop on Biological Reference Points of the Northern Committee took place in Fukuoka, Japan, 6 September 2010. The meeting was attended by Members from Canada, Japan, Republic of Korea, Philippines, Chinese Taipei, and United States of America (USA), and by Observers from ISC and the WCPFC Secretariat. The list of meeting participants is included in Attachment A.

1.1 Welcome

2. M. Miyahara, Chair of the Northern Committee (NC), convened the meeting and welcomed participants to this Workshop.

1.2 Adoption of agenda

3. Canada requested time to present a delegation paper on a proposed management framework for the Northern Committee. This request was accepted and added to the agenda. The modified agenda was adopted (Attachment B). The documents that supported the meeting were made available on the WCPFC website.

1.3 Meeting arrangements

4. The Chair announced the proposed meeting schedule and logistical arrangement to support the Workshop.

AGENDA ITEM 2. REPORT FROM ISC10 AND SC6

2.1 Report from the ISC10

5. G. Sakagawa, out-going Chairman of ISC, gave an introduction to the concept of use of biological reference points (BRP), target (TRP) and limit (LRP), for implementing the precautionary approach in fishery management. He noted that the approach is a management responsibility and used to avoid serious harm to the stock while permitting sustainable yield or other catch scenario. Two types of harm are of concern, i.e., growth overfishing and recruitment overfishing. The limit BRP is

established to avoid recruitment overfishing, the more serious and potentially more harmful impact. The target BRP is established to permit long-term sustainable exploitation with consideration of productivity objectives for the stock, broader biological factors, and socio-economic considerations. With this in mind, the ISC addressed the request for advice from the NC5 on BRPs, both target and limit, using the following guidelines: (1) identify potential BRPs for each northern stock, (2) focus on "generic" BRPs typically used in stock assessment status evaluations, (3) provide pros and cons of using each BRP, and (4) list estimated value for each BRP and stock from the ISC's latest stock assessment. The results of the discussion on biological reference points at ISC10 are contained in WCPFC-NC6-WP-09 (ISC/10/Plenary/04) and reported under agenda item 3.

6. Regarding the ISC's introductory presentation on BRPs, the US emphasized the concept of precautionary approach and the role of using BRPs in that approach and in achieving the maximum economic benefit.

7. In response to Japan's question on the scale of time series that produces stable yield considering the changing characteristics of carrying capacity along with time horizon, G. Sakagawa responded that capacity changes can occur due to fishery itself including socio-economic factors driving decisions to fish, environmental changes and changes in gear selectivity. Fluctuation of the yields will be subject to long-term or short-term projection, which will be determined by the management objective, fishery environment (selectivity) and timeline.

8. A request was made to explain why MSY decreases when the size of fish caught decreases. Dr. Sakagawa explained that the key assumption behind MSY is that populations of organisms grow and replace themselves. It is also assumed that because the growth rates, survival rates, and reproductive rates increase when harvesting reduces population density, they produce a surplus of biomass that can be harvested. A third assumption is that populations of organisms do not continue to grow indefinitely but reach an equilibrium population size, which occurs when the number of individuals matches the resources available to the population. At this equilibrium population size, called the carrying capacity, the population remains at a stable size. MSY aims to maintain the population size at this point of maximum growth rate by harvesting the surplus individuals that would normally be added to the population, allowing the population to continue to be productive indefinitely.

9. Dr. Sakagawa explained that the concept of MSY treats all individuals in the population as identical, ignoring population structure such as size or age classes and differential rates of growth, survival, and reproduction of different size or age classes. Thus a fishery that takes proportionately more small fish than large fish will have a lower estimated MSY than a fishery focusing on larger fish. Thus, the mix of gears in a fishery will influence the size of fish caught and hence estimated MSY for this catch scenario. Changes in the mix of gears from year-to-year may account for some of the annual fluctuations in MSY observed in the WCPO bigeye tuna stock. Furthermore, the static interpretation of MSY (i.e., MSY as a fixed catch that can be taken year after year) ignores the fact that fish populations undergo natural fluctuations (i.e., MSY treats the environment as unvarying) in abundance and constant MSY catch strategy will have high risk of depleting the population.

2.2 Report of the Sixth Regular Session of the Scientific Committee

10. N. Miyabe, the Chair of the Scientific Committee, presented the outcomes of the SC6 on reference points issue. He noted that this issue was discussed in the Management Issue Theme. The Theme session was reminded that the Commission at WCPFC5 in December 2008 directed that a special workshop on Reference Points had been held at SC5. The aims of this workshop were to provide capacity building on this issue and review some of the technical characteristics of reference points. SC5 endorsed the recommendation from this workshop that a work program should be undertaken during 2010 to assist

SC6 in identifying candidate reference points (both type and value) for each of the key target species in the WCPFC, and to make suitable recommendations on reference points to the Commission. The meeting listed the inter-sessional work program agreed at SC5 on the Scientific Research plan. Two papers were provided to SC6. One paper attempts to identify possible limit reference points (LRP) for target species in the WCPFC area and the other paper describes a framework to evaluate the potential impacts of LRPs on target species, including multi-species considerations. After reviewing these papers, the SC recommended a continuation of the Project 57 on Reference Points, and the results are to be reported to SC7 and, if appropriate, to the proposed Management Objectives Workshop to be held in 2011.

