Review of SPC Estimation of Species and Size Composition of the Western and Central Pacific Purse Seine Fishery from Observer-based Sampling of the Catch

A Report Prepared for the
Center for Independent Experts

By

Joseph E. Powers

November 2012

Executive Summary

The current estimation methods for determining purse seine catch by species in the Western Pacific Ocean were reviewed through the review of documents, listening to scientific presentations on the subject, interviewing key personnel, exploring the data and examining raw logsheets. Additionally, a simulation model of set operations was created to make initial evaluations of biased brailing and sampling processes.

The key findings and recommendations were:

1) There is a need to move away from the model based estimation procedure toward the experimental design based multinomial estimation
2) There is a need for developing a purse seine set-simulation template to be used to examine the robustness of estimation to bias and variance and to evaluate alternative sampling protocols
3) The impact of layering in the brail needs to be evaluated through simulation and experimental sequential sampling of brails
4) Mixed sampling protocols and associated estimation procedures should be developed to encompass the cost efficiency of grab type samples and the less biased but more difficult spill samples

Background

Estimates of species and size composition of the purse seine fishery in the western and central Pacific Ocean (WCPO) are fundamental to stock assessments of skipjack, yellowfin and bigeye tunas conducted by the Secretariat of the Pacific Community (SPC). These assessments provide the scientific basis for management decision making by the Western and Central Pacific Fisheries Commission for the world's largest tuna fishery.

Currently the purse seine observer program is expanding with the goal of 100% coverage. However, there are a number of transitional issues that remain. Additionally, statistical procedures which use the increased observer data more efficiently are needed.

Estimates of purse seine catch by species and their size compositions are currently based on at-sea observer sampling protocol known as 'grab sampling', whereby 5 fish are randomly selected from each brail of each purse seine set as they are loaded onboard during observed trips, and some total catch information taken from skippers logbooks. However, it was recently recognized that grab sampling was biased because of human and other factors involved in selecting the fish for sampling and that some logsheet reporting of catches is biased towards skipjack tuna.

A series of experiments were conducted whereby grab sampling was conducted alongside another sampling method, termed 'spill sampling', in which a substantial quantity of fish was 'spilled' from selected brails during the fish loading process. These paired sampling trials allowed a bias correction to be estimated and applied to the historical grab sampling data. The corrected grab sampling data were then analyzed using statistical modeling approaches to estimate species and size composition, testing for and taking account of as appropriate potential independent variables, such as latitude, longitude, set type, year and season. The derived models are used to estimate historical catches and size composition of each species, by fleet and various spatial, temporal and operational strata.

A Center for Independent Experts (CIE) review was requested to evaluate the scientific information and methodology of the SPC estimation of species and size composition of the western and central Pacific purse seine fishery. In particular we (the CIE reviewers) were asked to evaluate: 1) the models used for bias correction between grab and spill samples; 2) statistical procedures for adjusting historical catches when only grab samples were taken and 3) the statistical methods currently used to estimate species composition and catch weight and requisite size frequencies for the three main species skipjack tuna (SKJ), yellowfin tuna (YFT) and bigeye tuna (BET).

The bases of the CIE review were the background documents supplied by the SPC documenting current procedures and how they evolved. These were previewed prior to the site visit to the SPC October 22-25, 2012. At the site visit SPC staff made presentations describing the fisheries and the methods currently used (see Appendix 1 for list of documents/presentations). Additionally, we requested and received additional summary analyses which allowed us to begin to understand the variability in these data sets. We also had the opportunity to examine observer logsheets and to question personnel who were expertly involved in the observer program.

Description of the Individual Reviewer's Role in the Review Activities

My role in this CIE review is the same as the other CIE reviewer as outlined in the statement of work (SoW; Appendix 2). The other CIE reviewer (Dr. Patrick Cordue; see Appendix 3) is providing an independent report. Key tasks were to understand current methodologies in the context of purse seine and observer operating procedures during the site visit. Then after completion of the site visit, we integrated the information to formulate our advice.

In my case I felt that in order to gain understanding of the sampling process there needed to be simulation experiments conducted to evaluate alternative sampling protocols for addressing known bias and to generate realistic data sets with known properties for evaluating future estimation methods. Therefore, I coded and implemented a Monte Carlo simulation model (Appendix 4). The results herein are limited but provide additional insight. The simulation methods and results in Appendix 4 represent an important part of my review effort and thus my understanding of the scientific issues.

Any further development of sampling protocols should require simulation exercises to evaluate operational efficiencies and perceived biases using simulations similar to the code provided here. Therefore, that is a recommendation: that there is a purse seine set simulation template for future evaluation of sampling and estimation procedures.

Summary of Findings for each Term of Reference

Estimation of catch by species by strata requires an estimate of catch-per-set in weight from skipper logs times the proportion of each species in weight which is obtained from length-frequencies converted to weight. Current methods use a modeling approach to estimate proportions whereby the "availability", i.e. selectivity bias in grab sampling or other sources of bias are estimated. These methods are *ad hoc* and have evolved from a simple approach toward a complex procedure that is difficult to interpret in terms of variance estimation. The procedure addresses species separately and can result in negative proportions when sample sizes are small. Additionally, it is unlikely that length strata are weighted appropriately. Having said that, there has not been a clear evaluation of the extent of bias that this method introduces. It is possible that biases are not large using this method. However, I do not know now. There is always the practical issue: can we accept biased methods which are easier or less costly if the biases are small? This is another argument for conducting Monte Carlo simulation experiments.

Nevertheless, I recommend that a statistical design approach be used for estimation rather than a modeling approach. An appropriate statistical model for doing this is the multinomial model in which proportions of skipjack p_{SKJ} and yellowfin p_{YFT} are estimated ($p_{BET} = 1 - p_{YFT} - p_{SKJ}$). With x_i being the random variable of the number of fish of species i, the probability mass function is

$$f(x_{SKJ}, x_{YFT}, x_{BET}, n) = \frac{n!}{x_{SKJ}!\, x_{YFT}!\, x_{BET}!} p_{SKJ}^{x_{SKJ}} p_{YFT}^{x_{YFT}} p_{BET}^{x_{BET}}$$

$$x_{SKJ} + x_{YFT} + x_{BET} = n$$

This model naturally incorporates the relation between the three species since they are all three part of the same stochastic process. Additionally, variance estimates are straightforward (mean=np_i, variance=$np_i(1\text{-}pi)$; i=SKJ,YFT,BET). MLE estimates of parameters proportions (-loglikelihood minimization) are easily obtained for multiple strata that might be imposed: broad strata such as region or set type, as well as strata internal to the set such as grab versus spill or layering within the brail. As the fisheries move toward near 100% observer coverage, it is more straightforward to take an experimental design approach rather than a modeling approach. It helps developing observer protocols and the estimation of variance. An equivalent nested multinomial model to the above is needed with parameters being proportions by size. These are needed to raise the observed size frequencies to the weight of the total set. So the estimation models can become detailed with many strata, but using a statistical model (the multinomial) allows the estimation to be fairly transparent.

Another aspect of the statistical design is that strata with low sample sizes, extrapolation to unobserved sets and, or new strata being relevant in a particular year are more easily accommodated. Post stratification would be useful for addressing changes in the relevant strata for any particular year. Analyses have shown the relevance of previously defined strata such as set type, area, season, location and fleet. It is expected that the multinomial approach will provide estimates of useful precision. When sample sizes are limited, I am an advocate of developing pooling rules when sample sizes are insufficient (the SoW refers to this as substitution, but effectively substitution is collapsing strata). Pooling also falls within the rubric of post stratification. Simulation work would be helpful in establishing appropriate rules.

Uncertainty: while variance estimates can be calculated with the multinomial approach, it would be extremely helpful that there be some simple Monte Carlo simulations conducted of a set with various observation characteristics. Repeated simulations would lead to aggregated estimates over say 200 sets. Additional replicates would help to indicate variances. Just as important, the simulations would provide a mechanism for evaluating the importance of such things as: layering in net and brail, observers non-random selection of species/sizes. See Appendix 4.

Historical catch estimates are needed when there were no paired spill samples. In this review we are asked to address appropriate ways to make this estimation. My first comment is that we do not have data at that time so whatever method is used will be based on untestable assumptions. A statistical approach essentially assumes that the processes are stationary between historical times without data and the present. Then substituting current parameters for historical strata is equivalent to substituting current observed strata for current unobserved strata. If the statistical tact were taken, then the multinomial model is an appropriate way to do it. It remains to define the appropriate strata for doing that. I have no strong feelings for defining appropriate historical strata. Since it is based upon assumption, that process should be debated by individuals familiar with the data, fisheries and stocks.

A possible alternative is to use the assessment process to determine catches. This is attractive to me as a stock assessment person because it accounts for differing dynamics of the three species, which the statistical method does not. There is a general belief that catch estimates are important in constraining the assessment. Therefore, one might use the reported aggregate catches and then assume a prior on the proportion of them that are skipjack; then use, for example, a random walk around that prior. A method such as this allows the catch estimates to adjust to the stock dynamics of the time (within the constraints imposed by the assumptions). While I like this approach in principle, I recognize there are difficulties: 1) the implication is that the assessment model should incorporate the three species simultaneously and most assessments are not at that stage yet; 2) the estimates derived would be at the aggregation level used in the assessment which might not be appropriate for all strata needed for management; and 3) the calculation of historical estimates would change with each new assessment which might cause management consternation. I would like to see this kind of approach but it probably is not appropriate at this time.

Ultimately we have to realize that no modeling/statistical estimates are foolproof because we do not have the data. Whatever estimation we make today based on one set of assumptions could be changed tomorrow using another set of assumption. An appropriate method, then, is one in which the assumptions are transparent and debated by those familiar with the data, stocks and fisheries.

My comments given above address the terms of reference. Short and specific term-by-term comments are given below

1. Evaluate and provide recommendations on the statistical methods used to estimate species and size composition (skipjack, yellowfin and bigeye tuna) in the purse seine fishery, with particular attention to the following issues:

a. *The need for, and approaches to, simultaneous estimation of catches for all three species*

Yes, there is a need to take a simultaneous approach since they are part of the same stochastic process. Hence, I advocate the statistical design approach through a multinomial model.

b. *The need for, and approaches to, simultaneous estimation of the size and species composition*.

I repeat, yes, there is a need to take a simultaneous approach since they are part of the same stochastic process. Hence, I advocate the statistical design approach through a multinomial model.

c. *Approaches to take into account factors that influence the size and species composition, e.g., season, location, set type, and vessel flag.*

Multinomial estimation for these appropriate strata should be considered.

d. *Approaches for interpolation (e.g., statistical versus substitution) where sample data are low or absent, especially for the estimation of historical catches.*

As noted above, I advocate establishing pooling rules (substitution) allowing post stratification.

e. *Approaches to characterize uncertainty in estimates of the catch by species;*

Multinomial variance estimations are straightforward. Additionally, simulation experiments should help to understand bias.

f. The ability to provide reliable estimates of catch by species at different levels, e.g. the set, the trip, vessel flag, assessment region.

