A Review of

Stock Assessment of Pacific Bluefin Tuna in 2012 conducted by the Pacific Bluefin Tuna Working Group of the International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean. 2013

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A review conducted for the

Center for Independent Experts
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Executive Summary

The assessment of Pacific bluefin tuna is a relatively recent process starting in 2008. Since then a great deal of progress has been made in organizing data, focusing research and stabilizing the assessment methodologies. The current report indicates that progress. As such the current assessment provides the best scientific information available.

There are additional suggestions for future evaluation. In terms of model structure, configuration and assumptions, I recommend that further investigation of Age 0 natural mortality rates. These should be addressed through the evaluation of the timing of the stock-recruitment process: when does density-dependence stop and density-independence begin, and whether there is overlap with ages within Age 0 which undergo fishing mortality.

Additionally, the tagging data used to evaluate Age 0 natural mortality should be integrated into the assessment. This should be done regardless of the density-dependent model chosen.

Uncertainty evaluations need to become a standard part of the assessments. These are the probability functions of the status of the stock relative to benchmarks and the probability density functions of catches required to achieve those benchmarks.

Alternative error structures for recruitment used in projections should be examined to incorporate uncertainty in future ecological conditions.

The assessment reports should have “Kobe” plots (phase disgrams of S/Slimit versus F/Flimit) as part of the standard output. Additionally, for scientific purposes, the assessment report should include stock-recruitment plots (without any model on the plot) so that these might put the historical data into the context of typical benchmarks. These will be useful to the scientists in the process of assisting the RFMOs in their determination of limits, targets and control rules.

Continued monitoring research is needed to improve size sampling, aging and catch-per-effort indices.

Background

The historical basis for the Pacific Bluefin Assessment is given in the assessment report (Pacific Bluefin Tuna Working Group. 2013. Stock Assessment of Pacific Bluefin Tuna in 2012. International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean) and is summarized here.

Pacific bluefin tuna (*Thunnus orientalis*) is considered a single Pacific-wide stock. Although found throughout the North Pacific Ocean, spawning grounds are recognized only in the western North Pacific Ocean. A portion of each cohort makes trans-Pacific migrations from the western to the eastern North Pacific Ocean, spending up to several years of their juvenile stage in the east before returning to the Western Pacific Ocean (WPO).

While historical Pacific bluefin tuna catch records are scant, landing records from coastal Japan date back to as early as 1804 and to the early 1900s for U.S. fisheries operating in the Eastern Pacific Ocean (EPO). Estimated catches of PBF were high from 1929 to 1940, with a peak catch of approximately 59,000 mt in 1935 (47,000 mt and 12,000 mt in the eastern and western Pacific Ocean, respectively). Thereafter estimated catches dropped precipitously due to WWII. Estimated catches increased significantly in 1949 as Japanese fishing activities expanded across the North Pacific Ocean. By 1952 a more consistent catch reporting process was adopted by most fishing nations and annual catches widely from 1952-2011. During this period reported catch peaked at 40,383 mt in 1956 and reached a low of 8,653 mt in 1990. While a suite of fishing gears catch Pacific bluefin (PBF), the majority are caught in purse seine fisheries. Historical catches (1952-2011) are predominately comprised of juvenile PBF, and since the early 1990s the catch of age 0 PBF has increased significantly.

Population dynamics were estimated using a fully integrated age-structured model (Stock Synthesis v3.23b; SS) fitted to catch, size composition and catch-per-unit of effort (CPUE) data from 1952 to 2011 provided by ISC Pacific Bluefin Tuna Working Group (PBFWG) members. Life history parameters included a length-at-age relationship from otolith-derived ages and natural mortality estimates from a tag-recapture study.

Discussion

Discussion of some relevant aspects of the assessment: M in Age 0

The fishing year (and the basis of the year denotation) is July1-June 30. Recruitment has been specified as the number of Age 0's on July 1. Thus, Age 0's are subjected to a large natural mortality rate M=1.6 and a large F which is >0.4 for much of the time series. Additionally, fish are specified to recruit at about 25 cm and are ~60-70 cm at Age 1. Significant numbers of fish at about this size are caught in some fisheries as indicated by the selectivities and the historical catches (Report Fig 5-7) including relatively large selectivities at the smallest sizes ~25cm. Thus, the implication is that the fishing mortality rates in the July1-Sept 30 quarter are large (as is indicated in the assessment).

