Modeling Larval Transport and Connectivity in Hawaiian Waters

CIE Independent Peer Review Report

Dr. Kenneth Frank

I. Executive Summary

Computer simulation modeling has been undertaken at the Pacific Islands Fisheries Science Center (NOAA/NMFS) to address insular species issues of metapopulation connectivity and larval transport in the Hawaiian Archipelago. These approaches utilize a variety of remotely-sensed and modeled oceanographic data in a lagrangian modeling framework. These activities have taken place within the Ecosystems and Oceanography Division at the Science Center (Project Leader: Fishery Biologist Donald R. Kobayashi). A review workshop was convened on 19-22 May 2008 at the Hawaii Imin International Conference Center, University of Hawaii East-West Center, Honolulu, Hawaii to provide an independent peer review of these modeling approaches (see Appendix 1). During the review workshop all review material was presented by and discussed with the project leader. The review determined the adequacy, appropriateness, and application of the biological and environmental data used in the analyses, analytical methods and model structure and assumptions applied to the problem of discerning the patterns of archipelagic connectivity among populations inhabiting the Hawaiian Islands. The research program is an adequate approach to the resolution of larval connectivity at the broad geographic scales under consideration. The program appears to be evolving from a generic, coarsely resolved description of larval connectivity to one of finer-scale, species-specific application. The methods and data sources have been appropriate to the general objectives and in most instances have utilized the best available science. The one major deficiency resides in the largely generic approach utilized in the larval transport modeling and connectivity, in terms of lack of specification of a target species. Several recommendations have been provided dealing with the input and parameterization of the simulation modeling, and output and validation of the simulation models.

II. Terms of Reference

1. Evaluate whether the adequacy, appropriateness, and application of data used in the analyses represents the best available science?

The primary type of data used in developing the simulation models can be categorized as either physical or environmental, the majority of which was derived from satellite sensors or output from ocean circulation models. As such, the derived data products are generally widely available to end users and, in most cases, represent the only available source of data at the requisite spatial and temporal scales. These data include the following: a) TOPEX POSEIDON altimeter and its various successors including ERS, JASON, AVISO which provided the geostrophic flow fields and the bathymetry product used in the simulations; b) OSCAR – Ocean Surface Current Analysis Real time which provided combined geostrophic and wind driven flow fields; c) SST and surface chlorophyll derived from AVHRR and SeaWiFs; d) Positional information on satellite drifter buoy tracks used for the flow field validation; e) TAO oceanographic mooring data used to compare observed mixed layer depth to the prediction from Topex altimetry; f) model outputs from NLOM – Naval Research Laboratory Layered Ocean Model; g) model outputs from NCOM – Naval Research Laboratory Coastal Ocean Model; h) University of Hawaii tidal model output; and i) various climate indices such as the SOI – Southern Oscillation Index and PDO – Pacific Decadal Oscillation Index. In each case examined, it was concluded that the data were adequate and appropriate for the simulation modeling exercise. It should be noted that the resolution of the flow field data used became increasingly higher and served to improve the simulation results, a trend expected to continue in the future. However, due to the limited time series for the higher resolution flow field data, some applications will be better served with the lower resolution, longer time series data.

2. Evaluate whether the adequacy, appropriateness, and application of analytical methods and modeling represents the best available science?

A variety of analytical and statistical methods were employed to search for patterns in the simulated particle distributions, partition variance in settlement output data, validate particle trajectories, and summarize dispersal outcomes. The analytical methods included: a) Generalized additive modeling (GAMs); b) NMDS (non-metric multi-dimensional scaling); c) Linear regression analysis; d) Student's t-test; e) a contouring algorithm for spatial analysis known as ConREC; and f) Matrix presentation of the probability density functions. All the analytical/statistical methods were adequate and appropriately applied and have precedent in the contemporary ecological literature dealing with connectivity research.

3. Do the biological data, population data, model structure and assumptions, and the analysis methods applied to archipelagic connectivity represent the best available data and methodology for sound science?