I am not sure about the definition of reliable but I expect that the multinomial approach will provide estimates of catches by species for these strata of useful accuracy and precision.

g. Approaches to analyze the paired spill and grab sample trials.

Estimates of proportions by grab and spill for the same strata are obtained from the multinomial. The ratio of proportions provides an adjustment factor.

Sampling protocols

I advocate conducting simulation experiments to fully address alternative protocols. Even the limited simulations in Appendix 4 provided useful insight.

There is evidence that grab samples are biased and that spill samples are not (or are less so). Therefore, this argues that spill samples should be used in the place of grab. However, there is also the concern that there is species and/or size layering in the brail which manifests as biased species/size sample when but a few brails are sampled within a set. The simulations (Appendix 4) clearly demonstrate that sequential sampling of brails (e.g. sample the first brail and every third one thereafter) can compensate for rather severe layering. However, spill samples are apparently being resisted by both observers and fishers because of operational concerns. It is unclear to me how feasible it would be to have sequential spill samples at a level appropriate to reducing the bias of layering.

Note that the grab samples are sequential samples (five fish from every brail). It would be interesting to understand the tradeoffs between biased sequential grab samples and unbiased unsequential spill samples when layering occurs. Is it possible that sequential grab samples reduce the bias of layering better than a single spill sample? This is a question to be addressed by simulation modeling.

Experimental data needed to address layering is needed. A few sets with sequential spill sampling would be quite useful. In the long run I foresee that a protocol is developed in which there are a number of sequential grab samples, a number of single brail spill samples and a few sequential spill samples. Simulations and experimental designs would be used to establish the appropriate mix. Then an estimation procedure would be developed to make the adjustments between the sampling types.

2. *Based on the findings of above provide recommendations for:*

a. Protocols for the sampling of species and size composition by scientific observers aboard purse seine vessels; and/or

I suggest a mix between sequential grab, unsequential spill and sequential spill.

b. Recommendations for future experimental work that would lead to the determination of new sampling protocols.

Experimental sets using sequential spill sampling are needed at some limited level initially.

3. Reviewers shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

In this instance the CIE reviewers were provided through the NMFS/CIE process, but I would not classify this as a NMFS review. The review was of the data collection and estimation activities through the SPC to which NMFS scientists are a party but were not part of this review. Having said that, I felt the level of effort in terms of the number of reviewers and the time spent at the site visit were appropriate for the level of review. I would note that our review is suggesting alternative estimation and thus, additional data base management activities. It is unclear to me what, if any, institutional constraints exist at SPC that might limit implementation.

Conclusions and Recommendations

The current estimation methods for determining purse seine catch by species in the Western Pacific Ocean were reviewed through the review of documents, listening to scientific presentations on the subject, interviewing key personnel, exploring the data and examining raw logsheets. Additionally, a simulation model of set operations was created to make initial evaluations of biased brailing and sampling processes.

The key findings and recommendations were:

1) There is a need to move away from the model based estimation procedure toward the experimental design based multinomial estimation
2) There is a need for developing a purse seine set-simulation template to be used to examine the robustness of estimation to bias and variance and to evaluate alternative sampling protocols
3) The impact of layering in the brail needs to be evaluated through simulation and experimental sequential sampling of brails
4) Mixed sampling protocols and associated estimation procedures should be developed to encompass the cost efficiency of grab type samples and the less biased but more difficult spill samples

Appendix 1: Bibliography of materials provided for review

Lawson, T.A. 2012. Estimation of the species composition of the catch by purse seiners in the Western and Central Pacific Ocean using grab samples and spill samples collected by observers. Working Paper SC8-ST-WP-03.

Lawson, T.A. 2011. Purse-Seine length frequencies corrected for selectivity bias in grab samples collected by observers. Information Paper SC7–ST–IP–02.

Hampton, J. & P. Williams. 2011. Misreporting of purse seine catches of skipjack and yellowfin-bigeye on logsheets. Working Paper ST–WP–02.

Lawson, T.A. 2010. Update on the estimation of selectivity bias based on paired spill and grab samples collected by observers on purse seiners in the Western and Central Pacific Ocean. Working Paper SC6–ST–WP–02.

Lawson, T.A. 2009. Selectivity bias in grab samples and other factors affecting the analysis of species composition data collected by observers on purse seiners in the Western and Central Pacific Ocean. Working Paper SC5–ST–WP–03.

Lawson, T.A. 2008. Factors affecting the use of species composition data collected by observers and port samplers from purse seiners in the Western and Central Pacific Ocean. Working Paper SC4–ST–WP3.

Lawson, T.A. 2007. Analysis of the proportion of bigeye in 'yellowfin plus bigeye' caught by purse seiners in the WCPFC Statistical Area. Information Paper SC3–ST–IP5.

Pianet, R., P. Pallarés & C. Petit. 2000. New sampling and data processing strategy for estimating the composition of catches by species and sizes in the European purse seine tropical tuna fisheries. IOTC Proceedings No. 3 (2000) : 104-139. Indian Ocean Tuna Commission, Seychelles.

Lawson, T.A. 2011. Estimation of catch rates and catches of key shark species in tuna fisheries of the Western and Central Pacific Ocean using observer data. Information Paper SC7–EB–IP–02.

Powerpoint Presentations

Lawson, T. Review of SPC Estimation of Species and Size Composition of the Western and Central Pacific Purse Seine Fishery From Observer-Based Sampling of the Catch.

Hoyle, S. PS species composition: Analyses of observer and logbook data

Overview of WCPFC Purse seine fishery

Other

Logsheets, including filled out observer logsheets

Additionally a number of additional summaries (Tables and Figures) were supplied by the SPC at the request of the CIE reviewers.

Appendix 2: CIE Statement of Work

Attachment A: Statement of Work for Dr. Joseph Powers

External Independent Peer Review by the Center for Independent Experts

Review of SPC estimation of species and size composition of the western and central Pacific purse seine fishery from observer-based sampling of the catch

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 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 Estimates of species and size composition of the purse seine fishery in the western and central Pacific Ocean (WCPO) are fundamental to stock assessments of skipjack, yellowfin and bigeye tunas conducted by the Secretariat of the Pacific Community (SPC). These assessments provide the scientific basis for management decision making by the Western and Central Pacific Fisheries Commission for the world's largest tuna fishery. Estimates of purse seine catch by species and their size compositions are currently based on at-sea observer sampling protocol known as 'grab sampling', whereby 5 fish are randomly selected from each brail of each purse seine set as they are loaded onboard during observed trips, and some total catch information taken from skippers logbooks. However, it was recently recognized that grab sampling was biased because of human and other factors involved in selecting the fish for sampling and that some logsheet reporting of catches is biased towards skipjack tuna.

A series of experiments were conducted whereby grab sampling was conducted alongside another sampling method, termed 'spill sampling', in which a substantial quantity of fish was 'spilled' from selected brails during the fish loading process. These paired sampling trials allowed a bias correction to be estimated and applied to the historical grab sampling data. The corrected grab sampling data were then analyzed using statistical modeling approaches to estimate species and size composition, testing for and taking account of as appropriate potential independent variables, such as latitude, longitude, set type, year and season. The derived models are used to estimate historical catches and size composition of each species, by fleet and various spatial, temporal and operational strata.

An independent CIE review is requested to evaluate the scientific information and methodology of the SPC estimation of species and size composition of the western and central Pacific purse seine fishery. 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 reviewer team shall have the combined expertise and current working experience in stock assessment, fisheries and mathematical statistics, and statistical modeling. Familiarity with the pelagic tuna fisheries and/or catch sampling protocols is desirable. 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 Noumea, Caledonia during October 22-25, 2012.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW, ToRs, 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, who forwards this information to the NMFS Project Contact no later than 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 COR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a US 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/
http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: At least 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. **CIE reviewer shall not be required to participate in a consensus review.** 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. **Modifications to the SoW and ToRs cannot be made during the peer review, and any modification to the SoW or ToRs prior to the peer review must be approved by the COR and CIE Lead Coordinator.**

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 the panel review meeting in Noumea, Caledonia during 22-25 October 2012.
3) In Noumea, Caledonia during 22-25 October 2012 as specified herein, and conduct an independent peer review in accordance with the ToRs (**Annex 2**).
4) No later than **November 23, 2012,** 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 CIE Regional Coordinator, via email to Dr. David Die 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 September 2012	CIE sends reviewer contact information to the COR, who then sends this to the NMFS Project Contact

8 October 2012	NMFS Project Contact sends the CIE Reviewers the pre-review documents
22-25 October 2012	Each reviewer participates and conducts an independent peer review during the panel review meeting
9 November 2012	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
23 November 2012	CIE submits CIE independent peer review reports to the COR
30 November 2012	The COR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COR within 10 working days after receipt of all required information of the decision on changes. 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) The CIE report shall completed with the format and content in accordance with **Annex 1**,
(2) The 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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Key Personnel:

NMFS Project Contact:

Keith Bigelow
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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.

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 shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   d. The CIE independent report shall be a stand-alone document for others to understand the weaknesses and strengths of the science reviewed.

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 Peer Review of the

Review of SPC estimation of species and size composition of the western and central Pacific purse seine fishery from observer-based sampling of the catch

1. Evaluate and provide recommendations on the statistical methods used to estimate species and size composition (skipjack, yellowfin and bigeye tuna) in the purse seine fishery, with particular attention to the following issues:

    a. The need for, and approaches to, simultaneous estimation of catches for all three species

    b. The need for, and approaches to, simultaneous estimation of the size and species composition.

    c. Approaches to take into account factors that influence the size and species composition, e.g., season, location, set type, and vessel flag.

    d. Approaches for interpolation (e.g., statistical versus substitution) where sample data are low or absent, especially for the estimation of historical catches.

    e. Approaches to characterize uncertainty in estimates of the catch by species;

    f. The ability to provide reliable estimates of catch by species at different levels, e.g. the set, the trip, vessel flag, assessment region.

    g. Approaches to analyze the paired spill and grab sample trials.

2. Based on the findings of (1) above provide recommendations for:

    c. Protocols for the sampling of species and size composition by scientific observers aboard purse seine vessels; and/or

    d. Recommendations for future experimental work that would lead to the determination of new sampling protocols.

Annex 3: Tentative Agenda

Review of SPC estimation of species and size composition of the western and central Pacific purse seine fishery from observer-based sampling of the catch

Secretariat of the Pacific Community
Promenade Roger Laroque
Noumea, New Caledonia
Phone: +687 262000
22-25 October 2012

1. Overview of observer sampling protocols including the paired spill and grab sample trials
2. Overview of logsheet data collection and known issues
3. Overview of historical and recent approaches to the estimation of species and size composition of purse seine catches.
4. Interactive examination of the issues outlined in the TOR. SPC staff will be available to produce data summaries and run statistical analyses to support this examination.
5. Reviewers prepare draft reports,
6. Presentation of preliminary review findings by the reviewers, with discussion and feedback from SPC staff.

Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Panel membership: Dr. Patrick Cordue also was a CIE reviewer and is providing an independent report.