The assessment assumes that all density-dependence occurs prior to fishing in the April-June quarter. However, we have a rather large F on Age 0. So how the timing occurs relative to the mortality rates implied by the stock-recruitment relationship can make a difference. Is fishing occurring during periods of density dependence? The current assumption is that all the density-dependence occurs from April-June. There are options to include density-dependence during periods when F occurs (Forest et al. 2013, Powers and Brooks 2005, Brooks and Powers 2007). I believe that this sort of evaluation should be a standard practice when there are large catches of Age 0. This might have improved S-R fits and the selection of a density-dependent model, but who knows. Catches occurring during density dependence make a difference in benchmarks. But alas, the density-dependent discussion becomes moot, once steepness is specified as 0.999.

The Iwata et al. (ISC/12-1/PBFWG/13) study derives the estimate of M 0 based on an entire year with all the released tags in July, August and September. This report is an update of earlier work, adjusting the tag-shedding rates. This Iwata et al. study indicates that fishing mortality rates are included in the estimation model, but there is no discussion of their values. I could not access the previous report, so I am not sure what significance of the F's in the tagging model has. For future use, I recommend that the tagging model should be integrated directly into the assessment as another likelihood component.

The Working Group has had an ongoing discussion about Age 0 natural mortality rates (Report of the Pacific Bluefin Tuna Working Group Workshop. International Scientific Committee for Tuna and Tuna -Like Species in the North Pacific Ocean 6-13 January 2011. Shizuoka, Japan). There is a school of thought that the M 0's should be parsed into quarterly estimates with earlier quarters having higher M's. While I agree that the early M's are likely to be higher, I find that such an assumption opens the possibility that the early quarters are part of the density-dependent process.

I understand that the current procedure is a standard best practice in assessments. Nevertheless, I would like to see some exploration of this, i.e. the interaction between density-dependence and fishing in the first year of life.

Discussion of some relevant aspects of the assessment: current status and benchmarks

One standard diagnostic that I like (require?) is to plot the stock-recruit data and interpret them in terms of the history of the fishery and in terms of the % SPR replacement lines, the equilibrium R/S with no fishing, etc. But there is no place in the report where the current status is stated. All the F benchmark results are expressed as ratios without specifying a scale. I can infer what the current SPR is by looking at the depletion ratio (Scurrent/So) for the base case in ReportTable 5-5; and since recruitment is ~ constant (h=.999), this means that SPR=S/So is about 4%.

I attempted to recreate the S/R and SPR calculations using life history data and estimated fishing rate vectors. My rendition is in MyTable 1. I expect that this is not exact (wt at age vector may be a little off, I did not use quarterly increments, etc). Also, using parameters in MyTable 1, I computed equilibrium SPRs for every year (1952-2010) using the estimated F vectors in ReportTable 5-2. Results are in MyFigure 1-2.

The result of this for the average F2007-09 vector results in an equilibrium SPR of about 5%. When comparing this to FSPR's at 10% and 20%, these results are consistent with the results in the ReportTable 5.4. So I am reasonably confident that MyTable 1 is consistent with the assessment. The equilibrium So/Ro value is 25. When this is multiplied by Ro, then the result is So=372,696. I used the average R over the times series as a surrogate Ro using a steepness=.999 model.

MyFigure 1 implies that the equilibrium achieved under current F's and current recruitment will result in stable SSB; this is equivalent to the projection in the report using this scenario.

Using MyFigure 1, current S is about 5% of So and the S at the beginning of the series (1950's) was about 1/3 of So. The current (2007-09) replacement lines imply that the equilibrium achieved under current F's and current recruitment will result in stable SSB; this is equivalent to the projection in the report using this scenario. Indeed, since h=0.999 all of the projections are simply transitional Y/R and S/R since recruitment does not change.

The 2007-09 equilibrium SPR was close to the lowest on record, although it increased in the last two years. Interestingly, there was an extended period of low equilibrium SPRs in the 1970s and 1980s and after reductions in mortality the SSB responded to near the historical high.