11. In response to a question about annual changes in MSY for the WCPO bigeye tuna stock, N. Miyabe noted that MSY estimates might be affected by improved input data, including size data from Japanese longline and from Philippines, where the majority of catch consists of small fish and a substantial portion of large-size fish.

AGENDA ITEM 3. FISHERIES MANAGEMENT REGIME

12. Canada introduced its delegation paper WCPFC-NC6-DP-02 (Developing a fishery management regime for stocks managed by the Northern Committee). The WCPFC Convention text requires members to determine stock-specific reference points, to take measures to ensure points are not exceeded, and to take action without delay if these reference points are exceeded. DP02 outlines one way to adopt a PA regime – through the establishment of control rules which identify three stock status zones – healthy, cautious and critical – based on pre-determined reference points. A removal rate is set, and decision rules and management actions are decided in advance, which come into effect as the stock approaches the critical zone. The US supported the Canadian proposal as a goal for NC management, and also noted that this workshop needs to provide such control rules to managers. While agreeing with the concept, Japan noted that we need to understand the existing uncertainty in the scientific information as we see sometimes observe drastic changes between stock assessments, and try to find out a practical approach to keep the stability of fisheries and avoid such uncertainty.

AGENDA ITEM 4. POSSIBLE REFERENCE POINTS FOR NORTHERN STOCKS

4.1 North Pacific Albacore

13. J. Holmes, Chairman of the ALBWG, summarized discussions of the ISC-ALBWG on biological reference points for north Pacific albacore. The ALBWG focused on limit and precautionary reference points since recruitment overfishing was considered more serious risk to the resiliency and productivity of a stock than growth overfishing. Information was compiled that describes and characterizes candidate reference points including FMSY and a suite of MSY-proxy reference points (F40%, F35%, F30%, F20%, F0.1, FMED, and FMAX). The WG has developed minimum spawning stock biomass (SSB) reference points that are F-based estimators (FSSB) to ensure that SSB will not decline below historically estimated SSB levels, including the average level of the ten historically lowest estimates of SSB (ATHL). The WG also identified a simulation framework based on the FSSB suite of reference points that illustrates the tradeoffs between uncertainty, risk, threshold levels, and reference point estimates. To use this framework, managers need to clearly specify management objectives for the stock, SSB threshold level, level of certainty concerning future SSB, their risk tolerance/avoidance, and the length of the projection period since the results will differ under shorter or longer projection periods. The WG did not endorse any particular reference point(s) at this time. but noted the following: (1) SSB-min occurs at beginning of SSB time series and is not reliably estimated by the stock assessment model, (2) estimates of SSB-X%, where X = lower 10-50 percentiles, are more robust statistically than SSB-ATHL, and (3) the probability that future SSB will fall below a limit reference point threshold in one or more years should be less than 50% (e.g., 5%), i.e., greater certainty is needed considering the risk to

the stock.

14. The US commented that it does not prefer the simulation-based reference points for the fishing mortality rate, first, because they are not tied in any way to MSY (Fmsy being the minimum standard under the Convention) or directly to the life history attributes of the stock, as well as because they require that many subjective decisions be made, including the projection period used, probability levels, conditions for failure and re-sampling options regarding productivity (recruitment). The US stated that RPs should be based on fisheries theory, not empirical simulations. The US also clarified that the Convention provides clear guidelines on adopting BRPs through its incorporation of Annex II of the UN Fish Stock Agreement, which says that LRPs for both fishing mortality and stock size *shall* be adopted while TRPs *may* be adopted. In addition, it says that F_{MSY} shall be treated as the minimum standard for the LRP for the fishing mortality rate. Therefore, US suggested that F_{MSY} should be the LRP for F unless there are compelling reasons not to adopt it, in which case a reasonable proxy for F_{MSY} should be considered.

15. The Chair also confirmed that we should focus on LRPs first, at least at this workshop, which is the basic requirement under the Convention.

16. Regarding the definition of LRPs, the meeting seemed to share the concept that reaching LRPs is to be avoided, where the continuity of resource production is in danger, and an immediate action to reduce the fishing mortality rate is needed, or in the extreme case, closure of the fishery for a period of time. The US read from Annex II of the UNIA, which explains that "limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield." "Target reference points are intended to meet management objectives." The US went on to paraphrase this by saying that LRPs are something to avoid and TRPs are something to achieve.

17. In response to Japan's queries, ALB WG Chair clarified that F_{loss} (F at the lowest observed spawning biomass level, same as SSB_{min}) is the lowest level ever seen and we need a buffer relative to that level where trigger action is required – this is the concept of precautionary RPs first proposed by the FAO. The Chair summed up the discussion that LRPs can be interpreted as the level which, if exceeded, catch should be reduced to the lowest level (zero). The US and Canada expressed disagreement with that view – rather, that the action triggered by crossing an LRP is not necessarily a reduction of catch to zero. The particular management response would be agreed in advance. In the case of exceeding an LRP for F, the response would be aimed at reducing F at least as low as the LRP, and in the case of crossing an LRP for stock size, the response would be aimed at rebuilding the stock to a specified level.