Appendix 4: Example of Set Simulations

A simulation model of set operations was constructed to provide insight into the extent of biases. I used this information to get an understanding of how biases are manifested in the data. It is recommended that a similar simulation be used to evaluate alternative operational sampling issues. In this particular case, the simulation was written in BASIC (old-fashioned, I know, and therefore slow, but I like the editor; Table BASIC CODE). But it could be easily translated into R or Fortran. A compiled version of the code runs for 200 sets in about 1 ½ minutes. An example input data file is in Table ExampleDataInputFile. The compiled version of the code as it exists now is available on request.

The simulation inputs a frequency, species, length, weight table for the three species (SKJ, YFT, BET), representing a type of school (e.g. associated and unassociated by other strata). This was the base data. In my example the frequencies were hypothetical, although the species distribution was realistic (SKJ=74%, YFT=22% and BET=5%). The school was constructed such that the aggregate weight of the school was 40 mt. Frequencies were placed in 200 cm-wide length classes. Lengths were converted to weights using the conversions in Lawson 2012.

Simulations were run by 1) generating a random catch C which was distributed lognormally with mean 40 and standard deviation 48; 2) fish were randomly drawn from the base data with replacement to populate a caught school whose size was C; 3) brailing was conducted in which the brail capacity was 5 mt and brails were equally likely to be 1/8 full, 2/8 full…(this can be changed); 4) individual fish are taken from the net and put in a brail according to specified brailing processes; 5) individual fish are sampled from the brail according to a sampling process; 6) statistics are accumulated and the process was repeated for 200 sets. Outputs are set-by set statistics (weight, number of fish, number brails, number of fish sampled) and the characteristics of every fish sampled (length, weight, species, the set number and the brail number).

The brailing processes modeled were: a) fish were randomly selected from the net to enter the brail; b) size layering: fish that were > 60 cm were 5 times as likely to be brailed than if by random; or c) species layering: BET were 5 times as likely to be brailed than if by random.

Sampling was conducted by drawing a uniform sample from a brail (20 fish +-5). Two sampling protocols were tested: i) sampling the 2nd brail only; and ii) sampling the 1st brail and every third brail, thereafter.

Note that all of these parameters can be easily changed.
Results are in
Table MyTest0. Size layering in brail, only the 2nd brail sampled
Table MyTest1. Species layering in brail (BET more likely to be brailed), only the 2nd brail sampled
Table MyTest2. Brailing random relative to species/size, only the 2nd brail sampled
Table MyTest3. Brailing random relative to species/size, 1st brail sampled and every 3rd thereafter

Table MyTest4. Species layering (BET more likely to be brailed), 1st brail sampled and every 3rd, thereafter

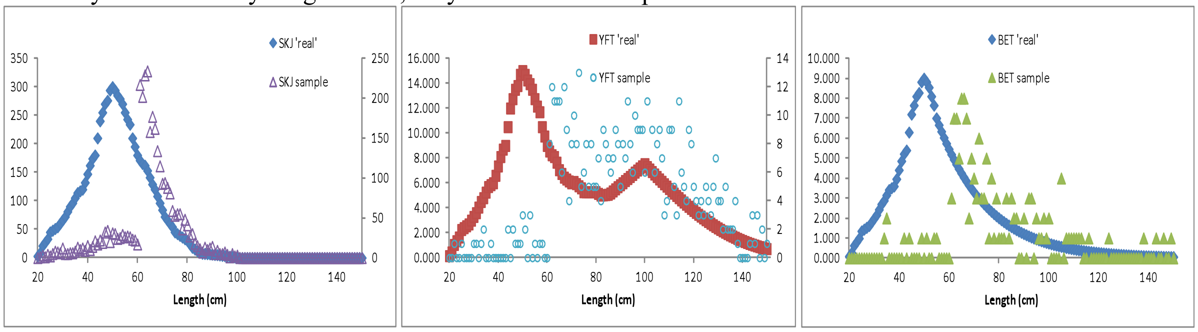
Results show that species/size layering has the potential for larger biases in species composition, but that sequential sampling of brails within a set alleviates some of the bias. Similarly, sequential sampling of brails within a set alleviates some bias associated with size layering.

Future evaluations should probably develop alternative school models. Real schools probably have more variability relative to size and species than those obtained by randomly selecting fish from the base data table. Additionally, alternative sampling biases should be modeled and evaluated.

This simulation model or an equivalent can be used to generate samples and known data sets for each stratum in the fishery which may be used to evaluate the estimation process.

It is recommended that a similar simulation be used to evaluate alternative operational sampling issues.

Table MyTest0. Size layering in brail, only the 2nd brail sampled



Rule_for_Brailing: Size_Layer ; Fish>60cm_are_5_times_as_likely_to_be_brailed_relative_to_random
Rule for sampling: Random; Uniform sample size (20fish+-5 fish) taken from brail #2 and no others

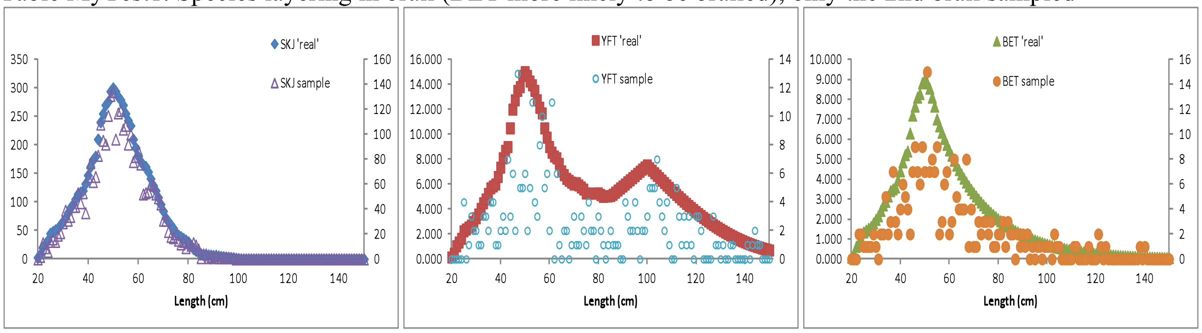
Per-set
Underlying_'real'_per-school_data_from_which_the_catches_are_drawn

_	Freq	Wt(mt)	Prop-by-wt
ALL	9267.848	40.007	1
SKJ	8246.4	29.419	0.7354
YFT	730.233	8.748	0.2187
BET	291.215	1.84	0.046

_	Num_sampled	Wt_sampled	Prop-by-wt
ALL	3854	33.167	1
SKJ	3141	20.678	0.6234
YFT	571	10.675	0.3219
BET	142	1.814	0.0547

	Set Data	Ave	StDev
ALL	Size of Catch (mt)	43.1582	53.631
	Number /Set	10004.88	12431.8919
	No. Fish Sampled	19.27	2.8083
SKJ	Size of Catch (mt)	31.7775	39.4538
	Number /Set	8906.475	11062.5001
	No. Fish Sampled	15.705	3.088
YFT	Size of Catch (mt)	9.4193	11.7306
	Number /Set	784.525	977.0366
	No. Fish Sampled	2.855	1.8112
BET	Size of Catch (mt)	1.9664	2.4588
	Number /Set	314.88	393.0546
	No. Fish Sampled	0.71	0.8541
Number Brails		16.015	19.2533

Table MyTest1. Species layering in brail (BET more likely to be brailed), only the 2nd brail sampled



Rule_for_Brailing: Species_Layer ; BET_are_5_times_as_likely_to_be_brailed_relative_to_random

Rule for sampling: Random, Uniform sample size (20fish+-5 fish) taken from brail #2 and no others

Per-set

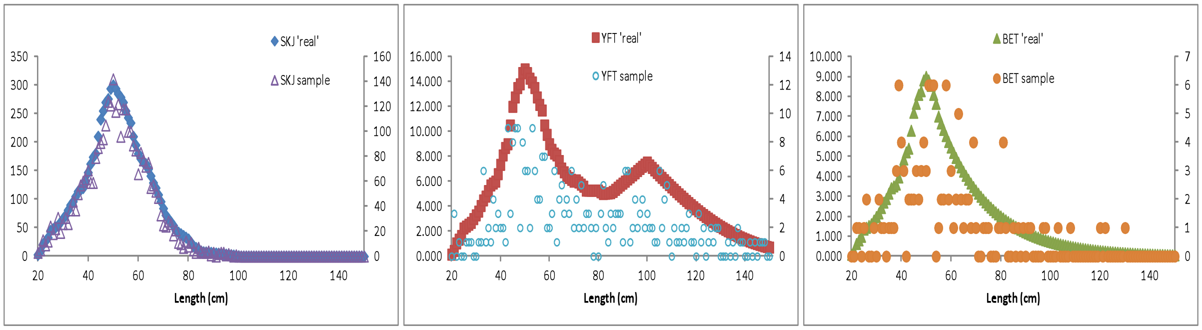
Underlying_'real'_per-school_data_from_which_the_catches_are_drawn

_	Freq	Wt(mt)	Prop-by-wt
ALL	9267.848	40.007	1
SKJ	8246.4	29.419	0.7354
YFT	730.233	8.748	0.2187
BET	291.215	1.84	0.046

_	Num_sampled	Wt_sampled	Prop-by-wt
ALL	3864	16.89	1
SKJ	3297	11.769	0.6968
YFT	295	3.338	0.1977
BET	272	1.782	0.1055

	Set Data	Ave	StDev
ALL	Size of Catch (mt)	33.375	38.4043
	Number /Set	7731.335	8931.1719
	No. Fish Sampled	19.32	2.7922
SKJ	Size of Catch (mt)	24.5438	28.3165
	Number /Set	6880.57	7952.7822
	No. Fish Sampled	16.485	2.9348
YFT	Size of Catch (mt)	7.2929	8.3354
	Number /Set	608.21	698.5883
	No. Fish Sampled	1.475	1.2757
BET	Size of Catch (mt)	1.5431	1.7677
	Number /Set	243.555	280.5379
	No. Fish Sampled	1.36	1.4494
Number Brails		12.415	14.2378

Table MyTest2. Brailing random relative to species/size only the 2nd brail sampled



Rule_for_Brailing: Random

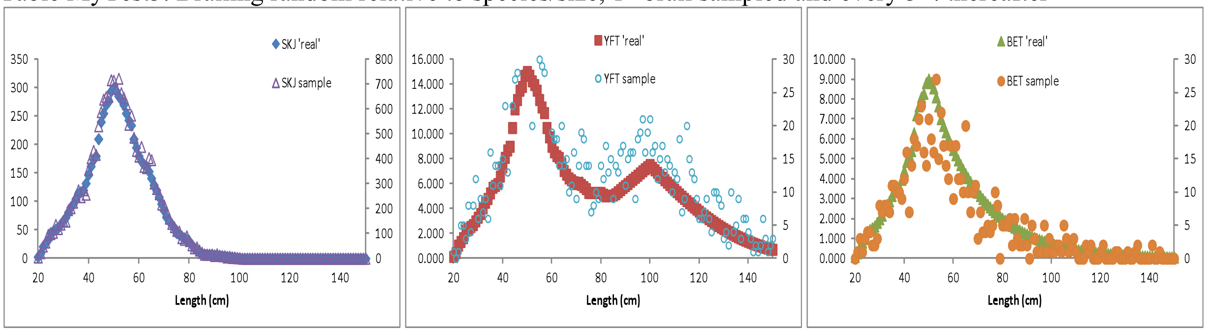
Rule for sampling: Random; Uniform sample size (20fish+-5 fish) taken from brail #2 and no others