While the current Fs are well above standard benchmarks, perusal of the figure raises important questions. There appears to be adequate historical bases for why the SPRs in the 1950s were not higher than 0.3 (periods of very high catch, primarily of age 0 prior to 1952). However, even though SPRs were very low and Fs were very high in the 1970s-80s, the stock still responded relatively rapidly once mortalities decreased. Was this just luck or are our perceptions of acceptable F's wrong? These are important questions which arise from examining the S-R plots. I recommend that they be included in assessment reports.

Also it was my understanding that the tuna RFMOs required "Kobe" plots (phase diagrams of S/Slimit versus F/Flimit. I understand that the WPFC and IATTC are currently going through the process of defining targets and limits. Therefore, I understand the reluctance of the WG to provide Kobe plots. However, these can be presented without the limit scale as in MyFigure 2. While MyFigure 2 is in an absolute scale, it will be a simple transformation of both scales once limits are chosen. Thus, the relative dynamics won't change.

These are important questions which arise from examining the S-R plots. I recommend that they be included in assessment reports along with the "Kobe" plots.

It is important to note the implications of using h=0.999 in the assessment model. I am sure that the assessment scientists are aware of the issues but sometimes I think it is lost in interpreting results of management benchmarks.

Assessments do not assume that steepness h is 0.999. Rather they make the evaluation that there is no trend/contrasts in the data to determine steepness and the best approximation for estimating dynamics over the *range of the data* is to assume a linear (horizontal) relationship between R and S. Specifying 0.999 is just a mechanical convenience for implementing the linear approximation.

Nevertheless there are inherent implications in making this assumption. Most important is that stock sizes have not declined to a level at which recruitment is impaired, especially in the latter years. An assessment estimates deviations around the horizontal line and is choosing the height of the line based upon fits to everything else.

But there are some inherent inconsistencies in arguing on the one hand that spawning biomass was not low enough to increase the probability of low recruitment (h=0.999) and arguing on the other hand that current SPRs and Fs are beyond benchmarks such that recruitment might be impaired. This comment is addressed to all assessments not just the Pacific BFT assessment in particular. What I am saying is that h=0.999 can be (and often is) a reasonable approximation for estimating historical dynamics but that one must be a bit circumspect in converting that to scientific advice about limits.

Common benchmarks are determined from the smallest S/R or SPR at which recruitment will/will not be impaired. For example, if the current SPR were 30% and there were periods that they were lower, then one could make the argument that the S/R or SPR limit could be lower than 30% because the stock experienced those low SPRs and still recovered. Therefore, there were levels < 30% at which the stock responded and de facto that level might be specified as a precautionary limit. Then targets may be specified proportional to the limit.

However, if the current SPR is at or near the all time low, then the argument deteriorates. One can't be sure that the stock will recover from the current low. In that case one makes the argument based on standard practices (typical benchmarks), recognizing that there are inconsistencies between this assumption and the horizontal approximation.

But there is still the mitigating factor that in the past, the stock experienced SPRs near the current low and still responded. This appears to be the case for Pacific BFT.

Additionally, definition of a limit is not solely a scientific process. A limit does not exist without some management action associated with it. What are the management actions taken if a limit is exceeded?

I am sure that the above will be important discussions in the process of defining targets/limits and control rules in the near future.

Discussion of some relevant aspects of the assessment: other

There are a number of outstanding issues about technical aspects of the assessment as outlined in: (Report of the Pacific Bluefin Tuna Working Group Workshop. International Scientific Committee for Tuna and Tuna -Like Species in the North Pacific Ocean 6-13 January 2011. Shizuoka, Japan). These include the weighting of size samples, aspects of CPUE standardization, estimation of catches of minor fleets, etc. I do not have any comments to suggest any improvements. Such things are best left with the ongoing investigations of the Working Group.

Additionally, as with most projections in stock assessments, recruitment process error and measurement error are assumed to be constant. This is a "best practice" in stock assessments and perfectly acceptable. However, in the context of integrating ecosystem effects into stock assessments, one effect might occur through the stock-recruitment process. Therefore, possible changes in process error (ecosystem effects) might be evaluated during projections. In current assessments because of constant variability assumptions, the variance determinations tend to stabilize over time; whereas logically one would expect that they always be increasing. This affects the probabilities of status determination in the future.

Summary of Findings for each ToR in which the weaknesses and strengths are described

This summary of findings essentially is a synthesis of the discussions above. My comments are organized as responses to each ToR. However, because of considerable overlap in the listed ToRs many of the answers are redundant.