The one immediate impression of the body of research reviewed was that biological data, either qualitative or quantitative, were generally lacking for either parameterization of the model inputs (e.g. PLD, time and location of spawning, reproductive output), or for evaluating the model predictions/output (e.g. egg and larval distributional data), on a species-specific level. For these reasons, at this stage in the research the modeling provides only a first order approximation of the potential for larval connectivity within the Hawaiian archipelago. It appeared that moving forward with the simulation modeling required making several assumptions (e.g. constant spawning timing, location and egg production), rather than waiting for detailed information to eventually become available. Embarking on such a strategy in the short term appears appropriate. However, development of detailed ecological profiles of species inhabiting the Hawaiian archipelago based on historical data is required. Some key species that may have been better studied elsewhere, or even knowledge gained from research on functionally equivalent species from other areas, could provide much needed information for parameterization of the transport and connectivity modeling. This would include information on egg size, development rates, larval growth rates, buoyancy, feeding ecology, vertical distribution and migration and so on. These and other basic life history parameters should be assembled and simulations developed to match as close as possible key species within the study area. Several recommendations have been offered to lessen the dependence on the existing assumptions.

The Lagrangian simulation model is based upon an individual based modeling structure, incorporating a random walk subcomponent. The approach is the appropriate framework for addressing larval dispersal and general questions of connectivity across large geographic scales. The development and application of this model rests upon several assumptions including: a) a constant diffusivity of 500 m^2/s; b) spawning output proportional to habitat area defined by the 0-100m depth range; c) a constant rate of spawning throughout the year (uniform distribution); d) pelagic larval duration or PLD ranging from 15 – 365 days, with no variability in settlement at the imposed PLD; e) a circular settlement zone of detection by dispersing larvae with a radius of 25 – 140 km; f) a passive and mixed (occupation of different broad layers) vertical distribution of larvae depending on the simulation run; and g) no response by dispersing larvae to coastal boundaries. The primary data input to the simulation model was the *u* and *v* components from altimetry or NLOM and these were taken to be representative of the flow fields dispersing larvae experienced. The assumptions were considered reasonable and appropriate given the scale of resolution evaluated, particularly when the simulations were based on flow field input from the altimeter. However, several of the assumptions will require modification in order to move the modeling from its present generic emphasis to a species-specific, high resolution depiction of the dispersal/connectivity process.

In many contemporary modeling studies of larval transport the type of modeling is categorized as "biophysical". Biophysical models of larvae generally simulate the drift, development, growth and mortality of released particles (or eggs). Typical components of biophysical models include i) a particle tracking routine that simulates egg/larval drift from flow fields produced by a circulation model and information regarding spawning ground location, ii) an egg production model which describes the space/time release of eggs, based on spawning stock data and iii) a controlling program, which, using particle tracking, the egg production model, and a mortality routine, computes the time dependent spatial distribution of eggs and larvae. While incorporation of more biological processes into a model is not always beneficial (see Brickman et al. 2007), the current approach within the Hawaiian archipelago falls short of this "biophysical" modeling standard. The approach that Brickman and his colleagues (see reference list) have adopted in the modeling of temperate, commercially exploited ground fish species (such as haddock and cod) should be of considerable interest to the transport and larval connectivity research program at Pacific Islands Fisheries Science Center.

Output from the Lagrangian simulations were used in a multiple generation metapopulation model. An important component of this model was the imposition of density dependence on spawning output (capped at an input value based on the number of simulation runs scaled by available habitat). A constraint to this exercise was that the derived measures of connectivity were based on a single year of modeled flow fields but applied to 1,000 generations. This modeling exercise was illustrative of the potential development of spatial structure and biogeographic patterning among populations in the Hawaiian archipelago. This was considered a minor and largely exploratory component of the larval connectivity research program. The extremely long times scales associated with this exercise makes it less relevant to potential management applications, although the generation length was never specified.

III. Further Analyses and Evaluations

During the course of the on-site review several requests were made concerning the availability of information related to the general level of interest in larval connectivity research and its application to the Hawaiian archipelago. Documents were provided dealing with the status of lobster stocks in the Northwestern Hawaiian Islands (1998-2000), a panel report from the 2004 Coral Reef Fish Stock assessment workshop, and Amendment 14 to the fishery management plan for the bottomfish and seamount groundfish fisheries of the western Pacific region from 2007 (see Appendix 2). Collectively, this information repeatedly stressed the importance of implementing a meta-population framework for the assessment and management of Hawaiian archipelago fisheries. A request was also made for details of the spiny lobster CPUE time series at other locations besides Maro reef and Necker Island. A last request was made for further information on the area closures and the associated restrictions within these areas for the Main Hawaiian Islands. All of the requested material was provided and discussed. At no time during the review were further analyses or evaluations requested.