Per-set
Underlying_'real'_per-school_data_from_which_the_catches_are_drawn

_	Freq	Wt(mt)	Prop-by-wt
ALL	9267.848	40.007	1
SKJ	8246.4	29.419	0.7354
YFT	730.233	8.748	0.2187
BET	291.215	1.84	0.046
_	Num_sampled	Wt_sampled	Prop-by-wt
ALL	3868	16.306	1
SKJ	3423	11.947	0.7326
YFT	318	3.61	0.2214
BET	127	0.75	0.046

	Set Data		
		Ave	StDev
ALL	Size of Catch (mt)	35.9804	34.3899
	Number /Set	8338.66	7968.5483
	No. Fish Sampled	19.34	2.4728
SKJ	Size of Catch (mt)	26.448	25.2819
	Number /Set	7417.575	7086.3063
	No. Fish Sampled	17.115	2.5856
YFT	Size of Catch (mt)	7.8713	7.5143
	Number /Set	658.55	630.5264
	No. Fish Sampled	1.59	1.2245
BET	Size of Catch (mt)	1.6673	1.614
	Number /Set	263.535	252.6803
	No. Fish Sampled	0.635	0.7242
Number Brails		13.67	12.7709

Table MyTest3. Brailing random relative to species/size, 1st brail sampled and every 3rd. thereafter



Rule_for_Brailing: Random
Rule for sampling: Random; Uniform sample size (20fish+-5 fish) taken from brail #1 and every 3rd brail, thereafter

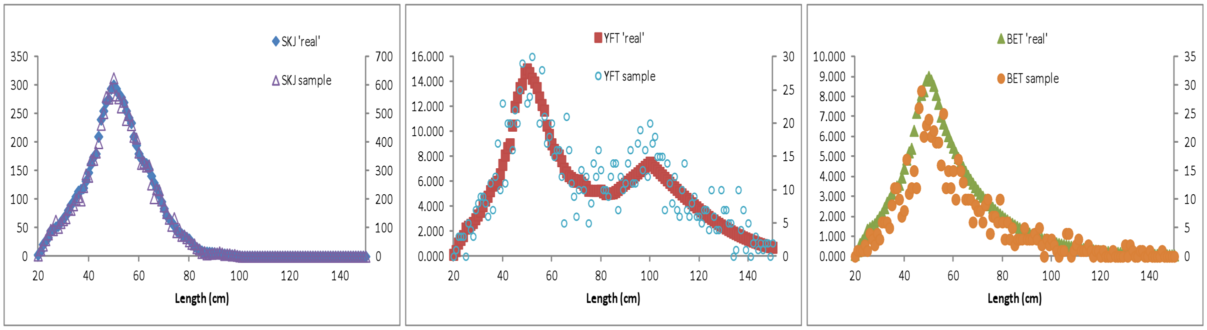
Per-set
Underlying_'real'_per-school_data_from_which_the_catches_are_drawn

_	Freq	Wt(mt)	Prop-by-wt
ALL	9267.848	40.007	1
SKJ	8246.4	29.419	0.7354
YFT	730.233	8.748	0.2187
BET	291.215	1.84	0.046

_	Num_sampled	Wt_sampled	Prop-by-wt
ALL	22215	97.269	1
SKJ	19705	70.728	0.7271
YFT	1790	21.955	0.2257
BET	720	4.585	0.0471

	Set Data	Ave	StDev
ALL	Size of Catch (mt)	43.5396	53.5476
	Number /Set	10076.76	12375.305
	No. Fish Sampled	111.075	120.9081
SKJ	Size of Catch (mt)	31.9866	39.2609
	Number /Set	8965.56	11005.2734
	No. Fish Sampled	98.525	108.1209
YFT	Size of Catch (mt)	9.5663	11.8273
	Number /Set	795.825	981.7433
	No. Fish Sampled	8.95	9.7159
BET	Size of Catch (mt)	1.9923	2.4768
	Number /Set	316.375	389.179
	No. Fish Sampled	3.6	4.0462
Number Brails		16.135	18.5301

Table MyTest4. Species layering in brail (BET more likely to be brailed), 1st brail sampled and every 3rd brail thereafter



Rule_for_Brailing: Species_Layer; BET_are_5_times_as_likely_to_be_brailed_relative_to_random

Rule for sampling: Random; Uniform sample size (20fish+-5 fish) taken from brail #1 and every 3rd brail, thereafter

Per-set

_	Freq	Wt(mt)	Prop-by-wt
ALL	9267.848	40.007	1
SKJ	8246.4	29.419	0.7354
YFT	730.233	8.748	0.2187
BET	291.215	1.84	0.046

All Sets	Num_sampled	Wt_sampled	Prop-by-wt
ALL	18531	81.175	1
SKJ	16334	58.473	0.7203
YFT	1443	17.721	0.2183
BET	754	4.981	0.0614

	Set Data		
		Ave	StDev
ALL	Size of Catch (mt)	31.8668	35.3183
	Number /Set	7384.6877	8175.685
	No. Fish Sampled	75.3239	92.655
SKJ	Size of Catch (mt)	23.43	25.9603
	Number /Set	6571.7057	7275.97
	No. Fish Sampled	66.5577	81.67
YFT	Size of Catch (mt)	6.9713	7.7382
	Number /Set	579.7245	643.845
	No. Fish Sampled	6.6468	7.215
BET	Size of Catch (mt)	1.4899	1.625
	Number /Set	234.2691	256.87
	No. Fish Sampled	3.3124	3.77
Number Brails		11.5692	13.18