1. Review the assessment methods to provide recommendations on how to improve its application, and/or recommend other methods that would also be appropriate for the species, fisheries, and available data.

Response:

My recommendations include: evaluating natural mortality rates of Age 0 including density-dependent relationships; integrating tagging data into the assessment model; including S-R plots as a standard diagnostic as with "Kobe" plots; evaluate alternative error structures for future projections.

2. Evaluate the assessment model configuration, assumptions, and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration.

Response:

My major suggestions for alternative model structure are: natural mortality rates of Age 0 including density-dependent relationships; integrating tagging data into the assessment model; and to evaluate alternative error structures for future projections.

3. Provide recommendations on improving the treatment of assumptions (e.g. sensitivity analyses) and description of uncertainty in estimates of stock dynamics and management quantities (e.g. reference points).

Response:

At this stage management has not established either target or limit benchmarks. Therefore, this assessment did not address this extensively. However, it is expected (and I recommend) that once these are chosen, then probability density functions be generated of current status relative to benchmarks and catch over the ensuing 2-3 years at the benchmarks, under various levels of management risk-taking.

4. Provide recommendations on improving the adequacy, appropriateness, and application of the methods used to project future population status.

Response:

The projection methodology is adequate, it being a standard part of the software. I might note that one can see the general effects of alternative F's by simply examining the S-R plots without doing projections. However, more detailed fisheries specific scenarios are often required, and thus, so too are the projections.

Additionally, as with most projections in stock assessments, recruitment process error and measurement error are assumed to be constant. This is a "best practice" in stock assessments and perfectly acceptable. However, in the context of integrating ecosystem effects into stock assessments, one effect might occur through the stock-recruitment process. Therefore, possible changes in process error (ecosystem effects) might be evaluated during projections.

5. Suggest research priorities to improve the stock assessment including data, life history and modelling.

Response:

As with most stocks, research priorities for Pacific bluefin include estimation of natural mortality rates (perhaps through continued tagging), direct aging of bluefin, improved size sampling, estimation of reproductive behavior (fecundity/maturity/spawning), continued evaluation of CPUE standardization. I do not know the financial/organizational feasibility of these priorities.

In terms of modelling, I suggest: that the consequences of density-dependence in the first year of life and the associated natural mortality rate be explored; that Age 0 tagging data be integrated into the assessment and that the evaluation of limit benchmarks be examined in the context of observed bluefin dynamics.

Conclusions and Recommendations in accordance with the ToRs.

The assessment of Pacific bluefin tuna is a relatively recent process starting in 2008. Since then a great deal of progress has been made in organizing data, focusing research and stabilizing the assessment methodologies. The current report indicates that progress. As such, the current assessment provides the best scientific information available.

Nevertheless, suggestions for further investigation which might be fruitful are listed below. These conclusions and recommendations are required to be related to the ToRs. As such, the rest of the Conclusions and Recommendations section is required to be associated with the ToRs. Therefore, they should be the same as the Summary of Findings, as they are:

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My recommendations include: evaluating natural mortality rates of Age 0 including density-dependent relationships; integrating tagging data into the assessment model; including S-R plots as a standard diagnostic as with “Kobe” plots; evaluate alternative error structures for future projections.

Evaluate the assessment model configuration, assumptions, and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration.

My major suggestions for alternative model structure are: natural mortality rates of Age 0 including density-dependent relationships; integrating tagging data into the assessment model; and to evaluate alternative error structures for future projections.

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At this stage management has not established either target or limit benchmarks. Therefore, this assessment did not address this extensively. However, it is expected (and I recommend) that once these are chosen, then probability density functions be generated of current status relative to benchmarks and catch over the ensuing 2-3 years at the benchmarks, under various levels of management risk-taking.

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In terms of modelling, I suggest the following:

- The consequences of density-dependence in the first year of life and the associated natural mortality rate be explored
- Age 0 tagging data be integrated into the assessment
- The evaluation of limit benchmarks be examined in the context of observed bluefin dynamics.