18. The meeting had a lengthy discussion on selecting RPs. Japan considered that F_{ATHL}, which according the latest ISC estimates, is equal to $F_{current\ (2002\text{-}2004)}$, is too conservative to be used as a LRP considering the current high level of stock size. Referring to the Interim Management Objective that was adopted at NC4, the US noted that it refers to particular levels of both stock size and fishing mortality, and that its operational part calls for reducing F when F exceeds the specified level of F (F_{AHTL}). The US emphasized that it is important to establish LRPs for F, as F is what management measures directly affect.

19. The Chair stated that the Interim Management Objective for NP Albacore established SSB_{ATHL} as a RP. The ALB WG Chair noted that the ALB WG calculated F associated with the Interim Management Objective last year to be 0.75/yr – that reference level of F is the level that is projected, with a 50% probability in one or more years of the projection period the SSB falls below the average level of its 10 historically lowest points (ATHL). The Chair re-clarified that the discussion should focus on the RPs, not the management actions, and proposed that the SSB_{loss} to be a LRP and introduced F_{ATHL} as a precautionary RP. No agreement was made on this proposal.

20. Regarding the definition of LRPs, several views were exchanged. At the Chair's suggestion, it was agreed that the Canadian paper will be the basis for future work. With respect to Canada's proposal, the US reiterated the Convention requirement that stock-specific limit reference points for F shall be established, and that the "removal reference" in Canada's proposal can be viewed as being such a limit reference point for F. The US also reiterated that the actions to be taken once the LRP is reached depend on what the NC has agreed. Illustrating the albacore case with F_{ATHL} as a LRP, Japan concerned about the current situation where F should be reduced even under albacore stock is abundant. As a result, the Chair reiterated his proposal of using dual LRPs, both B_{loss} and F_{ATHL} (F_{ATHL} as a precautionary RP). There are different views among members on this proposal, but the US agreed that LRPs for both stock size and the fishing mortality rate are needed and called for under the Convention.

21. The US stated that, consistent with the Convention, F_{MSY} is its preferred LRP for the fishing mortality rate, and the US offered it as a proposal. The US added that it was also open to RPs in the $F_{\%SPR}$ as proxies for FMSY. These reference points are preferred over the simulation-based reference points because they are related to the life history attributes of the stock. With respect to the LRP for stock size, the US stated that it is open to a wide variety of candidate reference points, including those related to historically observed stock sizes. Japan expressed its reluctance of using LRPs based on B_0 or MSY because of high sensitivity to biological parameters. Because it was apparent that different members had different views of the meanings of the various types of reference points (e.g., limit versus target), the US proposed that the meeting focus on adopting RPs generally, without worrying too much about what to call them. In addition, the US reminded that selecting RPs for management purposes is not a scientific exercise, but a management exercise. Science may provide a range of options of RPs with plausible consequences to managers, and the ISC Chair also supported this point. Regarding Japan's proposal on the use of F_{ATHL} with a projection period of 10 years versus 25, the US commented that this is one of the problems with simulation-based RPs – that they require many subjective decisions to be made, including deciding upon the projection period. The US again stated that RPs should be based on life history attributes and fisheries theory, not empirical simulations. The workshop agreed consider RPs that would be reviewed every three years. Canada advised of the need to establish a specific management objective for each stock as shown in the Interim Management Objective, as a benchmark for review every three years.

4.2 Pacific Bluefin Tuna

22. Y. Takeuchi, Chair of ISC PBF WG, focused on the WG's effort on the BRP of Pacific bluefin tuna after NC5. The WG convened one session on BRP during 6-9 July 2010. The WG crafted a table describing the characteristics, pros/cons and special comments on BRPs used by other tuna RFMOs. In PBF WG WS, most of the effort has been spent for limit or "precautionary" reference point. When formulating the table, there was no disagreement that MSY is difficult to estimate, although there was no much discussion whether MSY proxy or alternative RPs be used for the above situation. There were different opinions in the WG with respect to the utility of the sensitivity of reference points as a criterion for choosing suitable reference points. One argument is that less sensitivity of RPs to the parameters, e.g. adult-M, is from structural assumptions of the stock assessment model, and the other is that it is a real one. It was suggested that, due to uncertainties of the stock assessment of PBF, it may be very difficult to have single estimate of MSY or MSY proxy type BRP with WG members' consensuses within a few years, while the WG is planning several improvement of the stock assessment model and input data.

23. Dr Takeuchi explained that in PBF assessment, the true level of natural mortality M is uncertain, nevertheless current adult M=0.25 is considered to be the best estimate. The assumption of adult M is found to be particularly influential to the estimate of absolute spawning biomass and fishing mortality. In response to a question from Chinese Taipai, Y. Takeuchi said that the sensitivity-to-M does not have any

bearing on the ISC's latest conservation advice.

24. H Nakano (Japan) made a presentation on the issues of current PBF stock assessment in relation to the sustainability of the stock (NC6-IP-05). PBF catch has increased since early 1990s, however catch declined in recent years (2009). Since the majority of the PBF catch is juvenile, variations of catch of each fishery is likely to be affected by the annual variation of recruitment. The assumption of adult M is particularly influential to the estimate of absolute spawning biomass (SSB) and fishing mortality (F). Although absolute estimates from the stock assessment model were sensitive to different assumptions of M, relative measures were less sensitive. Biological reference points (BRPs) based on Maximum Sustainable Yield (MSY) and unfished biomass level (B0) are also highly sensitive to the assumption of adult M. And hence, it is presently difficult to manage the PBF stock using MSY or its related management benchmarks. H. Nakano suggested that as an interim measure, it is advisable to manage the PBF stock in terms of keeping the stock sustainable to obtain the reasonable level of yield. H. Nakano stated that the historical trends of SSB and recruitment suggest that PBF can be expected to remain productive even very close to the historical lowest SSB level, and that the substantial expected increases of %SPR from that in 2004-2006 to that in 2002-2004 may contribute to keeping the stock at a sustainable level without losing future yield.