Table BASIC Code

```
Public NumberSets, MaxNumFishInSet, SumAllFish, BaseData, SchoolRule, Kspecies, Beta
Public BrailRule, NLengthClasses, SampleRule, WT, SetData, NumSpec, Describe
Public FishLeftInNet, NSizeL, NumFishInBrail, NStartSampleBrail
Public NumInSample, SampleData, NumFishSampled, NCountBrail, BrailFull, NGreater
Public MaxNumFishSampled, BrailCapacity, Alpha, SampSize, PlusMinus, NBrailtoSamp
Public Cmean, CSigma2, iseed, RunChar, NumFishInNetMore, NumFishInNetLess
Public FishInNet, FishInBrail, FishInSample, FishInNetLow, FishInNetHigh
Public FishLeftMore, FishLeftLess

Private Sub RunCommand_Click()
  Call Initialize    'set up matrices and input data
  Call SetSimulation      'set simulation
  Call OutputTables   'output SetData and Sample Data
End Sub

Sub Initialize()
        iseed = 12345
      RunChar = "1"
      ReDim Describe(5)   'enter a description of the run
      Describe(1) = "|  describe run"
      Describe(2) = "|  describe run"
      Describe(3) = "|  describe run"
      Describe(4) = "|  describe run"
      Describe(5) = "|  describe run"

      NumberSets = 200
      NLengthClasses = 200
      MaxNumFishInSet = 20000
      MaxNumFishSampled = 100000
      BrailCapacity = 5#    'input 5 tonnes
      SchoolRule = "Random" 'school structure rule that you are modeling, I start with a random selction
      'BrailRule = "Random"
      'BrailRule = "Size_Layer"
        'Assume fish>"NSizeL"cm are "beta" times as likely to be brailed relative to random
          Beta = 1.1: NSizeL = 50
      BrailRule = "Species_Layer"
        'Assume species "Kspecies" is "alpha" times as likely to be brailed relative to random
          Alpha = 2#: Kspecies = 3 'BET
      SampleRule = "Random" 'sampling rule that you are modeling
        'uniform w/ mean=Sampsize +- PlusMinus
        'Sampling every "NBrailtoSamp"th brail
          SampSize = 20#: PlusMinus = 5#: NBrailtoSamp = 3: NStartSampleBrail =1
        ‘  NStartSampleBrail; 1st brail to be sampled

      ReDim BrailFull(8) 'proportion of brails that are 1/8th to 1 full
        BrailFull(1) = 0.125: BrailFull(2) = 0.125
        BrailFull(3) = 0.125: BrailFull(4) = 0.125
        BrailFull(5) = 0.125: BrailFull(6) = 0.125
        BrailFull(7) = 0.125: BrailFull(8) = 0.125

      Cmean = 40                'Mean of a lognormal catch/set distribution
      CSigma = 0.9              'std dev of the normal dev used in a lognormal catch/set distribution

      ReDim BaseData(3, 2, NLengthClasses) 'specify a"population" of fish
                   ' classified into the frequency
                   ' of fish by species in length classes
      'BaseData(species, 1, j)= freq of fish in jth of NLengthClasses length classes
      'BaseData(species, 2, j)= wt(mt)/fish of fish in jth of NLengthClasses length classes


      ReDim SetData(NumberSets, 10, 0 To 3) ' table of set results
          'SetData(i, 1, species)=wt of fish in set; "species 0" is sum
          'SetData(i, 2, species)=# of fish in set; "species 0" is sum
```

```
                'SetData(i, 3, species)=#brails in set
                'SetData(i, 4, species)=# fish sampled in set; "species 0" is sum
                'SetData(i, 5, species)=NSchoolRule 'school structure rule that you are modeling, I start with a random selction
                'SetData(i, 6, species)= NBrailRule 'brailing rule that you are modeling
                'SetData(i, 7, species)= NSampleRule 'sampling rule that you are modeling
                For i = 1 To NumberSets
                For j = 1 To 10
                For k = 0 To 3: SetData(i, j, k) = 0#: Next k
                Next j
                Next i
        ReDim SampleData(MaxNumFishSampled, 7)
            'SampleData(i,1)=set number
            'SampleData(i,2)=brail number
            'SampleData(i,3)=species
            'SampleData(i,4)=length class
            'SampleData(i,5)=wt
            'SampleData(i,6)=NSampleRule
            'SampleData(i,7)=sample size from brail

        ReDim WT(0 To 3) 'ave wt of fish in a set's catch by species
                        'Wt(3, 0) is ave wt of fish per catch


          ReDim FishInNet(MaxNumFishInSet, 4) 'table that follows the fish
              'FishTable(MaxNumFishInSet, j) j=1,4 are attributes
          ReDim FishInBrail(MaxNumFishInSet, 4) 'table that follows the fish
              'FishTable(MaxNumFishInSet, j) j=1,4 are attributes
          ReDim FishInSample(MaxNumFishInSet, 4) 'table that follows the fish
              'FishTable(MaxNumFishInSet, j) j=1,4 are attributes
          ReDim FishInNetLow(MaxNumFishInSet, 4) 'table that follows the fish
              'FishTable(MaxNumFishInSet, j) j=1,4 are attributes
          ReDim FishInNetHigh(MaxNumFishInSet, 4) 'table that follows the fish
              'FishTable(MaxNumFishInSet, j) j=1,4 are attributes


                  'these tables are zeroed out at the beginning of each set
        Call GetData
        For isets = 1 To NumberSets
            For j = 0 To 3
             SetData(isets, 5, j) = SchoolRule 'school structure rule that you are modeling, I start with a random selction
             SetData(isets, 6, j) = BrailRule 'brailing rule that you are modeling
             SetData(isets, 7, j) = SampleRule 'sampling rule that you are modeling
            Next j
        Next isets
          Randomize iseed
End Sub

Sub SetSimulation()
          'for NumberSets
            '1) randomly generate a catch in a set based on the base data and a Poisson distribution
            '2) place the catch in the net
            '3) Brailing
              '3a draw the fish from the net into the braile according to a rule
              '3b sample the fish from a braile according to a rule
              '3c repeat until no fish left in net
            '4) accumulate statistics
          'next set
            NumFishSampled = 0
          For isets = 1 To NumberSets
            ReDim FishInNet(MaxNumFishInSet, 4)
            ReDim FishInBrail(MaxNumFishInSet, 4)
            ReDim FishInSample(MaxNumFishInSet, 4)
            ReDim FishInNetLow(MaxNumFishInSet, 4)
            ReDim FishInNetHigh(MaxNumFishInSet, 4)
                    jk = 0
                    If BrailRule <> "Random" Then jk = 1
```

```
  'Generate Catch Size in weight 'Poisson # tons in the set
  Call CatchWt(isets)

   Allwt = 0#: NumFishInSet = 0:
   NumFishInNetMore = 0: NumFishInNetLess = 0
   'select fish by converting basedata into a school
    'construct a captured school from
      'the "population" according to a rule
  Do
    Call School(ikeep, jkeep)
    'put fish into the net
    wtoffish = BaseData(ikeep, 2, jkeep) ' / BaseData(ikeep, 1, jkeep)
    Allwt = Allwt + wtoffish
    If Allwt <= SetData(isets, 1, 0) Then
      NumFishInSet = NumFishInSet + 1
     If jk = 0 Then
      FishInNet(NumFishInSet, 1) = isets
      FishInNet(NumFishInSet, 2) = ikeep
      FishInNet(NumFishInSet, 3) = jkeep
      FishInNet(NumFishInSet, 4) = wtoffish
     Else
      jq = 1
      If BrailRule = "Species_Layer" And ikeep = Kspecies Then jq = 2
      If BrailRule = "Size_Layer" And jkeep > NSizeL Then jq = 2
      If jq = 1 Then
        NumFishInNetLess = NumFishInNetLess + 1
        FishInNetLow(NumFishInNetLess, 1) = isets
        FishInNetLow(NumFishInNetLess, 2) = ikeep
        FishInNetLow(NumFishInNetLess, 3) = jkeep
        FishInNetLow(NumFishInNetLess, 4) = wtoffish
      ElseIf jq = 2 Then
        NumFishInNetMore = NumFishInNetMore + 1
        FishInNetHigh(NumFishInNetMore, 1) = isets
        FishInNetHigh(NumFishInNetMore, 2) = ikeep
        FishInNetHigh(NumFishInNetMore, 3) = jkeep
        FishInNetHigh(NumFishInNetMore, 4) = wtoffish
      End If
     End If
    End If
     SetData(isets, 1, ikeep) = SetData(isets, 1, ikeep) + wtoffish
     SetData(isets, 2, ikeep) = SetData(isets, 2, ikeep) + 1
  Loop Until Allwt > SetData(isets, 1, 0)
    SetData(isets, 2, 0) = NumFishInSet
    FishLeftInNet = NumFishInSet
    FishLeftMore = NumFishInNetMore
    FishLeftLess = NumFishInNetLess
    If jk = 1 Then FishLeftInNet = NumFishInNetLess + NumFishInNetMore
'Brail and sample
  NumBrail = 0: NCountBrail = 0
  Do Until FishLeftInNet = 0
  NumBrail = NumBrail + 1: NCountBrail = NCountBrail + 1
  If NumBrail < NStartSampleBrail Then NCountBrail = 0
      'BrailFullness randomly drawn from the 8
        'categories in the data
      u = Rnd: bb = 0#
      For i = 1 To 8
      If bb > u Then Exit For
      bb = bb + BrailFull(i)
      ikeep = i
      Next i

      NumFishInBrail = 0
      BrailSize = ikeep * BrailCapacity / 8#
      'select fish from net
        ‘ diff algorithms for diff bias
         Awt = 0#: nc = 0
```

```
                    Do Until Awt > BrailSize Or FishLeftInNet <= 0
                      Call Brailing(ifish, imore)
                      If ifish > 0 Then
                       If imore = 0 Then   ‘random selection
                        Awt = Awt + FishInNet(ifish, 4)
                        If Awt <= BrailSize Then
                         NumFishInBrail = NumFishInBrail + 1
                         For j = 1 To 4: FishInBrail(NumFishInBrail, j) = FishInNet(ifish, j): Next j
                         For j = 1 To 4: FishInNet(ifish, j) = FishInNet(FishLeftInNet, j): Next j
                         FishLeftInNet = FishLeftInNet - 1
                        End If
                       ElseIf imore = 1 Then   ‘size layering or species layering … fish = Kspecies or fish>Nsizel
                         Awt = Awt + FishInNetLow(ifish, 4)
                        If Awt <= BrailSize Then
                         NumFishInBrail = NumFishInBrail + 1
                         For j = 1 To 4: FishInBrail(NumFishInBrail, j) = FishInNetLow(ifish, j): Next j
                         For j = 1 To 4: FishInNetLow(ifish, j) = FishInNetLow(FishLeftLess, j): Next j
                         FishLeftLess = FishLeftLess - 1
                         FishLeftInNet = FishLeftInNet - 1
                        End If
                       ElseIf imore = 2 Then  ‘size layering or species layering … fish <> Kspecies or fish<=Nsizel
                         Awt = Awt + FishInNetHigh(ifish, 4)
                        If Awt <= BrailSize Then
                         NumFishInBrail = NumFishInBrail + 1
                         For j = 1 To 4: FishInBrail(NumFishInBrail, j) = FishInNetHigh(ifish, j): Next j
                         For j = 1 To 4: FishInNetHigh(ifish, j) = FishInNetHigh(FishLeftMore, j): Next j
                         FishLeftMore = FishLeftMore - 1
                         FishLeftInNet = FishLeftInNet - 1
                        End If
                       End If
                      End If
                    Loop
                  'sample from Brail
                    'different algorithms for diff biases (grab vs spill etc); only random modeled here
                   isample = 0
                    Do
                      Call Sampler(ifish, isample)
                      isample = isample + 1
                     If isample <= NumInSample And ifish > 0 Then
                     If NumFishInBrail > 0 Then
                      'update sampling statistics
                      For j = 1 To 4: FishInSample(isample, j) = FishInBrail(ifish, j): Next j
                      For j = 1 To 4: FishInBrail(ifish, j) = FishInBrail(NumFishInBrail, j): Next j
                          NumFishInBrail = NumFishInBrail - 1
                          NumFishSampled = NumFishSampled + 1
                          ispecies = Int(FishInSample(isample, 2))
                          SampleData(NumFishSampled, 1) = isets
                          SampleData(NumFishSampled, 2) = NumBrail
                          SampleData(NumFishSampled, 3) = ispecies 'species
                          SampleData(NumFishSampled, 4) = FishInSample(isample, 3) 'length
                          SampleData(NumFishSampled, 5) = FishInSample(isample, 4) 'weight
                          SetData(isets, 4, ispecies) = SetData(isets, 4, ispecies) + 1
                          SetData(isets, 4, 0) = SetData(isets, 4, 0) + 1
                     End If
                     End If
                    Loop Until isample >= NumInSample 'no fish left in sample
                Loop 'end brailing no fish left in the net
                For j = 0 To 3: SetData(isets, 3, j) = NumBrail: Next j
          Next isets

End Sub


Sub GetData()
        'Purse Seine Base Data
```

```
'a "population" of fish by species/size representing particular schools; distributions will be different for associated and unassociated sets
'_   SKJ MT  YFT kg  BET MT
'cm_length_class FREQ    WT  FREQ    WT  FREQ    WT
'1                 0.0000000000    0.0000000804    0.0000000000    0.0000001927    0.0000000000    0.0000001606
'2   0.0000000000    0.0000007474    0.0000000000    0.0000014785    0.0000000000    0.0000013066
'3   0.0000000000    0.0000027548    0.0000000000    0.0000048694    0.0000000000    0.0000044543
Open "PurseSetData.txt" For Input As #6
Line Input #6, aa: Line Input #6, aa
Line Input #6, aa: Line Input #6, aa: iseed = Int(Val(aa) + 0.001)
Line Input #6, aa:
For i = 1 To 5
Line Input #6, aa: Describe(i) = Trim(aa)
Next i
Line Input #6, aa: Line Input #6, aa: RunChar = Trim(aa)
Line Input #6, aa: Line Input #6, aa: NumberSets = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: NLengthClasses = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: MaxNumFishInSet = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: MaxNumFishSampled = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: BrailCapacity = Val(aa)
Line Input #6, aa: Line Input #6, aa: SchoolRule = Trim(aa)
Line Input #6, aa: Line Input #6, aa: BrailRule = Trim(aa)
Line Input #6, aa: Line Input #6, aa: Line Input #6, aa: Beta = Val(aa)
Line Input #6, aa: Line Input #6, aa: NSizeL = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: Line Input #6, aa: Alpha = Val(aa)
Line Input #6, aa: Line Input #6, aa: Kspecies = Int(Val(aa) + 0.001)
Line Input #6, aa: Line Input #6, aa: SampleRule = Trim(aa)
Line Input #6, aa: Line Input #6, aa: Line Input #6, aa: SampSize = Val(aa)
Line Input #6, aa: Line Input #6, aa: PlusMinus = Val(aa)
Line Input #6, aa: Line Input #6, aa: NStartSampleBrail = Val(aa)
Line Input #6, aa: Line Input #6, aa: NBrailtoSamp = Int(Val(aa) + 0.001)
Line Input #6, aa3:

For i = 1 To 8
Line Input #6, aa: Line Input #6, aa: BrailFull(i) = Val(aa)
Next i
Line Input #6, aa: Line Input #6, aa: Cmean = Val(aa)
Line Input #6, aa: Line Input #6, aa: CSigma2 = Val(aa)
Line Input #6, aa1: Line Input #6, aa:

Do Until EOF(6)
  Input #6, f0, f1, f2, f3, f4, f5, f6
    n1 = Int(f0)
   BaseData(1, 1, n1) = f1: BaseData(1, 2, n1) = f2
   BaseData(2, 1, n1) = f3: BaseData(2, 2, n1) = f4
   BaseData(3, 1, n1) = f5: BaseData(3, 2, n1) = f6
Loop
Close #6

   SumAllFish = 0#
   For i = 1 To 3
      For j = 1 To NLengthClasses
      SumAllFish = SumAllFish + BaseData(i, 1, j)
      Next j
   Next i

      For i = 1 To 3: WT(i) = 0#: Next i

      For i = 1 To 3
        For k = 1 To NLengthClasses: WT(i) = WT(i) + BaseData(i, 1, k) * BaseData(i, 2, k): Next k
        'WT(i) = WT(i) / NumberSets
      Next i
      WT(0) = WT(1) + WT(2) + WT(3)
End Sub

Sub School(ikeep, jkeep)
```

```
            If SchoolRule = "Random" Then  'Randomly select fish from the population to create a captured school
               u = Rnd: prb = 0#
               For i = 1 To 3
               For j = 1 To NLengthClasses
                 prb = prb + BaseData(i, 1, j) / SumAllFish
                 If prb > u Then
                   ikeep = i: jkeep = j
                   Exit For
                 End If
               Next j
                 If prb > u Then Exit For
               Next i
            Else    'other school rules
            End If  'end school rules
End Sub

Sub CatchWt(isets)
            'Based on a lognormal with mean=CMean and Normal Variance=Csigma2
             CSigma = Sqr(CSigma2)
             xmu = Log(Cmean) - 0.5 * CSigma2
              u2 = Rnd: v2 = 2# * u2 - 1#
        1   continue = 0#
              u1 = u2: v1 = v2: u2 = Rnd: v2 = 2# * u2 - 1#: w = v2 * v2 + v1 * v1
              If w > 1# Then GoTo 1
              yy = Sqr(-2# * Log(w) / w)
              SetData(isets, 1, 0) = Exp(xmu + v2 * yy * CSigma)
End Sub

Sub Brailing(ifish, imore)
        ifish = 0: imore = 0
        If FishLeftInNet <= 0 Then Exit Sub
        If BrailRule = "Random" Then
           ifish = Int(Rnd * FishLeftInNet) + 1
        ElseIf BrailRule <> "Random" Then
          xmult = Alpha: If BrailRule = "Species_Layer" Then xmult = Beta
        'Assume fish>NSizeL cm are "beta" times as likely to be brailed relative to random
          p = xmult * FishLeftMore / FishLeftInNet

           If p > 1 Then p = 1#
           u1 = Rnd
           If u1 <= p And FishLeftMore > 0 Then
             ifish = Int(Rnd * FishLeftMore) + 1
             imore = 2
           End If
           If u1 > p And FishLeftLess > 0 Then
             ifish = Int(Rnd * FishLeftLess) + 1
             imore = 1
           End If
           If imore = 0 Then
             If FishLeftMore <= 0 Then ifish = Int(Rnd * FishLeftLess) + 1
             If FishLeftLess <= 0 Then ifish = Int(Rnd * FishLeftMore) + 1
           End If
        End If
End Sub

Sub Sampler(ifish, isample)
       If SampleRule = "Random" Then
          'Sample SampSize fish +- PlusMinus for every NBrailtoSamp"th" brail
          ifish = 0
          If isample = 0 Then NumInSample = Int(SampSize + (0.5 - Rnd) * PlusMinus)
          If NCountBrail = 1 Then ifish = Int(Rnd * NumFishInBrail) + 1
          If NCountBrail = NBrailtoSamp Then NCountBrail = 0
       ElseIf SampleRule = "?" Then  'another process?
       End If
End Sub
```

```
Sub OutputTables()
                'output set data

                SetOutputFile = "SetOut" + RunChar + ".txt"
                SampleOutPutFile = "SampleOut" + RunChar + ".txt"
                Open SetOutputFile For Output As #7
                  Print #7, Tab(4); Date; Tab(20); Time
                  For i = 1 To 5: Print #7, Tab(4); Describe(i): Next i
                  Print #7, "  Sample_data_is_in: " + SampleOutPutFile
                  Call PrintInputs
                      ReDim av(0 To 3, 4, 2)
                       For isets = 1 To NumberSets
                          For j = 0 To 3
                          For k = 1 To 4
                           av(j, k, 1) = av(j, k, 1) + SetData(isets, k, j)
                           av(j, k, 2) = av(j, k, 2) + SetData(isets, k, j) ^ 2
                          Next k
                          Next j
                       Next isets
                     For i = 1 To 2
                      ad = "Ave "
                      If i = 2 Then ad = "StDev "
                     Print #7, Tab(4); ad;
                       ntab = 0
                     For j = 0 To 3
                       For k = 1 To 4
                       xm = av(j, k, 1) / NumberSets
                       If i = 2 Then xm = Sqr((av(j, k, 2) - (av(j, k, 1) ^ 2) / NumberSets) / (NumberSets - 1))
                       ntab = ntab + 15: Print #7, Tab(ntab); Format(xm, "###0.0###");
                       Next k
                     Next j
                       ntab = ntab + 15: Print #7, Tab(ntab); "_";
                       ntab = ntab + 15: Print #7, Tab(ntab); "_";
                       ntab = ntab + 15: Print #7, Tab(ntab); "_"
                     Next i

                       ReDim atab(7)  'column titles for output
                     atab(1) = "Wt_In_Set"
                     atab(2) = "#_In_Set"
                     atab(3) = "Num_Brail"
                     atab(4) = "Sample_In_Set"
                     atab(5) = "School_Rule"
                     atab(6) = "Brail_Rule"
                     atab(7) = "Sample_Rule"
                       'print header

                            Print #7, Tab(4); "_";
                        ntab = 0
                        For j = 0 To 3
                        For k = 1 To 4
                          ntab = ntab + 15
                         ad = "_"
                           If k = 1 Then
                                If j = 0 Then ad = "All_Species"
                                If j = 1 Then ad = "SKJ"
                                If j = 2 Then ad = "YFT"
                                If j = 3 Then ad = "BET"
                           End If
                          Print #7, Tab(ntab); ad;
                        Next k
                        Next j
                         For k = 5 To 7
                          ntab = ntab + 15
                         ad = "_"
                          Print #7, Tab(ntab); ad;
                        Next k
```

```
            Print #7, ""


          Print #7, Tab(4); "Set_No";
          ntab = 0
          For j = 0 To 3
          For k = 1 To 4
            ntab = ntab + 15
            Print #7, Tab(ntab); atab(k);
          Next k
          Next j
          For k = 5 To 7
            ntab = ntab + 15
            Print #7, Tab(ntab); atab(k);
          Next k
            Print #7, ""


  For isets = 1 To NumberSets
       'print set by set data
        Print #7, Tab(4); isets;
        ntab = 0
      For j = 0 To 3
        ntab = ntab + 15: Print #7, Tab(ntab); Format(SetData(isets, 1, j), "###0.0###");
        ntab = ntab + 15: Print #7, Tab(ntab); Format(SetData(isets, 2, j), "#####0");
        ntab = ntab + 15: Print #7, Tab(ntab); Format(SetData(isets, 3, j), "##0");
        ntab = ntab + 15: Print #7, Tab(ntab); SetData(isets, 4, j);
      Next j
        ntab = ntab + 15: Print #7, Tab(ntab); SetData(isets, 5, 3);
        ntab = ntab + 15: Print #7, Tab(ntab); SetData(isets, 6, 3);
        ntab = ntab + 15: Print #7, Tab(ntab); Format(SetData(isets, 7, 3), "##0");
      Print #7, ""
  Next isets
Close #7
 'output sample data

Open SampleOutPutFile For Output As #7
   Print #7, Tab(4); Date; Tab(20); Time
   For i = 1 To 5: Print #7, Tab(4); Describe(i): Next i
   Print #7, "  Set_data_is_in: " + SetOutputFile
   Call PrintInputs
        ReDim xn(0 To 3, 2), yn(3, NLengthClasses)
   For ilen = 1 To NLengthClasses
      For j = 0 To 3: yn(j, ilen) = 0: Next j
   Next ilen
   For isamp = 1 To NumFishSampled
     xn(0, 1) = xn(0, 1) + 1: xn(0, 2) = xn(0, 2) + SampleData(isamp, 5)
     jspecies = SampleData(isamp, 3)
     xn(jspecies, 1) = xn(jspecies, 1) + 1: xn(jspecies, 2) = xn(jspecies, 2) + SampleData(isamp, 5)
      Length = SampleData(isamp, 4)
      yn(jspecies, Length) = yn(jspecies, Length) + 1
   Next isamp




    Print #7, Tab(10); "_"; Tab(17); "Num_sampled";
    Print #7, Tab(37); "Wt_sampled";
    Print #7, Tab(57); "Prop-by-wt"
   For i = 0 To 3
     ad = "ALL":
     If i = 1 Then ad = "SKJ"
     If i = 2 Then ad = "YFT"
     If i = 3 Then ad = "BET"
    Print #7, Tab(10); ad; Tab(17); xn(i, 1);
    Print #7, Tab(37); Format(xn(i, 2), "#####0.0##");
```

```
      Print #7, Tab(57); Format(xn(i, 2) / xn(0, 2), "0.0###")
     Next i
       Print #7, ""
       Print #7, "Sample-Results"; Tab(55); "'Real'_data"
       Print #7, Tab(2); "Size(cm)";
       Print #7, Tab(12); "Freq_SKJ";
       Print #7, Tab(25); "Freq_YFT";
       Print #7, Tab(40); "Freq_BET";
       Print #7, Tab(57); "Size(cm)";
       Print #7, Tab(67); "Freq_SKJ";
       Print #7, Tab(80); "Freq_YFT";
       Print #7, Tab(90); "Freq_BET"
     For ilen = 1 To NLengthClasses
       Print #7, Tab(2); ilen;
       Print #7, Tab(12); Format(yn(1, ilen), "######0");
       Print #7, Tab(25); Format(yn(2, ilen), "######0");
       Print #7, Tab(40); Format(yn(3, ilen), "######0");
       Print #7, Tab(57); ilen;
       Print #7, Tab(67); Format(BaseData(1, 1, ilen), "####0.0##");
       Print #7, Tab(80); Format(BaseData(2, 1, ilen), "####0.0##");
       Print #7, Tab(90); Format(BaseData(3, 1, ilen), "####0.0##")
     Next ilen
       Print #7, ""




       Print #7, ""
       Print #7, Tab(1); "Fish#";
       Print #7, Tab(10); "Set";   '= isets
       Print #7, Tab(20); "Brail_No."; '= NumBrail
       Print #7, Tab(30); "Species"; '= ispecies                'species
       Print #7, Tab(40); "Length"; '= FishInSampleTable(isample, 3)              'length
       Print #7, Tab(50); "Weight" '= FishInSampleTable(isample, 4)                 'weight

     For isamp = 1 To NumFishSampled
       Print #7, Tab(1); isamp;
       Print #7, Tab(10); SampleData(isamp, 1);   '= isets
       Print #7, Tab(20); SampleData(isamp, 2); '= NumBrail
       ad = "SKJ"
       If SampleData(isamp, 3) = 2 Then ad = "YFT"
       If SampleData(isamp, 3) = 3 Then ad = "BET"
       Print #7, Tab(30); ad; '= ispecies                'species
       Print #7, Tab(40); SampleData(isamp, 4);  'length
       Print #7, Tab(50); Format(SampleData(isamp, 5), "###0.0####")  'weight

     Next isamp
   Close #7
End Sub

Sub PrintInputs()
        Print #7, Tab(10); "Number_Sets_Simulated= "; NumberSets;
        Print #7, Tab(40); "Number_Length_Classes= "; NLengthClasses;
        Print #7, Tab(70); "Brail_Capacity= "; BrailCapacity
        Print #7, Tab(10); "Rule_for_forming_Catch: "; SchoolRule
        Print #7, Tab(10); "Rule_for_Brailing: "; BrailRule;
          ad = ""
          If BrailRule <> "Random" Then
           ab = Trim(Str(Beta)): ac = Trim(Str(NSizeL))
           ad = " Fish>" + ac + "cm_are_" + ab + "_times_as_likely_to_be_brailed_relative_to_random"
           If BrailRule = "Species_Layer" Then
            ac = " BET"
            If Kspecies = 2 Then ac = " YFT"
            If Kspecies = 1 Then ac = " SKJ"
             ad = ac + "_are_" + Trim(Str(Alpha)) + "_times_as_likely_to_be_brailed_relative_to_random"
           End If
```

```
    End If
    Print #7, ad
    rd = "th"
    ed = "#" + Trim(Str(NStartSampleBrail))
    If NBrailtoSamp = 1 Then rd = "st"
    If NBrailtoSamp = 2 Then rd = "nd"
    If NBrailtoSamp = 3 Then rd = "rd"
    ad = " Uniform_sample_size_(" + Trim(Str(SampSize)) + "_fish+-" + Trim(Str(PlusMinus))
    ad = ad + "_fish)_taken_from_set_" + ed + "_and_every_" + Trim(Str(NBrailtoSamp)) + rd + "_set,_thereafter"
Print #7, Tab(10); "Rule_for_sampling: "; SampleRule; ad
Print #7, Tab(10); "Random_Number_seed= "; iseed

ad = "         Brail_Fullness: "
ac = "           Probability: "
For i = 1 To 8
ad = ad + "       " + Trim(Str(i)) + "/8"
cd = Trim(Str(BrailFull(i))): nl = Len(cd): nd = 10 - nl: dc = ""
For j = 1 To nd: dc = dc + " ": Next j
ac = ac + dc + cd
Next i
Print #7, ad: Print #7, ac

Print #7, Tab(10); "LogNormal_Catch-per-Set_Parameters: ";
Print #7, "Mean(mt)= "; Cmean; , "   Lognormal_Sigma^2_of_normal_dev= "; CSigma2
Print #7, ""

        ReDim xn(0 To 3, 2)
        For ilen = 1 To NLengthClasses
          For j = 1 To 3
            xn(j, 1) = xn(j, 1) + BaseData(j, 1, ilen)
            xn(j, 2) = xn(j, 2) + BaseData(j, 2, ilen) * BaseData(j, 1, ilen)
          Next j
        Next ilen
         Print #7, Tab(10); "Per-set"
         Print #7, Tab(10); "Underlying_'real'_per-school_data_from_which_the_catches_are_drawn"
         Print #7, Tab(10); "_"; Tab(17); "Freq";
         Print #7, Tab(37); "Wt(mt)";
         Print #7, Tab(57); "Prop-by-wt"
            xn(0, 1) = xn(1, 1) + xn(2, 1) + xn(3, 1)
            xn(0, 2) = xn(1, 2) + xn(2, 2) + xn(3, 2)
        For i = 0 To 3
          ad = "ALL":
          If i = 1 Then ad = "SKJ"
          If i = 2 Then ad = "YFT"
          If i = 3 Then ad = "BET"
         Print #7, Tab(10); ad; Tab(17); Format(xn(i, 1), "#####0.0##");
         Print #7, Tab(37); Format(xn(i, 2), "#####0.0##");
         Print #7, Tab(57); Format(xn(i, 2) / xn(0, 2), "0.0###")
        Next i
         Print #7, ""
         Print #7, Tab(10); "For_all_" + Trim(Str(NumberSets)) + "_sets"
         Print #7, Tab(10); "Underlying_'real'_school_data_from_which_the_catches_are_drawn"
         Print #7, Tab(10); "_"; Tab(17); "Freq";
         Print #7, Tab(37); "Wt(mt)";
         Print #7, Tab(57); "Prop-by-wt"
        For i = 0 To 3
          ad = "ALL":
          If i = 1 Then ad = "SKJ"
          If i = 2 Then ad = "YFT"
          If i = 3 Then ad = "BET"
         Print #7, Tab(10); ad; Tab(17); Format(xn(i, 1) * NumberSets, "######0.0##");
         Print #7, Tab(37); Format(xn(i, 2) * NumberSets, "######0.0##");
         Print #7, Tab(57); Format(xn(i, 2) / xn(0, 2), "0.0###")
        Next i
```

```
        Print #7, ""
End Sub
```