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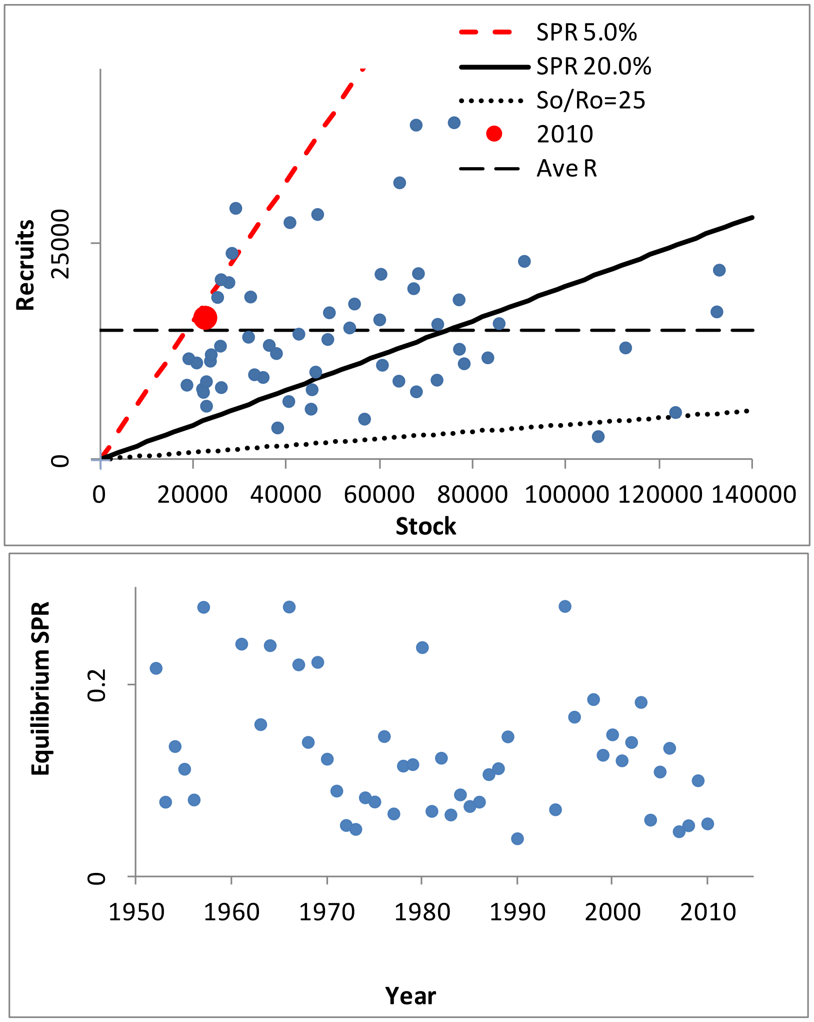
http://isc.ac.affrc.go.jp/pdf/ISC11pdf/Annex_5_ISC11_PBFWG-1_FINAL.pdf