IV. Additional Comments

Additional discussions were centered on a variety of topics many of which represented future directions leading to improvements in the larval transport and connectivity research program. The additional topics discussed ranged from exploring newer circulation model data, incorporating larval behavior such as orientation and horizontal swimming, re-coding the model into a more efficient language, and development of a connectivity web interface for resource managers resembling the connectivity web interface developed by CSIRO. One near future development was discussed involving the merger of two flow field models involving the collaboration with University of Hawaii scientists. This initiative was described as a possible regional contribution to the CAMEO program.

V. Recommendations

Basic biological data, based on literature review and directed research, to develop connectivity models for target species is needed. It appears that the historical studies such as those by Boehlert and others can be used to provide species-specific information. For example, Boehlert and Mundy (1994) document seasonal distribution patterns of larval scombrids off Oahu with data showing vertical distributions, onshore/offshore patterns, some information on larval behavior (or lack thereof) and a basic description of larval scombrid habitat from a physical perspective. If there were other field studies of a design similar to Boehlert, then compilation/consolidation of this information into a database could have multiple uses for the modeling program. There does not appear to ever have been a commitment to the development a common database consolidating the output from the variety of historical field research programs conducted either in the government or university laboratories for the Hawaiian archipelago.

What would also be very valuable would be to see more studies like the one provided in the background material, i.e. Polovina et al. (1999) on the transport dynamics of spiny lobster. In Polovina et al. (1999) it was noted that further research was needed to improve input parameters and to attempt to validate the simulation results. Because the simulations produce near-real time spatial distributions, larval surveys (field sampling) could be designed to sample not all areas, but those where the model predicts the occurrence of very high and or very low densities. The model results could also be evaluated by comparing bank-specific recruitment index time series against estimated recruitment. Collation of the historical egg, larval, and pelagic juvenile data from this and other studies would an important step in moving from a generic (or virtual) to a species-specific approach. Unfortunately, nearly a decade has elapsed since the seminal study by Polovina et al. (1999) with no evidence to date of follow-up along the lines they had suggested.

In general, species can exert control on the effective strength of advection and diffusion and thus the balance between the two through timing of spawning, the duration of spawning, the duration of the planktonic period, adult life span/number of reproductive events, and larval behavior. For example, adults may choose spawning times to make use of desirable flow fields. Many species exhibit temporal variation in spawning either at seasonal or shorter time scales linked to changes in environmental conditions favorable for early larval survival. Routine collections of adults and assessment of maturity state provide one means of assessing temporal variation in spawning.

It should be possible to develop a space/time characterization of the distributional pattern for some of the key commercial species such as those based on the hook and line bottom fishing for the grouper-snapper-jack complex, pelagic fisheries such as bigeye and yellowfin tuna, net fishing for species such as the bigeye scad and so on. There does not appear to be any standardized, fishery independent surveys as well. It is somewhat ironic that such a high biological diversity system as the Hawaiian archipelago is relatively data poor. It was stated during the review that collection of data has been irregular and somewhat inconsistent with the type of data reflective of the interests and availability of key research staff.

Application of the simulation results is presently hampered by the non-specific profile of the model organism. There is an obvious need to develop species-specific scenarios for such purposes. Ecological profiles of species inhabiting the Hawaiian archipelago but better studied elsewhere, or even functionally equivalent species from other areas, could provide much needed information for parameterization of the transport and connectivity modeling. This would include information on egg size, development rates, larval growth rates, buoyancy, feeding ecology, vertical distribution and migration and so on. This and other basic life history parameters should be assembled and simulations developed to match as close as possible key species within the study area. Steps taken in this direction will lessen the dependency on many of the questionable assumptions used in the modeling such as spawning output occurs uniformly throughout the year, spawning output is proportional to the amount of shallow water habitat, no growth or mortality, no daily or ontogenetic vertical migration, etc.

It would be useful to have genetic or morphological data on any one or more of the potential focal species to establish the diversity of the population structure, in other words to have some reliable estimate of the total number of sub-components that ultimately make up the population complex or metapopulation.

Further evaluation and possibly modification of the choice of the single eddy diffusivity constant used for the wide variety of simulations undertaken is required and there is a need for multiple year data products from the ocean modeling to extend the simulations to other years. The adequacy of the representation of the current fields in those areas where the larvae originate, e.g. spawning occurring in shallow-water reef areas, is probably quite limited. However, it does appear that steps are being taken to address this concern. The use of a single year of current data as representative of the average flow fields over time is also a concern. Additional years of flow field data are needed to properly investigate the overall patterns of connectivity.