Table ExampleDataInputFile

```
**Purse Seine Base Data            **denotes comments, i.e. lines that are read on input but ignored
**a "pop" of fish by species/size in a school; distributions will be diff for assoc and unassoc sets
**iseed
 12345
**enter a description of the run
|  describe run
|  describe run
|  describe run
|  describe run
|  describe run
**Name of Run   appended to output file names
  MyTest4
**#_Sets
 200
**NLengthClasses
 200
**MaxNumFishInSet
   100000
**MaxNumFishSampled
   1000000
**BrailCapacity
  5.
**SchoolRule = Random 'school structure rule that you are modeling, I start with a random selection
  Random
**BrailRule = Random, Size_Layer or Species_Layer
    Species_Layer
**  Size Later Params: fish>"NSizeL"cm are "beta" times as likely to be brailed
**Beta
  5
**Length limit cm, i.e. size where layering starts
  60
**   Species Layer Params: species "Kspecies" is "alpha" times as likely to be brailed  KSpecies=1,2,3 for SKJ,YFT,BET
**alpha
  5
** Kspecies
  3
**SampleRule
  Random
**Random ParamS: uniform w/ mean=Sampsize +- PlusMinus 'Sampling every "NBrailtoSamp"th brail after the first=NStartSampleBrail
**SampSize
  20.
**PlusMinus
  5.
**NStartSampleBrail; 1st brail to sample
   1
**NBrailtoSamp; sample every 'NBrailtoSamp'th brail
   3
**BrailFull(8) 'proportion of brails that are 1/8th to 1 full
**BrailFull(1)
   0.125
**BrailFull(2)
   0.125
**BrailFull(3)
   0.125
**BrailFull(4)
   0.125
**BrailFull(5)
   0.125
**BrailFull(6)
   0.125
**BrailFull(7)
   0.125
**BrailFull(8)
   0.125
**LogNormal Mean of Catch per Set
   40.
```