Figures and Tables

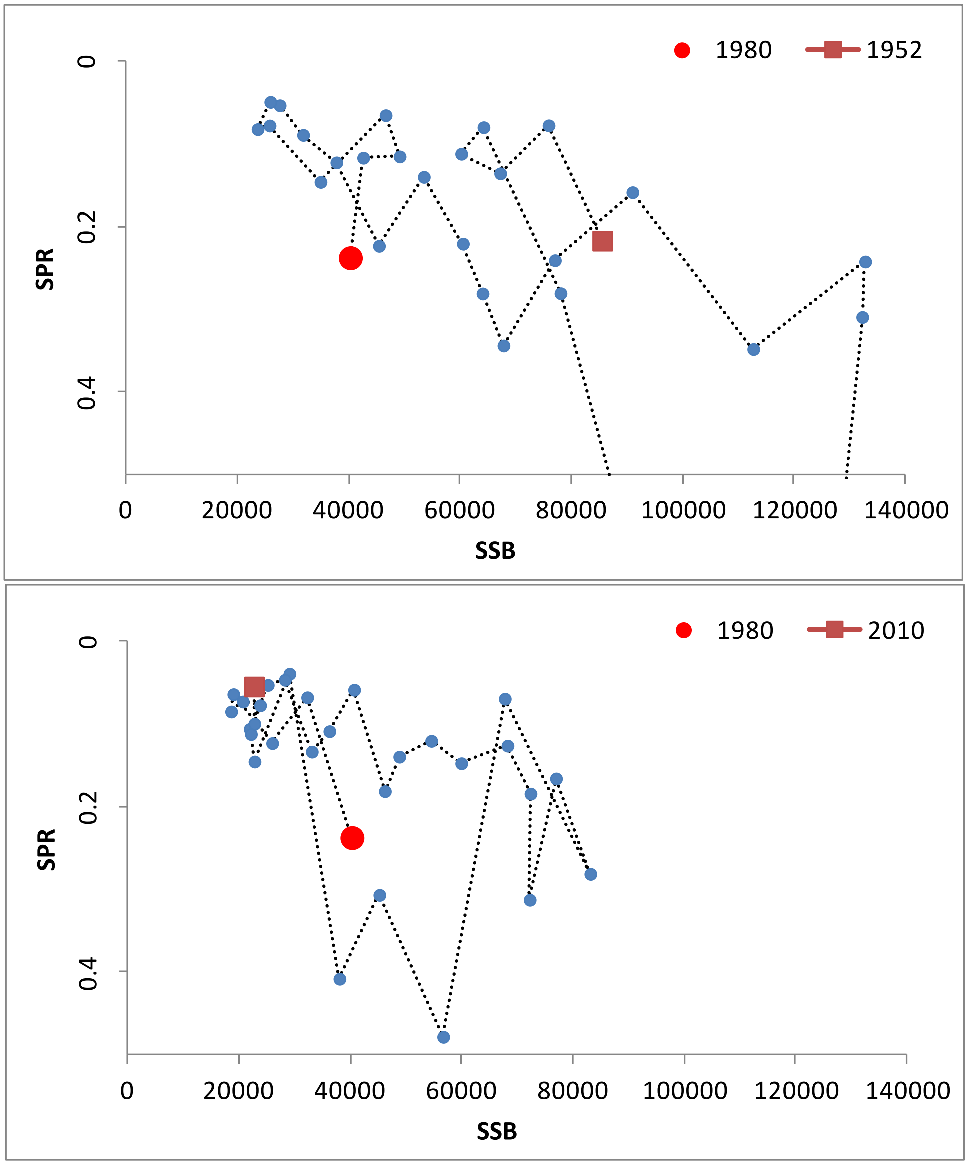
Table MyTable 1. Spreadsheet estimation of SPR and So for the average 2007-09 F.

				SPR					
Linf	254.4137	L2	109.194	0.0532	R ave=	14988	So/Ro		S/R
K	0.157473	L1	21.5		S0=	372696	25		1.324
W=aL^b									
a:	1.71E-05	A1	0						
b	3.0382	A2	3		2007-9	No F	No F	With F	With F
Age	M	Lage	Mature	Wage	F Year	Nage	SSBage	Nage	SSBage
0	1.6	21.5	0	0.1913	0.5200	1.0000	0.0000	1.0000	0.0000
1	0.386	55.43564	0	3.3994	1.0300	0.2019	0.0000	0.1200	0.0000
2	0.25	84.42683	1	12.2028	0.6300	0.1372	0.8374	0.0291	0.1777
3	0.25	109.194	1	26.6614	0.2800	0.1069	1.4249	0.0121	0.1611
4	0.25	130.3526	1	45.6651	0.1500	0.0832	1.9006	0.0071	0.1624
5	0.25	148.4283	1	67.7532	0.1500	0.0648	2.1962	0.0048	0.1615
6	0.25	163.8705	1	91.5216	0.1500	0.0505	2.3104	0.0032	0.1462
7	0.25	177.0627	1	115.7943	0.1500	0.0393	2.2766	0.0021	0.1240
8	0.25	188.3327	1	139.6713	0.1500	0.0306	2.1386	0.0014	0.1003
9	0.25	197.9608	1	162.5153	0.1500	0.0238	1.9379	0.0010	0.0782
10	0.25	206.186	1	183.9119	0.1500	0.0186	1.7080	0.0006	0.0593
11	0.25	213.2128	1	203.6236	0.1500	0.0145	1.4727	0.0004	0.0440
12	0.25	219.2158	1	221.5463	0.1500	0.0113	1.2479	0.0003	0.0321
13	0.25	224.3441	1	237.6713	0.1500	0.0088	1.0426	0.0002	0.0231
14	0.25	228.7253	1	252.0554	0.1500	0.0068	0.8611	0.0001	0.0164
15	0.25	232.4681	1	264.7969	0.1500	0.0053	0.7046	0.0001	0.0116
16	0.25	235.6656	1	276.0183	0.1500	0.0041	0.5720	0.0001	0.0081
17	0.25	238.3972	1	285.8538	0.1500	0.0032	0.4613	0.0000	0.0056
18	0.25	240.7308	1	294.4403	0.1500	0.0025	0.3701	0.0000	0.0039
19	0.25	242.7244	1	301.9113	0.1500	0.0020	0.2955	0.0000	0.0027
20	0.25	244.4276	1	308.3937	0.1500	0.0015	0.2351	0.0000	0.0018
21	0.25	245.8825	1	314.0050	0.1500	0.0012	0.1864	0.0000	0.0012
22	0.25	247.1255	1	318.8526	0.1500	0.0009	0.1474	0.0000	0.0008
23	0.25	248.1874	1	323.0335	0.1500	0.0007	0.1163	0.0000	0.0006
24	0.25	249.0946	1	326.6342	0.1500	0.0006	0.0916	0.0000	0.0004
25	0.25	249.8696	1	329.7316	0.1500	0.0004	0.0720	0.0000	0.0003
26	0.25	250.5317	1	332.3932	0.1500	0.0003	0.0565	0.0000	0.0002
27	0.25	251.0973	1	334.6784	0.1500	0.0003	0.0443	0.0000	0.0001
28	0.25	251.5805	1	336.6390	0.1500	0.0002	0.0347	0.0000	0.0001
29	0.25	251.9933	1	338.3200	0.1500	0.0002	0.0272	0.0000	0.0001