The current modeling approach within the Hawaiian archipelago falls short of being considered a truly biophysical model. There are issues concerning the combined effects of diffusion and mortality leading to such a great reduction in densities over small distances as to have little or no meaningful effect on populations in so-called “sink” habitats. However, mortality was not considered in any of the modeling and it has been established that mortality rates are relatively high at the egg and early larval stages due to predation, food limitation and other environmental processes. Inclusion of mortality fields into future modeling is required to develop realistic estimates of the spatial scale typifying larval connectivity. Dispersal processes at older life stages (juveniles and adults) could be another way that local populations are connected and should be considered.

Further, stock and recruitment relationships should be explored where data are available.

Major conservation and management issues within the Pacific Islands Fisheries Science Center do not highlight the need for research on the larval transport and connectivity issues within the Hawaiian archipelago. However, it is widely acknowledged that such research is extremely important particularly with respect to HWHI spiny lobster, the belief being that local recruitment is dependent upon external as well as local sources and that some banks may be acting as either recruitment sources, sinks, or both. This lack of understanding appears to be a shortcoming in the estimation of bank-scale, exploitable population levels and future improvements to lobster stock assessments will require population models that provide reliable estimates of the quantitative linkages between local populations. The possibility exists that some of the factors affecting the spatial and temporal patterns of lobster abundance, particularly the recruitment differences in the HWHI spiny lobster population between the southeastern and northwestern segment of the archipelago, could be resolved through the larval transport modeling. This body of research may ultimately lead to a redefinition of management units within the Hawaiian archipelago, not only for lobster, but for bottom fish as well, since they are currently managed at a coarse geographic scale by combining stocks from within the main Hawaiian islands and the NWHI. In addition, the growing awareness for the need of alternative management measures, such as temporary area closures and MPA sighting, design, and evaluation will be made more rigorous and exacting as the larval transport and connectivity research evolves.

The anticipated, positive developments within the larval connectivity research program will require a commitment to the timely production of reports and publications to be vetted within the local as well as broader scientific community. Effort should be expended to develop a web interface to provide information on the connectivity data products for the Hawaiian Island archipelago. A potential framework for such a development is the CSIRO connectivity interface. It should be noted that improvements to the modeling as recommended will strain existing resources, in terms of personnel and computing hardware and that steps should be taken to ensure that this is not a limitation to the execution of future applications.

References

Boehlert, G.W. and B.C. Mundy. 1994. Vertical and onshore-offshore distributional patterns of tuna larvae in relation to physical habitat features. *Mar. Ecol. Prog. Ser.* 107: 1-13.

Brickman, D. and P.C. Smith. 2002. Lagrangian Stochastic Modeling in Coastal Oceanography. *J. Atmos. Ocean. Tech.* 19: 83-99.

Brickman, D. 2003. Controls on the distribution of Browns Bank juvenile haddock. *Mar. Ecol. Prog. Ser.* 263: 235-246.

Brickman, D., G. Marteinsdottir and L. Taylor. 2007.Formulation and application of an efficient optimized biophysical model. *Mar. Ecol. Prog. Ser.* 347: 275-284.

VI. Reviewer Statement

The contents of the Peer Review Report provide an accurate and concise summary of my views on the issues covered. I was extremely impressed with the clarity and content of the presentations, the broad, multi-faceted scope of the research program, and the scientific capability of the lead investigator, Donald Kobayashi. It was unfortunate that the scientific program was represented by only one individual during the course of the review, leaving him alone to shoulder the entire weight of the review. Finally, there is no need to further elaborate on any points raised in the Consensus Summary Report as described in Annex I.

Appendix 1: Statement of Work for Dr. Kenneth Frank

External Independent Peer Review by the Center for Independent Experts

Modeling Larval Transport and Connectivity in Hawaiian Waters

Panel Review Meeting, 19-22 May 2008, Honolulu, Hawaii

Overview:

Computer simulation modeling has been undertaken at the Pacific Islands Fisheries Science Center to address insular species issues of metapopulation connectivity and larval transport in the Hawaiian Archipelago. These approaches utilize a variety of remotely-sensed and modeled oceanographic data in a lagrangian modeling framework. These activities have taken place within the Ecosystems and Oceanography Division at the Science Center (Project Leader: Fishery Biologist Donald R. Kobayashi).