25. Considering the continuous decline of SSB since mid-1990s, the US questioned the efficiency of fishing that we have today compared with 1970s and 1980s. Fishing gears are likely more efficient. In response, Japan said that though detailed impact assessment was not conducted, the essence of this presentation lies in i) strong recruitment continued to occur even under the lowest historical level of SSB and subsequently the stock was rebuilt, and ii) the importance of monitoring recruitment so that it can continue to contribute to the stock rebuilding. It was noted that autocorrelation in the analysis of SSB and recruitment made it difficult to draw strong conclusions about recruitment at low SSB sizes.

26. T. Koya made a presentation on effective and practical Pacific bluefin tuna management (Attachment C). In his presentation, he made the following points. Pacific bluefin tuna stock has been highly fluctuating over the past 50 years, while fisheries have been relatively stable. Oceanographic factors are likely influential on the stock, in particular its larval period. Also, the stock experienced the lowest SSB levels in 1970s and 1980s and then bounced back repeatedly. It is evident that the sustainability of the stock will be ensured by managing stock above the historically lowest level. Another aspect is that the majority of PBF catch is juvenile fish, which has increased over the past 40 years. Given these characteristics, Koya pointed out that efforts to reduce juvenile fish catches and increase Y/R should be a central concept in management measures for this stock. Also, actual value of SSB and B_0 and MSY-based reference points are highly sensitive to biological parameters, in particular natural mortality rate (M). While introducing an example of stock assessments for Pacific whiting, the retrospective stock size estimates of which changed from assessment to assessment, he stressed that managers would not like to see such drastic and frequent changes in management due to such uncertainty in stock assessments. To that end, he concluded that a management approach designed to prevent the stock from falling below the lowest SSB level is feasible for PBF stock and controlling fishing effort on juvenile fish is a key to this approach, together with timely and effective monitoring of new recruitment levels. The US pointed out that in the case of the Pacific whiting assessments, all the assessments shared the same general trend in stock size (dramatically downward) – and that only the absolute magnitudes of stock size varied among the assessments. The US also expressed concern about managing the PBF stock as such low levels of biomass.

27. Japan stated that the uncertainty in stock assessments had significant management implications that were difficult for managers and their industry to accept. Japan emphasized that practical approaches and achieving stability in the fishery are important.

28. Japan reiterated the ISC's conservation advice that "… the level of F is decreased below the 2002-2004 levels, particularly on juvenile age classes". Japan stated its preference for using B_{loss} (or $F_{2002-2004}$) as an interim 3-year RP because of the lack of scientific basis of MSY-based RPs. The US responded that it was open to using an historical stock size-based reference point such as Bloss, but only if an appropriate LRP for F is also adopted. The US reiterated that it supports FMSY or certain points within the F%SPR family as LRPs for F. The US referred to the point made by Canada that reference points should be based on the management objectives for a given stock, and noted that establishing management objectives is an iterative exercise, and that lacking more stock-specific objectives, we can look to the fundamental management objectives as expressed in the Convention. The US added that it was open to adopting interim LRPs that do not necessarily meet the standards of the Convention for RPs, as the NC has done for NP albacore.

29. The US made the same proposals for LRPs for stock size and F for PBF as it did for NP albacore.

30. The US said that even if MSY-based reference points are not adopted, it would be very useful for the ISC to include MSY-based results in its stock assessments, and that the NC should request the ISC to do so for all the northern stocks.

4.3 North Pacific swordfish

31. Gerard DiNardo, Chair of the ISC Billfish WG, provided a summary of the ISC Billfish Working Group's task to identify potential billfish limit and target BRPs. This was a request stemming from the 5th Meeting of the Northern Committee, and 17 potential BRPs were identified, including 10 fishing mortality-based and 7 biomass-based reference points. Each BRP was characterized based on attributes including management purpose, model structure required to compute the BRP, data needs, the type of BRP (limit or target), the type of overfishing addressed, simple pros/cons, and any special comments. The ISC's latest estimates of MSY, F_{MSY}, and B_{MSY} for each of the two North Pacific swordfish stocks were also presented.

32. Japan and the BILL WG Chair reminded the workshop that the assessment produces results that can be compared to MSY-based RPs because a surplus production model is used in the assessments. While the US proposed that F_{MSY} be adopted as the LRP for NP swordfish, Japan proposed B_{MSY} as currently estimated by ISC to be a RP.