30	0.25	252.346	1	339.7605	0.1500	0.0001	0.0213	0.0000	0.0000
31	0.25	252.6472	1	340.9944	0.1500	0.0001	0.0166	0.0000	0.0000
32	0.25	252.9046	1	342.0509	0.1500	0.0001	0.0130	0.0000	0.0000
33	0.25	253.1245	1	342.9553	0.1500	0.0001	0.0101	0.0000	0.0000
34	0.25	253.3123	1	343.7291	0.1500	0.0000	0.0079	0.0000	0.0000
35	0.25	253.4728	1	344.3911	0.1500	0.0000	0.0062	0.0000	0.0000
36	0.25	253.6099	1	344.9573	0.1500	0.0000	0.0048	0.0000	0.0000
37	0.25	253.727	1	345.4415	0.1500	0.0000	0.0038	0.0000	0.0000
38	0.25	253.8271	1	345.8556	0.1500	0.0000	0.0029	0.0000	0.0000
39	0.25	253.9125	1	346.2095	0.1500	0.0000	0.0023	0.0000	0.0000
40	0.25	253.9856	1	346.5121	0.1500	0.0000	0.0018	0.0000	0.0000
41	0.25	254.0479	1	346.7707	0.1500	0.0000	0.0014	0.0000	0.0000
42	0.25	254.1012	1	346.9918	0.1500	0.0000	0.0011	0.0000	0.0000
43	0.25	254.1468	1	347.1807	0.1500	0.0000	0.0008	0.0000	0.0000
44	0.25	254.1857	1	347.3422	0.1500	0.0000	0.0007	0.0000	0.0000
45	0.25	254.2189	1	347.4802	0.1500	0.0000	0.0005	0.0000	0.0000
46	0.25	254.2473	1	347.5981	0.1500	0.0000	0.0004	0.0000	0.0000
47	0.25	254.2715	1	347.6988	0.1500	0.0000	0.0003	0.0000	0.0000
48	0.25	254.2922	1	347.7849	0.1500	0.0000	0.0002	0.0000	0.0000
49	0.25	254.3099	1	347.8584	0.1500	0.0000	0.0002	0.0000	0.0000
50	0.25	254.3251	1	347.9213	0.1500	0.0000	0.0001	0.0000	0.0000



MyFigure 1.Top: S-R data and equilibrium replacement lines. These were calculated from MyTable 1 and S-R data from ReportTable 5-1. Bottom: equilibrium SPRs.