The review workshop provides an independent peer review of these modeling approaches. The review panel will be composed of two Center for Independent Experts (CIE) appointed reviewers. Other PIFSC, PIRO, Council, or UH staff may attend the review panel meeting as observers or participants.

Overview of CIE Peer Review Process:

The Office of Science and Technology implements measures to strengthen the National Marine Fisheries Service's (NMFS) Science Quality Assurance Program (SQAP) to ensure the best available high quality science for fisheries management. For this reason, the NMFS Office of Science and Technology coordinates and manages a contract for obtaining external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of stock assessments and various scientific research projects. The primary objective of the CIE peer review is to provide an impartial review, evaluation, and recommendations in accordance to the Statement of Work (SoW), including the Terms of Reference (ToR) herein, to ensure the best available science is utilized for the National Marine Fisheries Service management decisions.

The NMFS Office of Science and Technology serves as the liaison with the NMFS Project Contact to establish the SoW which includes the expertise requirements, ToR, statement of tasks for the CIE reviewers, and description of deliverable milestones with dates. The CIE, comprised of a Coordination Team and Steering Committee, reviews the SoW to ensure it meets the CIE standards and selects the most qualified CIE reviewers according to the expertise requirements in the SoW. The CIE selection process also requires that CIE reviewers can conduct an impartial and unbiased peer review without the influence from government managers, the fishing industry, or any other interest group resulting in conflict of interest concerns. Each CIE reviewer is required by the CIE selection process to complete a Lack of Conflict of Interest Statement ensuring no advocacy or funding concerns exist that may adversely affect the perception of impartiality of the CIE peer review. The CIE reviewers conduct the peer review, often participating as a member in a panel review or as a desk review, in accordance with the ToR producing a CIE independent peer review report as a deliverable. At times, the ToR may require a CIE reviewer to produce a CIE summary report. The Office of Science and Technology serves as the COTR for the CIE contract with the responsibilities to review and approve the deliverables for compliance with the SoW and ToR. When the deliverables are approved by the COTR, the Office of Science and Technology has the responsibility for the distribution of the CIE reports to the Project Contact.

CIE Reviewer Requirements:

The CIE shall provide two CIE reviewers to conduct independent peer reviews in accordance with the ToR and Schedule herein, and each CIE reviewer's duties shall not exceed a maximum of 14 days for pre-review preparations, conducting the peer review, and completion of the CIE independent peer review reports. The CIE reviewers shall have expertise in one or more of the following areas: larval transport processes, recruitment dynamics, physical oceanography, larval ecology, zooplankton ecology, coral reef ecology, biogeography, population dynamics, and fisheries oceanography to complete their primary task of conducting an impartial and independent CIE peer review report in accordance with the ToR to determine if the best available science is utilized in this research.

Statement of Tasks for CIE Reviewers:

Roles and responsibilities:

1. Approximately 3 weeks prior to the meeting, CIE reviewers shall be provided with supporting documents and review workshop instructions including terms of reference. CIE reviewers shall read these documents to gain an in-depth understanding of the transport modeling methodology, the oceanographic data utilized, and their responsibilities as reviewers.

2. During the review panel meeting, CIE reviewers shall participate in panel discussions and conduct an independent peer review on methods, data, validity, results, uncertainties, recommendations, and conclusions in accordance to the Terms of Reference (ToR). Each CIE reviewers shall conduct an independent peer review in accordance with the ToR and guidelines in Annex II. The CIE reviewers shall participate in development of a peer review consensus summary report, as described in Annex I.

3. Following the review panel meeting, reviewers shall work together to complete and review the peer review consensus summary report, as described in Annex I. This report shall be completed, reviewed by both panelists, and comments submitted to the Chair by June 5, 2008.

4. Following the review panel meeting, each reviewer appointed by the CIE shall prepare an individual CIE reviewer report. These reports shall be submitted to Mr. Manoj Shivlani, CIE Lead Coordinator, via email at shivlanim@bellsouth.net, and

to Dr. David Die, CIE Regional Coordinator, via email at ddie@rsmas.miami.edu no later than June 12, 2008. See Annex II for complete details on the report outline.

The duties of each review panelist shall not exceed a maximum of 14 workdays; several days prior to the meeting for document review; four days at the review panel meeting; and several days following the meeting to complete the independent peer review in accordance with the ToR, and to assist the review panel Chair with the development of the summary report.

