

A Center for Independent Experts (CIE) Independent Peer Review Report: Time-Area Closures In the Hawaii-Based Longline Swordfish Fishery

by

Jon M. Conrad

Executive Summary

The CIE Review Team met with PIFSC scientists from 28th – 30th June 2010 to evaluate research into the use of time-area closures to limit the interaction between loggerhead and leatherback turtles and the Hawaii-based longline swordfish fleet. The simulation model described in Li and Pan (2009) is a considerable improvement over Kobayashi and Polovina (2005). The model has been updated to predict the impact on net revenue and to account for the reduced rates of turtle interaction resulting from the switch from J-hooks baited with squid to circle-hooks baited with mackerel. It is the only bioeconomic analysis that accounts for this relatively recent change in gear and it presents the best scientific analysis currently available.

Like all models, the model in Li and Pan (2009) can be improved. It would benefit from the development of an effort re-allocation sub-model. When an area or combination of areas is closed to the swordfish fleet, the effort re-allocation sub-model would allocate displaced effort to the next highest net-revenue area in that month or later in the year.

Based on recent trends, the number of shallow sets in the Hawaii-based longline swordfish fishery appears to also depend on the net revenue that can be obtained using a deeper longline set for bigeye tuna. Specifically, the decline in the relative price of swordfish, and thus swordfish net revenue, has caused a switch from shallow sets for swordfish to deeper sets for bigeye tuna. The recent reduction in the number of shallow sets has also contributed to fewer turtle interactions. In the future, it would be useful to develop a model that would predict shallow swordfish sets and deeper bigeye tuna sets as a function of the net revenue that can be obtained in each fishery, sea turtle caps, and future regulations on bigeye tuna in the western Pacific.

Terms of Reference for the Peer Review

1. Approach and Methodology

The simulation model in Li and Pan (2009) uses a modified version of the generalized additive model (GAM) developed by Kobayashi and Polovina (2005) to predict the number of sea turtle interactions with Hawaiian-based longline vessels fishing for swordfish. Given a spatial and temporal (monthly) distribution of fishing effort (shallow longline sets) the modified model can predict the number of sea turtle interactions by location and month as well as the net revenue earned by the longline swordfish fleet. The modified model is an improvement over Kobayashi and Polovina (2005) which only predicted gross revenue and did not include a sub-model to estimate of the variable cost

of fishing. This is a significant improvement because the appropriate *opportunity cost* of time-area closures is net revenue. The model is also an improvement because turtle interaction rates have been recalibrated to account for the change from J-hooks to circle-hooks; a change which has greatly reduced turtle interaction rates. The modified model identifies annual net revenue and the likely number of loggerhead and leatherback turtle interactions for a given combination of time-area closures. The model allows one to estimate the likely reduction in net revenue if one wishes to reduce the number of loggerhead or leatherback turtle interactions.

The only shortcoming of the methodology in Li and Pan (2009) is that it fails to account for the behavioral response of fishers to a particular combination of time-area closures. In the current model, effort that is displaced when an area is closed is reallocated to open areas based on the historical effort levels in those areas. In reality, if certain areas are closed to swordfishing, fishers will likely re-optimize to fish in open areas with the highest expected net revenue. While it is possible to develop a behavioral model of time-area choice by fishers (see Curtis and Hicks 2000), it may be difficult to integrate such a model into the current GAMS-net revenue model. The fact that fishers will respond (re-optimize) to a particular pattern of time-area closures has two important implications for the predictions in Li and Pan (2009). Re-optimization means that the actual reduction in net revenue is likely to be *less than predicted*, but the actual number of turtle interactions is likely to be *more than predicted*. In other words, the opportunity cost of a particular time-area closure will likely to be *lower* than predicted while the reduction in turtle interactions is likely to be *smaller* than predicted. That said, the methodology of Li and Pan (2009) is certainly a reasonable and useful approach to managing the by-catch of protected species using time-area closures.

2. Data

The model in Li and Pan (2009) makes use of unique data sets from vessel log books, cost surveys, auction price-quantity data, and observer reports of turtle interactions. It is not often that biologists and economists have such extensive data sets. They allow one to estimate, by location and month, swordfish harvest, variable harvest cost, and turtle interactions as a function of effort (number of shallow longline sets) and other exogenous variables. The quality of the data is excellent.