33. Any outstanding issues on RPs will be revisited at NC6.

AGENDA ITEM 5. OTHER MATTERS

5.1 Other matters

34. No other matters discussed.

AGENDA ITEM 6. REPORT TO THE NORTHERN COMMITTEE

6.1 Adoption of the Summary Report for the Workshop on Biological Reference Points

35. The workshop report was adopted on Thursday, 9 September 2010.

AGENDA ITEM 7. CLOSE OF MEETING

36. The workshop was closed at 17:00, 6 September 2010.

Attachment A

Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

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6 September 2010
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Attachment B

Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean

WORKSHOP ON BIONLOGICAL REFERENCE POINTS

6 September 2010
Fukuoka, Japan

PROVISIONAL AGENDA

WCPFC/NC6/04
24 August 2010

AGENDA ITEM 1. OPENING OF MEETING

1.1 Welcome

The NC Chair (Mr Masanori Miyahara, Japan) will open the NC Workshop on Reference Points (the NC Workshop), 6 September 2010. He will welcome delegations of WCPFC members, cooperating non-members and participating territories (CCMs), the WCPFC Secretariat and observers.

1.2 Adoption of agenda

The Chair will introduce the Provisional Agenda. The Rules of Procedure of the Commission will apply *mutatus mutandis* until such time as the Northern Committee adopts its own Rules of Procedure (Rule 31).

1.3 Meeting arrangements

The Chair will announce the proposed meeting schedule and logistical arrangement in place to support the NC Workshop.

AGENDA ITEM 2. Report from ISC10 and SC6

2.1 Report from the ISC10

The former Chair of the ISC (Dr. Gary Sakagawa) will introduce the general discussion and outcomes on biological reference points from ISC 10.

2.2 Report of the Sixth Regular Session of the Scientific Committee (SC6)

The NC Workshop will review the issues and discussion on reference point from the Sixth Regular Session of the Scientific Committee (SC6), Nuku'alofa, Tonga, 10-19 August 2010 as they relate to discussion at the Workshop.

AGENDA ITEM 3. Possible Reference Points for Northern Stocks

3.1 North Pacific albacore

The Chair of the ISC Albacore Working Group (Dr. John Holmes) will introduce discussion and outcomes on biological reference points from the Working Group.
The NC Workshop will discuss possible reference points for North Pacific albacore.

3.2 Northern Pacific bluefin

The Chair of the ISC Bluefin tuna Working Group (Dr. Yukio Takeuchi) will introduce discussion and outcomes on biological reference points from the Working Group.
The NC Workshop will discuss possible reference points for Pacific Bluefin tuna.

3.3 North Pacific swordfish

The Chair of the ISC Albacore Working Group (Dr. Gerald DiNardo) will introduce discussion and outcomes on biological reference points from the Working Group.
The NC Workshop will discuss possible reference points for North Pacific swordfish.

AGENDA ITEM 4. OTHER MATTERS

4.1 Other Matters

The NC Workshop will discuss any other related matters.

AGENDA ITEM 5. REPORT TO THE NORTHERN COMMITTEE

5.1 Adoption of the Summary Report of the NC6

The NC Workshop will adopt a Summary Report. It will make every effort to adopt its Summary Report by consensus. If every effort to achieve consensus has failed, the Summary Report will indicate the majority and minority views and may include the differing views of the representatives of the members on all or any part of the Summary Report.

AGENDA ITEM 6. CLOSE OF MEETING

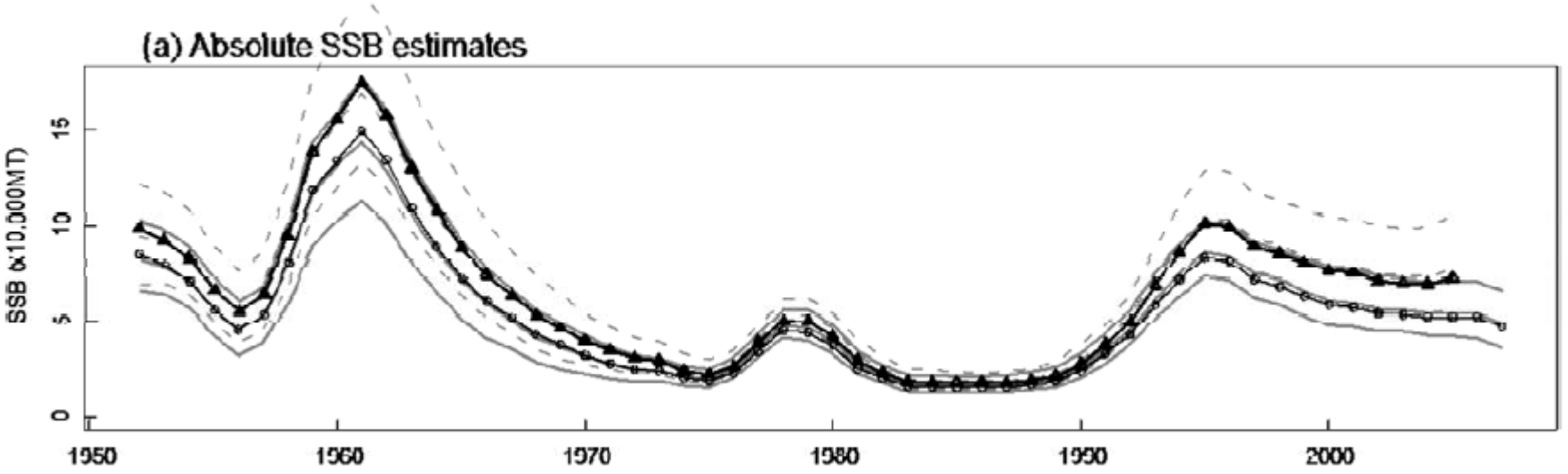
6.1 Closing of the meeting

The NC Workshop is scheduled to close at 17:00, 6 September 2010.