The CIE reviewers shall conduct necessary preparations prior to the peer review, conduct the peer review, and complete the deliverables in accordance with the ToR and deliverable dates herein.

Prior to the Peer Review: The CIE shall provide the CIE reviewers contact information (name, affiliation, address, email, and phone) to the Office of Science and Technology COTR no later than the date as specified in the SoW, and the COTR will forward this information to the Project Contact.

Foreign National Clearance: The CIE shall provide the necessary information (e.g., name, birth date, passport, travel dates, country of origin) for each CIE reviewer to the COTR who will forward this information to the Project Contact. The Project Contact is responsible for the completion and submission of required Foreign National Clearance forms with sufficient lead-time (30 days) in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations at the Deemed Exports NAO link http://deemedexports.noaa.gov/sponsor.html

Pre-review Documents: Approximately three weeks before the peer review, the Project Contact will send the CIE reviewers the necessary documents for the peer review, including supplementary documents for background information. The CIE reviewers shall read the pre-review documents in preparation for the peer review. This list of pre-review documents may be updated prior to the panel review meeting. Meeting materials will be forwarded electronically to review panel participants and made available through the internet (http://www.hawaiieod.com/CIE/); printed copies of any documents are available by request. The names of reviewers will be included in workshop briefing materials.

Panel Peer Review Meeting: The CIE reviewers shall participate and conduct the peer review panel meeting as specified in the dates and location of the attached Agenda and Schedule.

The review workshop will take place at the Hawaii Imin International Conference Center, University of Hawaii East-West Center, Honolulu, Hawaii, from 8:30 a.m. Monday, May 19, 2008 through 4:30 p.m. Thursday, May 22, 2008. The Project Contact is responsible for the facility arrangements.

Please contact Donald Kobayashi (PIFSC Research Fishery Biologist; (808) 983-5394, Donald.Kobayashi@noaa.gov) for additional details.

Review Workshop Panel Tasks:

The review workshop panel will evaluate modeling of larval transport and connectivity in the Hawaiian Archipelago conducted by the PIFSC. Before the evaluation the panel will review the provided documents and any supporting material. During the evaluation the panel will consider the data, methods, and results of the material presented. The evaluation will be guided by terms of reference that are specified in advance. A summary report as described in Annex I will be prepared by the Chair with input from the review workshop panel. The individual reviewers on the panel will document their findings in separate CIE reviewer reports produced as described in Annex II to provide distinct, independent analyses of the technical issues and scientific merit.

Terms of Reference for CIE Peer Review:

The CIE reviewers shall conduct a peer review of the pre-meeting documents specified above, participate during the panel review meeting, and complete their CIE reports according to the Terms of Reference herein;

1. Evaluate whether the adequacy, appropriateness, and application of data used in the analyses represents the best available science?
2. Evaluate whether the adequacy, appropriateness, and application of analytical methods and modeling represents the best available science?
3. Do the biological data, population data, model structure and assumptions, and the analysis methods applied to archipelagic connectivity represent the best available data and methodology for sound science?

Each CIE reviewer shall evaluate and indicate as to whether the presented models, analysis and conclusions are the best available science at this time. The CIE reviewers shall not provide specific management advice. If the panel rejects the models or any components, analysis, results or conclusions, the panel should explain the rejection and provide recommendation for suitable alternatives. According to the schedule outlined below, two CIE reviewers shall submit independent peer review reports in accordance with the ToR and schedule herein, and assist as the panel review Chair in the development of a summary report.

Request for Changes:

Requests for changes shall be submitted to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the Contractor within 10 working days after receipt of all required information of the decision on substitutions. The contract will be modified to reflect any approved changes. The Terms of Reference (ToR) and list of pre-review documents herein may be updated without contract modification as long as the role and ability of the CIE reviewers to complete the SoW deliverable in accordance with the ToR are not adversely impacted.

Submission and Acceptance of CIE Reports:

Upon review and acceptance of the CIE reports by the CIE Coordination and Steering Committees, CIE shall send via e-mail the final independent CIE reports to the COTRs (William Michaels William.Michaels@noaa.gov and Stephen K. Brown Stephen.K.Brown@noaa.gov) at the NMFS Office of Science and Technology by the date in the Schedule of Deliverables. The COTRs will review the CIE reports to ensure compliance with the SoW and ToR herein, and have the responsibility of approval and acceptance of the deliverables. Upon notification of acceptance, CIE shall send via e-mail the final CIE report in *.PDF format to the COTRs. The COTRs at the Office of Science and Technology have the responsibility for the distribution of the final CIE reports to the Project Contacts.