MyFigure 2. Phase plots of SSB versus SPR

Appendix 1: Bibliography of materials provided for review

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Appendix 2. Statement of Work

External Independent Peer Review by the Center for Independent Experts
Stock assessment of Pacific bluefin tuna in the North Pacific Ocean

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Representative (COR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: Pacific bluefin tuna in the North Pacific Ocean (NPO) are harvested multi-nationally primarily using purse-seine, troll and set net gear. The U.S. catches bluefin mostly in sport fishery and incidentally in the albacore troll and pole-and-line fishery. An assessment of Pacific bluefin tuna in the North Pacific Ocean was conducted by NMFS staff of the Southwest Fisheries Science Center and collaborating scientists from members of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), within the ISC's Pacific Bluefin Working Group (PBFWG) in 2012. Results of the 2012 assessment indicate that the 2010 biomass is near the lowest since 1952 (22,606 mt) and at about 3.6% of the unfished levels. Fishing mortality for 2007-09 period was high and above all calculated biological reference points; Fishing mortality increased since the last assessment period of 2002-04. Population dynamics were estimated using a fully integrated age-structured model (StockSynthesis v3.23b; SS) fitted to catch, size composition, and catch-per-unit of effort (CPUE) data from 1952 to 2011 provided by PBFWG members. Life history parameters included a length-at-age relationship from otolith-derived ages and natural mortality estimates from a tag-recapture study. The assessment provides the basis for scientific advice on the status of the Pacific bluefin tuna stock and will be the foundation for international management decisions of the Inter-American Tropical Tuna Commission and Western and Central Pacific Fisheries Commission and its Northern Committee, and domestic management decisions by the Pacific Fishery Management Council (PFMC). An independent peer review of the assessment will provide valuable feedback to the PBFWG in conducting future assessments. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have expertise, working knowledge, and recent experience in various subject areas involved in the review: tuna biology; analytical stock assessment, including population dynamics theory, integrated stock assessment models, and estimation of biological reference points; and Stock Synthesis and AD Model Builder. Scientists employed by or have significant interactions with the Inter-American Tropical Tuna Commission (IATTC) and the Western and Central Pacific Fisheries Commission (WCPFC), and the Secretariat of the Pacific Community (SPC), should not be considered as reviewers. Scientists associated with the ISC also should be excluded as reviewers. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a "desk" review of the necessary documentation of the current assessment of Pacific bluefin tuna. Therefore, no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COR, whom forwards this information to the NMFS Project Contacts no later than the date specified in the Schedule of Milestones and Deliverables. Any changes to the SoW or ToRs must be made through the COR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact must send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports of the current assessment and sensitivity analyses to be peer reviewed. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Documents will include: The PBFWG stock assessment report and some working papers. **Please note that supporting documentation for the review is confidential and reviewers are not to circulate these documents.**

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs shall not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report addressing each ToRs in accordance with the SoW.

Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contacts in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than 7 June 2013, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and to Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. Each CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

6 May 2013	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact
15 May 2013	NMFS Project Contact sends the CIE Reviewers the report and background documents
16 – 31 May 2013	Each reviewer conducts an independent peer review as a desk review
7 June 2013	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
21 June 2013	CIE submits the CIE independent peer review reports to the COR
28 June 2013	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on substitutions. The COR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards:
(1) Each CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) Each CIE report shall address each ToR as specified in **Annex 2**,
(3) The CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon acceptance by the COR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COR. The COR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Support Personnel:

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Roger W. Peretti, Executive Vice President
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Key Personnel - NMFS Project Contact:

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall 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 main body of the reviewer report shall consist of a Background and Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

Stock assessment of Pacific bluefin tuna

1. Review the assessment methods to provide recommendations on how to improve its application, and/or recommend other methods that would also be appropriate for the species, fisheries, and available data.

2. Evaluate the assessment model configuration, assumptions, and input parameters (fishery, life history, and spawner recruit relationships) to provide recommendations on how to improve: the use of data, specification of fixed input parameters, and specification of model configuration.

3. Provide recommendations on improving the treatment of assumptions (e.g. sensitivity analyses) and description of uncertainty in estimates of stock dynamics and management quantities (e.g. reference points).

4. Provide recommendations on improving the adequacy, appropriateness, and application of the methods used to project future population status.

5. Suggest research priorities to improve the stock assessment including data, life history and modelling.

Please note that supporting documentation for the review is confidential and reviewers are not to circulate these documents.