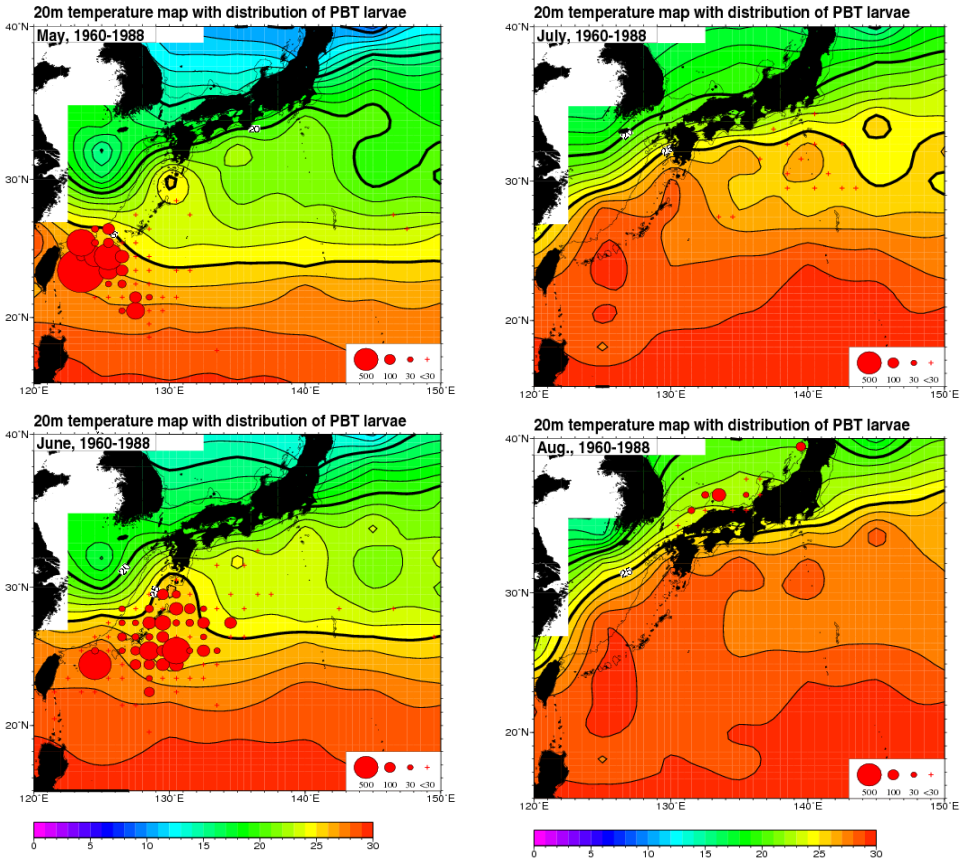
Effective and Practical Conservation and Management for Pacific bluefin tuna

1. Historical observation of PBF stock

• In PBF stock, large fluctuations have been repeatedly observed for the past 50 years, while PBF has been historically subject to relatively stable fisheries.



- Oceanographic environmental factors are considered to be significantly influential over the PBF stock, particularly larvae stage, but the mechanism has not been elucidated.



Sea water temperature map with distribution of PBF larvae

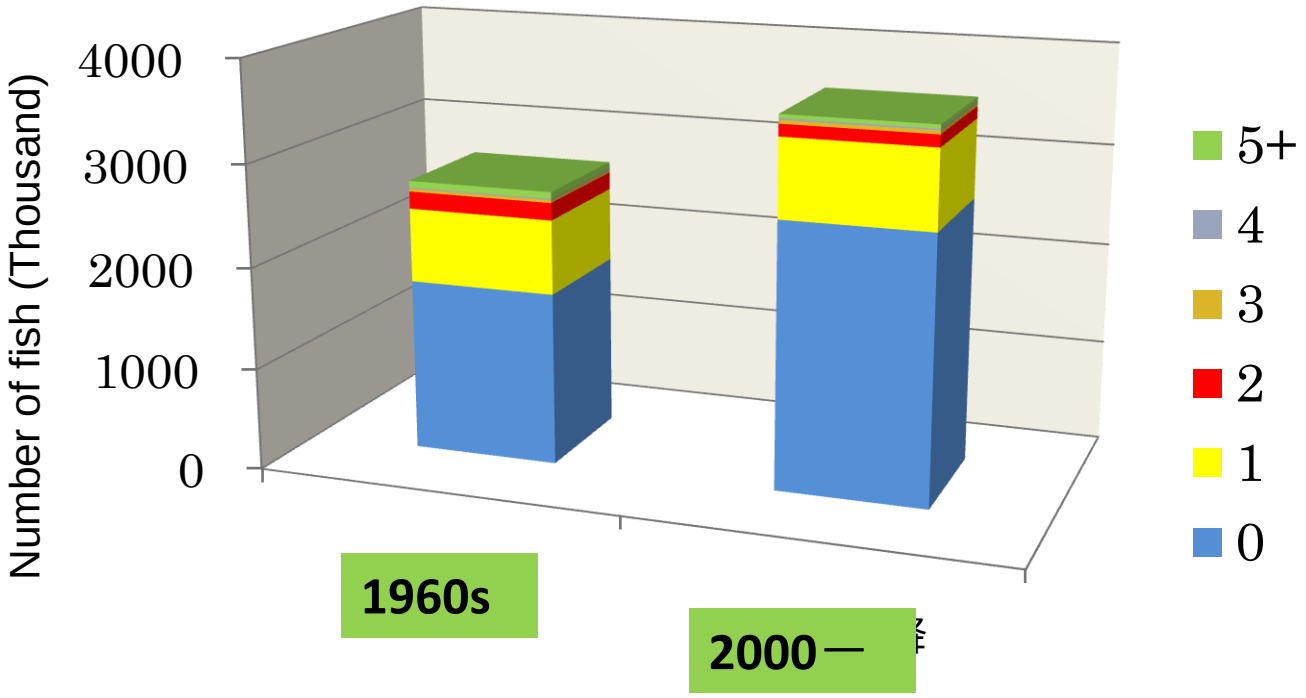
- PBF stock has experienced nearly the lowest SSB levels for the 1970's and 1980's, and then bounced back to higher levels, while fishing effort has been generally stable.