**Variance of Catch per Set Deviations on Log scale
0.9

** **cm	SKJ FREQ	WT(mt)	YFT FREQ	WT(mt)	BET FREQ	WT(mt)
1	0.00000000	3.18434E-08	0	8.27289E-08	0	6.72556E-08
2	0.00000000	1.64739E-07	0	3.71368E-07	0	3.15322E-07
3	0.00000000	4.86349E-07	0	9.98532E-07	0	8.72464E-07
4	0.00000000	1.09172E-06	0	2.09027E-06	0	1.86585E-06
5	0.00000000	2.08212E-06	0	3.77042E-06	0	3.42358E-06
6	0.00000000	3.56394E-06	0	6.16112E-06	0	5.67445E-06
7	0.00000000	5.64788E-06	0	9.38317E-06	0	8.74788E-06
8	0.00000000	8.44843E-06	0	1.35562E-05	0	1.27738E-05
9	0.00000000	1.20835E-05	0	1.87991E-05	0	1.78824E-05
10	0.00000000	1.66739E-05	0	2.52294E-05	0	2.42045E-05
11	0.00000000	2.23436E-05	0	3.29645E-05	0	3.18712E-05
12	0.00000000	2.92188E-05	0	4.21208E-05	0	4.10137E-05
13	0.00000000	3.74282E-05	0	5.2814E-05	0	5.17637E-05
14	0.00000000	4.7103E-05	0	6.51594E-05	0	6.42532E-05
15	0.00000000	5.83763E-05	0	7.92718E-05	0	7.86143E-05
16	0.00000000	7.13832E-05	0	9.52655E-05	0	9.49793E-05
17	0.00000000	8.62609E-05	0	0.000113254	0	0.000113481
18	0.00000000	0.000103148	0	0.000133351	0	0.000134252
19	0.00000000	0.000122186	0	0.00015567	0	0.000157425
20	3.00000000	0.000143516	0.15	0.000180323	0.09	0.000183133
21	9.00000000	0.000167283	0.45	0.000207422	0.27	0.00021151
22	21.00000000	0.000193631	1.05	0.00023708	0.63	0.00024269
23	27.00000000	0.000222709	1.35	0.000269408	0.81	0.000276805
24	33.00000000	0.000254663	1.65	0.000304518	0.99	0.00031399
25	45.00000000	0.000289645	2.25	0.000342519	1.35	0.000354378
26	48.00000000	0.000327804	2.4	0.000383525	1.44	0.000398104
27	51.00000000	0.000369294	2.55	0.000427644	1.53	0.000445302
28	54.00000000	0.000414268	2.7	0.000474987	1.62	0.000496106
29	60.00000000	0.00046288	3	0.000525664	1.8	0.00055065
30	66.00000000	0.000515288	3.3	0.000579786	1.98	0.000609069
31	72.00000000	0.000571647	3.6	0.000637461	2.16	0.000671498
32	81.00000000	0.000632116	4.05	0.000698798	2.43	0.000738072
33	90.00000000	0.000696855	4.5	0.000763909	2.7	0.000808925
34	96.00000000	0.000766024	4.8	0.0008329	2.88	0.000884192
35	105.00000000	0.000839785	5.25	0.00090588	3.15	0.000964008
36	114.00000000	0.0009183	5.7	0.00098296	3.42	0.001048509
37	117.00000000	0.001001732	5.85	0.001064246	3.51	0.00113783
38	120.00000000	0.001090247	6	0.001149847	3.6	0.001232106
39	132.00000000	0.001184009	6.6	0.001239871	3.96	0.001331473
40	147.00000000	0.001283185	7.35	0.001334426	4.41	0.001436066
41	162.00000000	0.001387942	8.1	0.001433619	4.86	0.00154602
42	174.00000000	0.001498449	8.7	0.001537559	5.22	0.001661472