3. An Alternative Modeling Approach

The problem might be more appropriately formulated as a *stochastic dynamic programming problem*, where loggerhead and leatherback turtle interactions (the stochastic state variables) accumulate over time until the shallow set limit or a turtle interaction limit is reached. The simulation model depicted in Figure 2, page 16, in Li and Pan (2009) is useful but does not identify the *optimal adaptive time-area closures* as turtle interactions increase during a particular year. Formulating and solving for the optimal sequence of closures as a function of cumulative loggerhead and leatherback turtle interactions is a very difficult problem. The binary optimization problem described below provides yet another methodology for solving for the combination of time-area

closures that maximizes net revenue while not exceeding the turtle caps. It can be solved with a mixed integer programming package such as CPLEX.

Let:

$A_{i,m,t} = \{0,1\}$ be a binary choice variable where $A_{i,m,t} = 1$ indicates that area i is *open* in month m during year t and $A_{i,m,t} = 0$ indicates that area i is *closed* in month m during year t , $i = 1,2,\dots,I$ and $m = 1,2,\dots,12$,

$E_{i,m,t}$ be the expected number of sets in area i in month m in year t ,

$N_{i,m,t}$ be the expected net revenue from $E_{i,m,t}$ sets in area i in month m in year t ,

$LH_{i,m,t}$ be the expected number of loggerhead turtle interactions from $E_{i,m,t}$ sets in area i in month m in year t ,

$LB_{i,m,t}$ be the expected number of leatherback turtle interactions from $E_{i,m,t}$ sets in area i in month m in year t ,

E_t be the cap on the number of sets in year t ,

LH_t be the cap on the number of loggerhead interactions in year t ,

LB_t be the cap on the number of leatherback interactions in year t .

Then in a particular year t , conditional on the location of the 65.5° SST isotherm and the matrices $E_{i,m,t} \geq 0$, $N_{i,m,t} \geq 0$, $LH_{i,m,t} \geq 0$, $LB_{i,m,t} \geq 0$, one would wish to

$$\begin{aligned}
 & \underset{A_{i,m,t} \in \{0,1\}}{\text{Maximize}} \quad N_t = \sum_{m=1}^{12} \sum_{i=1}^I A_{i,m,t} \cdot N_{i,m,t} \\
 & \text{Subject to} \quad \sum_{m=1}^{12} \sum_{i=1}^I A_{i,m,t} \cdot E_{i,m,t} \leq E_t \\
 & \quad \sum_{m=1}^{12} \sum_{i=1}^I A_{i,m,t} \cdot LH_{i,m,t} \leq LH_t \\
 & \quad \sum_{m=1}^{12} \sum_{i=1}^I A_{i,m,t} \cdot LB_{i,m,t} \leq LB_t \\
 & \quad E_{i,m,t} \geq 0, N_{i,m,t} \geq 0, LH_{i,m,t} \geq 0, LB_{i,m,t} \geq 0, \text{ given.}
 \end{aligned}$$

Comments on the above alternative model

For 2°X2° areas within 20° N to 40° N and 140° W to 180°, $I = 200$ and there would be $200 \cdot 12 \cdot 2 = 4,800$ time-area closure combinations. A problem of this size should be easily solved in CPLEX.

The above problem assumes that $E_{i,m,t} \geq 0$, $N_{i,m,t} \geq 0$, $LH_{i,m,t} \geq 0$, $LB_{i,m,t} \geq 0$ can be generated each year from the GAM, the existing simulation model, or a behavioral-choice model of time-area fishing decisions by the Hawaiian longline swordfish fleet. When areas are closed in a particular month a sub-model would need to re-allocate displaced effort to open areas during that month or to open areas later in the year.

4. Best Available Science?

Is the modified model in Li and Pan (2009) the best available science? The simple answer is “Yes.” Could the model be improved? “Yes.” As noted above, the most important addition to the model would be to build a sub-model which would re-allocate fishing effort to the highest open net revenue areas during that month or later in the year. This is not a trivial sub-model, and because it has not been done, the existing model in Li and Pan (2009) is currently the best available science for determining the impact on net revenue from time area closures to reduce turtle interactions.