- It is, therefore, evident that:

the sustainability of PBF stock will be ensured by maintaining the SSB above the historically observed lowest level.

2. Characteristics of PBF stock and fisheries

- The juvenile catch has increased .
- The vast majority of PBF catch is juvenile fish. (approx. 90% of catch is Age 0-1).



- PBF is matured at relatively young ages (+3). Mortality rates in this short juvenile period (0-3) in the PBF life history (0-20) directly result in the SSB level.

- Regardless of the sophisticate stock assessment, it is natural that reduction of juvenile catch will lead to increase in the SSB level.

Reduction of juvenile catch and increase of Yield per Recruitment should be a center concept in PBF conservation and management measure.

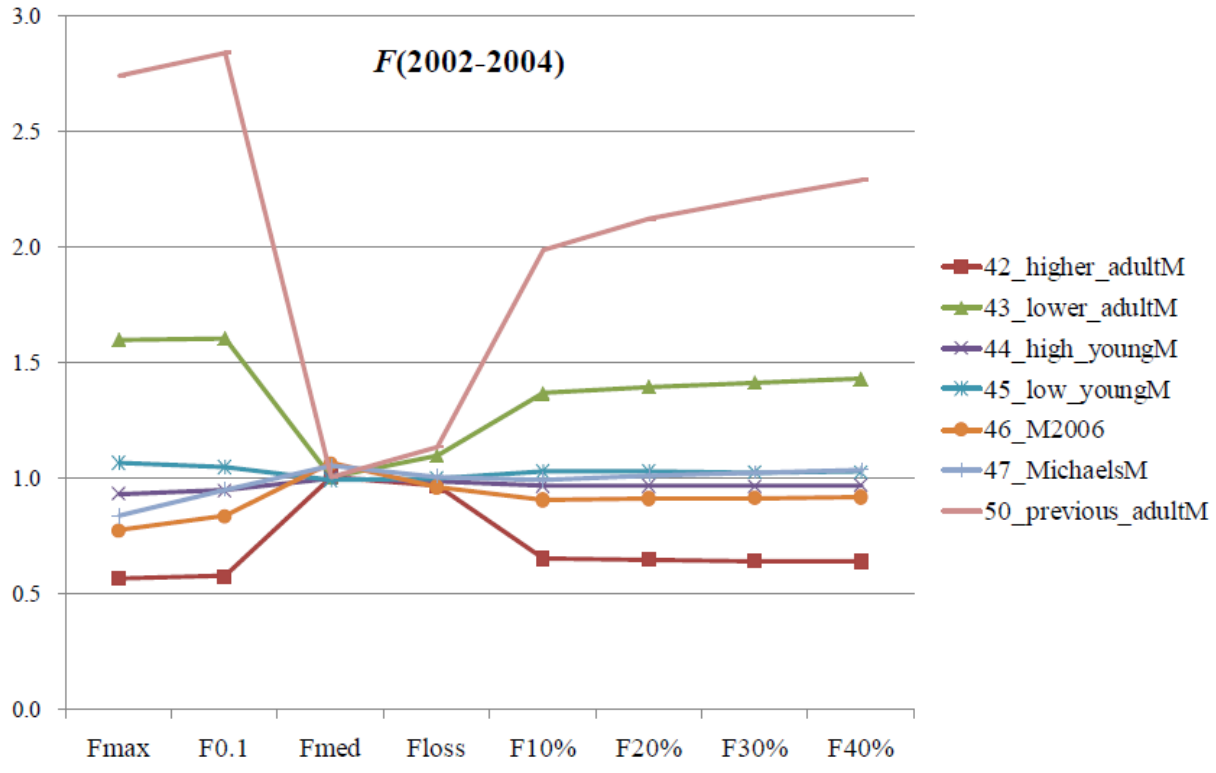
3. Reference Points for PBF stock

- Current stock assessment results by the SS model are sensitive to biological parameters, in particular natural mortality rate (M).

- Unfortunately, it is difficult, at this stage, to obtain reliable assumptions of biological parameters.

- B_0 or MSY-based reference points are highly sensitive to various assumptions of natural mortality (M).

- On the other hand, F_{loss} or F_{med} based reference points are relatively robust to M.