The COTR shall provide the final CIE reviewer reports to:

PIFSC Director: Dr. Samuel Pooley, NMFS Pacific Islands Fisheries Science Center, 2570 Dole Street, Honolulu, HI 96822 (Samuel.Pooley@noaa.gov)

Schedule:

April 2, 2008:	CIE shall provide COTR contact information for the selected CIE reviewers, and the COTR will forward this to the Project Contact who is responsible for the Foreign National Clearance during the CIE reviewers participation on the panel review meeting.
April 28, 2008:	Pre-meeting documents provided to CIE technical reviewers
May 19-22, 2008:	CIE technical reviewers participate in panel review workshop in Honolulu, HI
May 22, 2008:	CIE technical review panel completes first draft of review panel consensus report (conclusion of review workshop)
June 5, 2008:	CIE technical review panel submits final draft review panel consensus report to workshop Chair.
June 12, 2008:	CIE technical reviewers submit individual reviewer reports to CIE.
June 26, 2008:	CIE submits final versions of review panel consensus report and all reviewer reports to the COTR
July 10, 2008:	COTR provides final CIE reviewer reports to PIFSC Director

Key Personnel:

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Agenda

Modeling Larval Transport and Connectivity in Hawaiian Waters

May 19 – May 22, 2008

Monday

8:30 a.m.	**Convene**	
8:30 – 9:00 a.m.	**Introductions and Opening Remarks** **Coordinator** *- Agenda Review, TOR, Task Assignments*	
9:00 a.m. – 10:00 a.m.	**Presentations** *- TBD*	**Chair**
10:00 a.m. – 10:30 a.m.	**Break**	
10:30 a.m. – 11:30 a.m.	**Presentations** *- TBD*	
11:30 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 2:30 p.m.	**Panel Discussion** **-** *Data & Methods* *- Identify additional analyses, sensitivities, corrections*	**TBD**
2:30 p.m. – 3:00 p.m.	**Break**	
3:00 p.m. – 4:30 p.m.	**Panel Discussion** *- Continue deliberations* *- Review additional analyses*	**Chair**

***Monday Goals*:** Initial presentations completed, sensitivities and modifications identified.

Tuesday

8:30 a.m. – 10:00 a.m.	**Presentations** *- TBD*	**Chair**
10:00 a.m. – 10:30 a.m.	**Break**	
10:30 a.m. – 11:30 a.m.	**Presentations** *- TBD*	
11:30 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 2:30 p.m.	**Panel Discussion** *- Review additional analyses* *- Consensus recommendations and comments*	**Chair**
2:30 p.m. – 3:00 p.m.	**Break**	
3:00 p.m. – 4:30 p.m.	**Panel Discussion** *- Continue deliberations*	**Chair**

Tuesday Goals: Presentations completed, final sensitivities identified, consensus report drafts begun

Wednesday

8:30 a.m. – 11:30 a.m.	**Panel Discussion** *- TBD*	**Chair**
11:30 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 2:30 p.m.	**Panel Discussion or Work Session** *- TBD*	**Chair**
2:30 p.m. - 3:00 p.m.	**Break**	
3:00 p.m. - 4:30 p.m.	**Panel Discussion** *- Independent peer review*	**Chair**

Wednesday Goals: Complete work and discussions. Final results available. Draft Consensus Report reviewed.

<u>Thursday</u>

8:30 a.m. – 11:30 p.m.	**Panel Discussion or Work Session** *- Draft summary report* *- TBD*	**Chair**
11:30 a.m. – 1:30 p.m.	**Lunch Break**	
1:30 p.m. – 2:30 p.m.	**Panel Discussion or Work Session** *- Draft summary report* *- TBD*	**Chair**
4:30 p.m.	**ADJOURN**	

Thursday Goals: Completion of bulk of report writing.

Appendix 2: Bibliography of all materials provided for review

Pre-meeting Documents

Background Document 1.

Polovina, J.J., P. Kleiber, D.R. Kobayhashi. 1999. Application of TOPEX-POSEIDON satellite altimetry to simulate transport dynamics of larvae of spiny lobster, *Panulirus marginatus*, in the Northwestern Hawaiian Islands, 1993-1996. Fish. Bull. 97: 132-143

Review Document 1.