5. A Viable Modeling Framework for Other Protected Species?

The simulation model in Li and Pan (2009) does provide a viable framework for time-area closure models for other protected species. The spatial and temporal interactions between the commercially harvested species and the protected species will obviously vary from case to case and may require changes in the underlying biological and economic sub-models. Also, the present model does not attempt to *dynamically model* swordfish, loggerhead, or leatherback turtle populations over time. Population dynamics may be important in determining the best pattern of time-area closures when modeling other protected species.

6. Further Improvements

It seems clear that the change to circle hooks and a switch in bait from squid to mackerel has resulted in a dramatic reduction in turtle interactions, perhaps obviating the need for time-area closures in the Hawaiian longline swordfish fishery. In the first six months of 2010, only two leatherback turtle interactions (against a cap of 16) and 4 loggerhead turtle interactions (against a cap of 46) have taken place. Aside from the change in hooks and bait, there may be other factors at work. It would appear that net revenue in the Hawaiian longline swordfish fishery has declined relative to the bigeye tuna fishery. See Table 1 below.

With a decline in net revenue from swordfish relative to bigeye tuna, there would be a decline in the number of swordfish shallow sets (effort) and in the number of turtle

interactions. Turtles have definitely benefited from circle hooks and the switch from squid to mackerel as bait, but they may also be benefiting from reduced demand and a lower price for swordfish. If the catch of bigeye tuna in the Hawaiian longline fleet is restricted in the future, Hawaiian vessels now fishing for tuna with deep longline sets may switch back to swordfish using shallow sets. It might be useful to develop a model where vessels can switch from swordfish to tuna, and *vice versa*, with a change in the relative net revenue of swordfish and bigeye tuna or a change in regulations.

Table 1. Number of Shallow Sets, Swordfish Landings, Swordfish Price, Bigeye Tuna Price, Relative Price Ratio, and Leatherback and Loggerhead Interactions

Year	Number of Sets x10 ³	Swordfish Landings (x10 ³ pounds)	Swordfish price, P _s (\$/lb)	Bigeye tuna price P _b (\$/lb)	P _s /P _b	Leatherback Interactions	Loggerhead Interactions
2004	135	549	2.36	2.92	0.81	1	1
2005	1645	3527	2.26	3.30	0.68	8	12
2006	850	2573	2.04	3.38	0.60	1	17**
2007	1570	3781	2.12	3.26	0.65	5	15
2008	1597	4285	1.87	3.71	0.50	2	0
2009	1762	3881	1.89	3.66	0.52	9	3
2010*	1233					2	4

*The number of sets and turtle interactions are for the period January 1st through June 25th, 2010.

**In 2004 the loggerhead cap was reached on March 17th and the swordfish fishery was closed.

7. Description of Panel Proceedings

During the first day, Monday, 28th June, Center Director, Sam Pooley, welcomed the review team. Review team members and PIFSC scientists introduced themselves and each gave a brief biographical sketch. For the rest of the morning and in the afternoon Dr. Minling Pan provided background information on the swordfish fishery and the protected species of sea turtles that interact with swordfish gear. For the rest of the morning and that afternoon, Dr. Pan discussed the data, described the simulation model, and presented the predicted turtle interactions and fleet net revenue for the time-area closure options considered in Li and Pan (2009). On Tuesday morning, 29th June, the review team had a chance to ask more detailed questions and to discuss the possible form of an effort re-allocation sub-model. At noon the review team Dr. Pan and Ms. Sarah Malloy went to Pier 38 in the Honolulu Harbor to see vessels that longline for swordfish and/or bigeye tuna.

On Tuesday afternoon the review team returned to the hotel to independently work on their peer review reports. On Wednesday morning, 30th June, the review team reconvened back at the PIFSC to ask additional questions about the recent status of the swordfish and bigeye tuna fisheries and to continue to work on their individual peer review reports.

The review format was effective but might have been compressed to two or two and one-half days instead of three full days. It is hard to know in advance how much time will be

needed to present background information, data, model structure, and analysis and to then identify and discuss relevant issues and model improvements. Overall, I think it was a good review, with both the reviewers and the PIFSC scientists knowing more at the end than they did at the start.

Appendix 1: References

Curtis, R. and Hicks, R. L. 2000. "The Cost of Sea Turtle Preservation: The Case of Hawaii's Pelagic Longliners," *American Journal of Agricultural Economics*, 5:1191-1197.