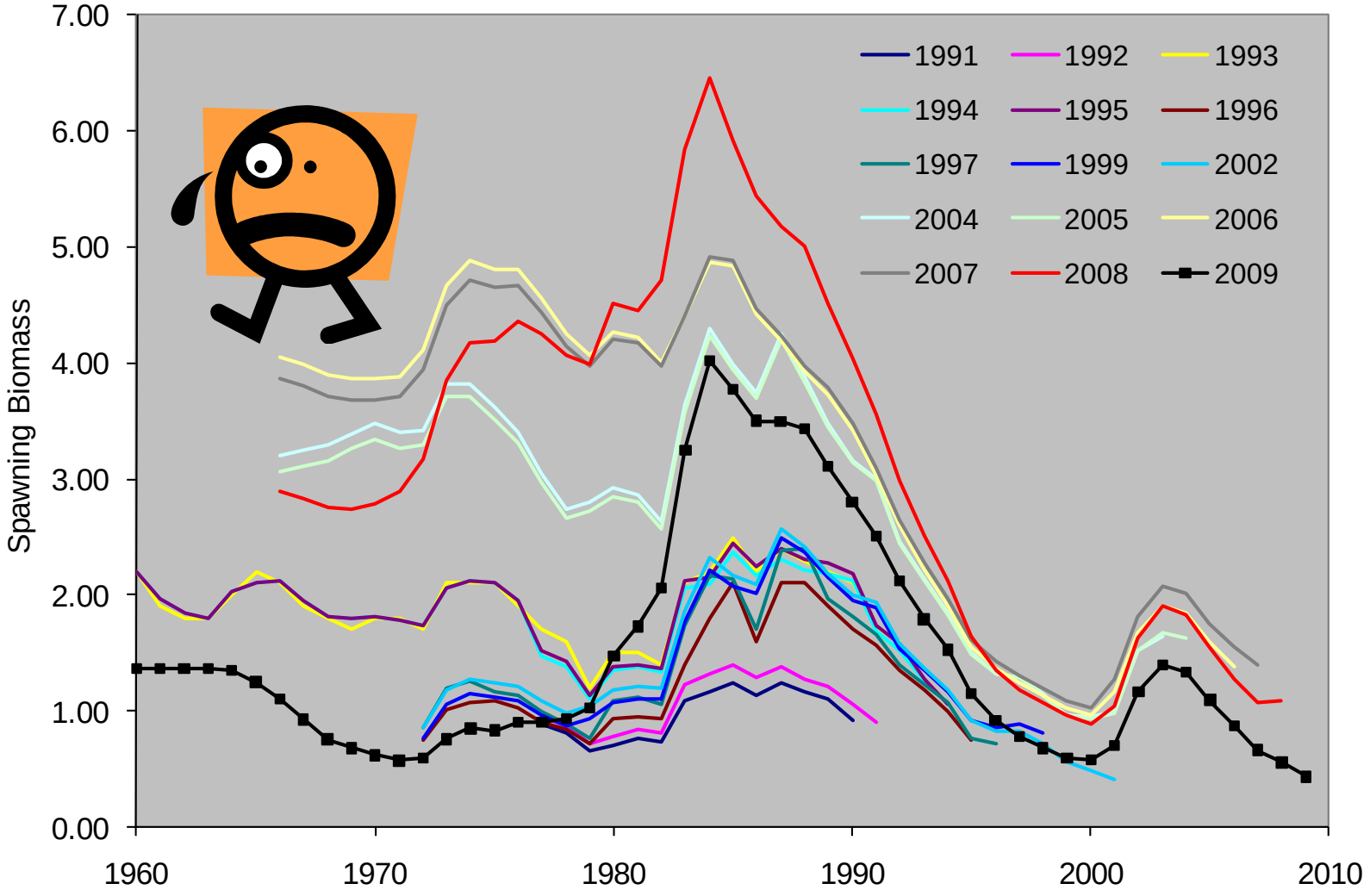
- In the case of PBF, it is difficult and impractical to introduce management measures based on B_0 or MSY-based reference points because of the high sensitivity to biological parameters with full of uncertainty.

- In addition, considering the long history of PBF fisheries, B_0 or MSY-based reference points will not function for PBF stock.

- Stability of fishery is very important for fisheries management.

  Drastic and frequent changes in management in a short period would result in the collapse of our important PBF fishery.

Real Assessment Uncertainty: An Example of 15 Repeats of the Pacific Whiting Stock Assessment



Courtesy Dr. Steve Ralston

4. Effective Management for PBF stock

- Under the present status of the PBF stock assessment model and the difficulty in estimating reliable biological parameters, management approach, designed to prevent the stock from lowering below the lowest SSB level, is feasible for PBF stock.

- Control of fishing efforts on juvenile fish is a key to this approach, together with timely and effective monitoring of new recruitment level.

5. Management Strategy

- **Reduction of juvenile fish catch**

- **Setting F_{loss}-based Limit Reference Point (i.e. $F_{loss\text{-}20\%}$)**

- **Once the SSB drops below the F_{loss}-based Limit Reference Point, PBF fishery will be closed.**

- To support sound PBF management, the following efforts should be extended;

  - **Timely collection of catch data and other information**

  - **Collection of wider sources of CPUE indices**

  - **Conducting comprehensive biological research**

Thank you