Kobayashi, D.R. and J.J. Polovina. 2006. Simulated seasonal and interannual variability in larval transport and oceanography in the Northwestern Hawaiian Islands using satellite remotely sensed data and computer modeling. *Atoll Research Bulletin* 543: 365-390.

Review Document 2.

Kobayashi, D.R. 2006. Colonization of the Hawaiian Archipelago via Johnston Atoll: a characterization of oceanographic transport corridors for pelagic larvae using computer simulation. *Coral Reefs* 25: 407-417.

Review Document 3.

Kobayashi, D.R. (submitted manuscript). Larval retention versus larval reception: marine connectivity patterns within and around the Hawaiian Archipelago. 47 p.

Review Document 4.

Kobayashi, D.R. (submitted manuscript). Natal retention mediated by diel vertical migration: larval transport modeling in the Hawaiian Archipelago with layered current fields. 24 p.

Documents provided during the 19-22 May 2008 review:

Dinardo, G.T. and R. Marshall. 2001. Status of lobster stocks in the Northwestern Hawaiian Islands, 1998-2000. Southwest Fisheries Science Center Administrative Report H-01-04.

Coral Reef Fish Stock Assessment Workshop. Interim Final Panel Report. 10-13 February 2004. Western Pacific Regional Fishery Management Council. Honolulu, Hawaii.

Amendment 14 to the Fishery Management Plan for Bottomfish and Seamount Groundfish Fisheries of the Western Pacific Region including a final supplemental environmental impact statement, a regulatory impact review and an initial regulatory flexibility analysis. Measure to end bottomfish overfishing in the Hawaiian Archipelago. Western Pacific Regional Fishery Management Council. 19 December 2007. Honolulu, Hawaii.

Bottomfish Stock Assessment Workshop. Western Pacific Fishery Management Council. Final Panel Report. 19 February 2004.

Condie, S.A., J. Waring, J.V. Mansbridge, and M.L. Cahill. 2005. Marine connectivity patterns around the Australian continent. *Environ. Model. Softw*. 20: 1149-1157.

Annex I. Review Panel Summary Report Contents

I. Executive Summary

An abstract of the summary peer review report.

II. Terms of Reference

List each Term of Reference, and include a concise summary from the panel review discussions and independent CIE reports indicating whether or not the criteria in each element of the Term of Reference are satisfied.

III. Further Analyses and Evaluations

Summary of analytical requests not previously addressed in TOR discussion above.

IV. Additional Comments

Provide a summary of any additional discussions not captured in the Terms of Reference statements.

V. Recommendations

Provide a summary statement as to how to improve upon using the best available science in regard to each of the Term of Reference criteria.

VI. Chair Statement

Provide a statement attesting whether or not the contents of the Summary Peer Review Report provide an accurate and concise summary of the panel review discussions and independent reviewer's views on the issues covered. Chair may also make any additional individual comments or suggestions desired.

CIE reviewers shall assist the panel review Chair will the development of a Summary Report

ANNEX II: Contents of CIE Independent Peer Review Report

I. Executive Summary

An abstract of the peer review report.

II. Terms of Reference

List each Term of Reference(ToR), and include a concise summary indicating whether or not the criteria in each element of the Term of Reference are satisfied.

III. Further Analyses and Evaluations

Summary of analytical requests not previously addressed in ToR discussion above.

IV. Additional Comments

Provide a summary of any additional issues not captured in the Terms of Reference statements.

V. Recommendations

Provide a summary statement as to how to improve upon using the best available science in regard to each of the Term of Reference criteria.

VI. Reviewer Statement

Provide a statement attesting whether or not the contents of the Peer Review Report provide an accurate and concise summary of the independent reviewer's view on the issues covered. Reviewer may also make any additional individual comments or suggestions desired.

- Individual reviewers shall elaborate on any points raised in the Consensus Summary Report as described in Annex I that they feel might require further clarification. Reviewers shall provide a critique of the review process including suggestions for improvements of both process and products. The CIE reviewers shall provide an independent peer review in their reports in accordance to the ToR, which is a separate responsibility from their contribution to the consensus summary report.

- Each CIE reviewer report shall include as separate appendices a copy of the CIE Statement of Work and a bibliography that includes all materials provided for review.