Kobayashi, D. R. and Polovina, J. J. 2005. "Evaluation of Time-Area Closures to Reduce Incidental Sea Turtle Take in the Hawaii-Based Longline Fishery: Generalized Additive Model (GAM) Development and Retrospective Examination," NOAA Technical Memorandum NMFS-PIFSC-4.*

Li, S. and Pan, M. 2009. "Fishing Opportunities Under the Sea Turtle Interaction Caps – A Spatial Bio-economic Model for the Hawaii-Based Longline Swordfish Fishery," Working Paper, PIFSC, Honolulu, Hawaii.*

*PDFs of Kobayashi and Polovina (2005) and Li and Pan (2009) were provided to the review panel prior to the CIE Review.

Statement of Work for Dr. Jon M. Conrad

External Independent Peer Review by the Center for Independent Experts

Economic Programming Model of Time-Area Allocation

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages 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 Technical Representative (COTR), 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.com.

Project Description: PIFSC has developed several fisheries oceanography models of time-area distribution of swordfish and loggerhead turtles relative to management of the Hawaii longline fishery. Based on these models, the PIFSC economics program has developed models that estimate the economic trade-offs of various time-area closure options. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**. The tentative agenda of the panel review meeting is attached in **Annex 3**.

Requirements for CIE Reviewers: Two CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of fisheries economics, especially with experience in spatial-temporal economic models in support of fisheries management and decision making. Each CIE reviewer's duties shall not exceed a maximum of 14 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 during the panel review meeting scheduled in Honolulu, Hawaii during 28-30 June 2010.

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 COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, foreign national security clearance, and other information concerning pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website: <http://deemedexports.noaa.gov/sponsor.html>).

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. 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.

Panel Review Meeting: 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 can not be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** Each CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified herein. The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The NMFS Project Contact is responsible for ensuring that the Chair understands the contractual role of the CIE reviewers as specified herein. The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report 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 Contact in advance of the peer review.
- 2) Participate in a panel review meeting in Honolulu, Hawaii during 28-30 June 2010.
- 3) During 28-30 June 2010 in Honolulu, Hawaii as specified herein, conduct an independent peer review in accordance with the ToRs (**Annex 2**).
- 4) No later than 16 July 2010, 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 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.

17 May 2010	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
24 May 2010	NMFS Project Contact sends the CIE Reviewers the pre-review documents
28-30 June 2010	Each reviewer participates and conducts an independent peer review during the panel review meeting
16 July 2010	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
30 July 2010	CIE submits CIE independent peer review reports to the COTR
6 August 2010	The COTR 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 COTR within 10 working days after receipt of all required information of the decision on substitutions. The COTR 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 COTR 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 COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR 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 be 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 COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the CIE reports to the NMFS Project Contact and Center Director.

Key Personnel:

William Michaels, Contracting Officer's Technical Representative (COTR)
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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, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.
 - a. Reviewers should describe in their own words the review activities completed during the panel review meeting, including providing a brief summary of findings, of the science, conclusions, and recommendations.
 - b. Reviewers should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.
 - c. Reviewers should elaborate on any points raised in the Summary Report that they feel might require further clarification.
 - d. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.
 - e. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.
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
 - Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review

Economic Programming Model of Time-Area Allocation

1. Evaluate and comment on the impact modeling approach and methodology.
2. Comment on the overall quantity and quality of data used in the model.
3. Evaluate model assumptions, estimates, and major sources of bias or uncertainty. Specifically, recommend improvements including alternative modeling approach, data sources or uses as appropriate.
4. Insert an explicit statement as to whether this model represents the best available science for estimating trade-off between reduction of sea turtle interaction and economic return to the Hawaii swordfish fishery.
5. Insert an explicit statement as to whether this model represents a viable modeling framework upon which other protected species (in addition to the sea turtle) interacting with this fishery can be added as needed in the future.
6. Recommendations for any further improvements given data limitations.
7. Brief description of panel review proceedings highlighting pertinent discussions, issues, effectiveness, and recommendations.

Appendix 3: Panel Membership

Jon M. Conrad, Professor, Applied Economics and Management, Cornell University,
Ithaca, New York, 14853, USA.

Ragnar Arnason, Professor, Faculty of Economics and Business Administration,
University of Iceland, Reykjavik, Iceland.