43	180.00000000	0.001614875	9	0.001646352	5.4	0.001782557
44	210.00000000	0.001737389	10.5	0.001760106	6.3	0.001909412
45	240.00000000	0.001866162	12	0.001878927	7.2	0.002042171
46	255.00000000	0.002001366	12.75	0.002002923	7.65	0.002180972
47	270.00000000	0.002143174	13.5	0.002132201	8.1	0.002325949
48	276.00000000	0.002291759	13.8	0.002266867	8.28	0.00247724
49	294.00000000	0.002447295	14.7	0.002407028	8.82	0.002634981
50	300.00000000	0.002609956	15	0.002552789	9	0.002799307
51	294.00000000	0.002779918	14.7	0.002704258	8.82	0.002970355
52	285.00000000	0.002957359	14.25	0.002861541	8.55	0.003148262
53	279.00000000	0.003142454	13.95	0.003024743	8.1	0.003333165
54	270.00000000	0.003335382	13.5	0.00319397	7.65	0.003525198
55	255.00000000	0.003536321	12.75	0.003369328	7.009207	0.003724501
56	243.00000000	0.003745451	12.15	0.003550923	6.667364	0.003931208
57	234.00000000	0.003962952	11.7	0.00373886	6.342193	0.004145457
58	210.00000000	0.004189004	10.5	0.003933245	6.03288	0.004367384
59	195.00000000	0.004423789	9.75	0.004134183	5.738653	0.004597127
60	180.00000000	0.004667488	9	0.004341779	5.458776	0.004834823
61	171.00000000	0.004920285	8.55	0.004556139	5.192548	0.005080607
62	165.00000000	0.005182363	8.25	0.004777366	4.939305	0.005334618
63	162.00000000	0.005453906	8.1	0.005005567	4.698412	0.005596993
64	153.00000000	0.005735099	7.65	0.005240846	4.469268	0.005867868
65	141.00000000	0.006026126	7.05	0.005483307	4.251299	0.006147381
66	129.00000000	0.006327175	6.75	0.005733055	4.043961	0.006435669
67	120.00000000	0.006638431	6.45	0.005990196	3.846734	0.006732869
68	108.00000000	0.006960081	6.3	0.006254832	3.659127	0.00703912
69	96.00000000	0.007292314	6.15	0.006527068	3.480669	0.007354557
70	84.00000000	0.007635318	6	0.00680701	3.310915	0.007679319
71	72.00000000	0.007989282	6.10283	0.007094759	3.14944	0.008013543
72	66.00000000	0.008354394	5.929859	0.007390422	2.99584	0.008357366
73	60.00000000	0.008730847	5.760902	0.007694101	2.849731	0.008710927
74	54.00000000	0.009118829	5.595935	0.008005901	2.710748	0.009074363
75	45.00000000	0.009518532	5.284926	0.008325925	2.578543	0.009447811
76	42.00000000	0.009930149	5.277831	0.008654277	2.452786	0.00983141
77	39.00000000	0.010353872	5.274598	0.00899106	2.333162	0.010225297
78	36.00000000	0.010789892	5.275164	0.009336379	2.219373	0.01062961
79	33.00000000	0.011238405	5.279455	0.009690336	2.111133	0.011044486
80	30.00000000	0.011699603	5.287388	0.010053035	2.008171	0.011470065
81	24.00000000	0.012173682	5.14887	0.010424579	1.910232	0.011906483
82	18.00000000	0.012660837	5.013797	0.010805072	1.817069	0.012353879
83	15.00000000	0.013161262	5.032055	0.011194616	1.728449	0.01281239
84	12.00000000	0.013675155	5.053521	0.011593314	1.644152	0.013282155
85	9.00000000	0.014202711	5.078063	0.012001271	1.563965	0.013763313
86	7.50000000	0.014744128	5.180538	0.012418587	1.48769	0.014256

87	7.20000000	0.015299604	5.345795	0.012845367	1.415134	0.014760356
88	6.90000000	0.015869336	5.513674	0.013281712	1.346118	0.015276518
89	6.60000000	0.016453523	5.684008	0.013727727	1.280467	0.015804625
90	6.00000000	0.017052365	5.84162	0.014183513	1.218018	0.016344816
91	5.40000000	0.01766606	6.001329	0.014649172	1.158614	0.016897228
92	5.10000000	0.018294809	6.177944	0.015124808	1.102108	0.017462
93	4.50000000	0.018938813	6.341269	0.015610523	1.048357	0.01803927
94	3.90000000	0.019598272	6.506104	0.016106418	0.997228	0.018629177
95	3.30000000	0.020273388	6.672243	0.016612598	0.948593	0.019231859
96	3.00000000	0.020964362	6.854473	0.017129162	0.90233	0.019847456
97	2.40000000	0.021671398	7.022582	0.017656215	0.858322	0.020476104
98	1.80000000	0.022394698	7.191353	0.018193857	0.816462	0.021117944
99	1.20000000	0.023134465	7.360566	0.018742191	0.776642	0.021773114
100	0.60000000	0.023890903	7.53	0.019301319	0.738765	0.022441752
101	0.00000000	0.024664216	7.300566	0.019871343	0.702735	0.023123997
102	0.00000000	0.025454609	7.101353	0.020452364	0.668462	0.023819989
103	0.00000000	0.026262288	6.902582	0.021044484	0.635861	0.024529864
104	0.00000000	0.027087456	6.704473	0.021647806	0.60485	0.025253764
105	0.00000000	0.027930322	6.507243	0.02226243	0.575351	0.025991826
106	0.00000000	0.02879109	6.311104	0.022888458	0.547291	0.026744189
107	0.00000000	0.029669967	6.116269	0.023525993	0.520599	0.027510992
108	0.00000000	0.030567162	5.922944	0.024175134	0.495209	0.028292375
109	0.00000000	0.031482881	5.731329	0.024835984	0.471057	0.029088475
110	0.00000000	0.032417332	5.54162	0.025508645	0.448084	0.029899433
111	0.00000000	0.033370724	5.354008	0.026193217	0.42623	0.030725387
112	0.00000000	0.034343266	5.168674	0.026889801	0.405443	0.031566476
113	0.00000000	0.035335168	4.985795	0.027598499	0.385669	0.03242284
114	0.00000000	0.036346638	4.805538	0.028319413	0.36686	0.033294617
115	0.00000000	0.037377887	4.628063	0.029052642	0.348968	0.034181947
116	0.00000000	0.038429126	4.453521	0.029798289	0.331949	0.035084969
117	0.00000000	0.039500565	4.282055	0.030556454	0.315759	0.036003822
118	0.00000000	0.040592415	4.113797	0.031327237	0.300359	0.036938646
119	0.00000000	0.041704889	3.94887	0.032110741	0.285711	0.037889579
120	0.00000000	0.042838198	3.787388	0.032907066	0.271776	0.038856761
121	0.00000000	0.043992556	3.629455	0.033716312	0.258522	0.039840331
122	0.00000000	0.045168173	3.475164	0.03453858	0.245914	0.040840429
123	0.00000000	0.046365265	3.324598	0.035373972	0.23392	0.041857195
124	0.00000000	0.047584044	3.177831	0.036222587	0.222512	0.042890767
125	0.00000000	0.048824724	3.034926	0.037084526	0.21166	0.043941285
126	0.00000000	0.05008752	2.895935	0.03795989	0.201337	0.045008888
127	0.00000000	0.051372647	2.760902	0.038848779	0.191518	0.046093717
128	0.00000000	0.052680319	2.629859	0.039751294	0.182177	0.04719591
129	0.00000000	0.054010752	2.50283	0.040667535	0.173292	0.048315607
130	0.00000000	0.055364162	2.379829	0.041597602	0.164841	0.049452948

131	0.00000000	0.056740766	2.260859	0.042541596	0.156801	0.050608073
132	0.00000000	0.058140778	2.145918	0.043499617	0.149154	0.05178112
133	0.00000000	0.059564417	2.034991	0.044471765	0.14188	0.05297223
134	0.00000000	0.0610119	1.928057	0.04545814	0.13496	0.054181543
135	0.00000000	0.062483444	1.825088	0.046458843	0.128378	0.055409197
136	0.00000000	0.063979268	1.726045	0.047473973	0.122117	0.056655334
137	0.00000000	0.065499589	1.630886	0.04850363	0.116161	0.057920092
138	0.00000000	0.067044626	1.539559	0.049547916	0.110496	0.059203612
139	0.00000000	0.068614599	1.452007	0.050606928	0.105107	0.060506033
140	0.00000000	0.070209726	1.368168	0.051680768	0.099981	0.061827495
141	0.00000000	0.071830228	1.287974	0.052769535	0.095105	0.063168138
142	0.00000000	0.073476324	1.21135	0.053873329	0.090467	0.064528102
143	0.00000000	0.075148234	1.13822	0.054992249	0.086054	0.065907527
144	0.00000000	0.07684618	1.068501	0.056126396	0.081857	0.067306553
145	0.00000000	0.078570383	1.002108	0.057275869	0.077865	0.06872532
146	0.00000000	0.080321063	0.938953	0.058440768	0.074068	0.070163967
147	0.00000000	0.082098443	0.878945	0.059621192	0.070455	0.071622635
148	0.00000000	0.083902744	0.821989	0.060817242	0.067019	0.073101464
149	0.00000000	0.08573419	0.767992	0.062029015	0.063751	0.074600594
150	0.00000000	0.087593002	0.716855	0.063256612	0.060642	0.076120166
151	0.00000000	0.089479403	0.668482	0.064500133	0	0.077660318
152	0.00000000	0.091393618	0.622773	0.065759676	0	0.079221191
153	0.00000000	0.093335869	0	0.067035342	0	0.080802926
154	0.00000000	0.095306381	0	0.068327229	0	0.082405663
155	0.00000000	0.097305377	0	0.069635436	0	0.084029541
156	0.00000000	0.099333084	0	0.070960063	0	0.085674702
157	0.00000000	0.101389724	0	0.07230121	0	0.087341285
158	0.00000000	0.103475524	0	0.073658974	0	0.089029431
159	0.00000000	0.10559071	0	0.075033456	0	0.090739279
160	0.00000000	0.107735506	0	0.076424755	0	0.092470971
161	0.00000000	0.10991014	0	0.077832968	0	0.094224646
162	0.00000000	0.112114837	0	0.079258197	0	0.096000445
163	0.00000000	0.114349825	0	0.080700539	0	0.097798509
164	0.00000000	0.116615331	0	0.082160093	0	0.099618977
165	0.00000000	0.118911581	0	0.083636958	0	0.10146199
166	0.00000000	0.121238804	0	0.085131234	0	0.103327689
167	0.00000000	0.123597227	0	0.086643019	0	0.105216215
168	0.00000000	0.12598708	0	0.088172411	0	0.107127706
169	0.00000000	0.128408589	0	0.08971951	0	0.109062305
170	0.00000000	0.130861985	0	0.091284414	0	0.111020151
171	0.00000000	0.133347497	0	0.092867222	0	0.113001386
172	0.00000000	0.135865353	0	0.094468033	0	0.115006149
173	0.00000000	0.138415784	0	0.096086945	0	0.117034582
174	0.00000000	0.14099902	0	0.097724056	0	0.119086824

175	0.00000000	0.143615291	0	0.099379466	0	0.121163017
176	0.00000000	0.146264827	0	0.101053273	0	0.123263302
177	0.00000000	0.14894786	0	0.102745575	0	0.125387818
178	0.00000000	0.151664621	0	0.104456471	0	0.127536707
179	0.00000000	0.154415341	0	0.106186059	0	0.129710109
180	0.00000000	0.157200252	0	0.107934437	0	0.131908165
181	0.00000000	0.160019586	0	0.109701704	0	0.134131016
182	0.00000000	0.162873575	0	0.111487959	0	0.136378802
183	0.00000000	0.165762452	0	0.113293299	0	0.138651665
184	0.00000000	0.168686449	0	0.115117822	0	0.140949745
185	0.00000000	0.171645801	0	0.116961628	0	0.143273183
186	0.00000000	0.174640739	0	0.118824814	0	0.14562212
187	0.00000000	0.177671499	0	0.120707478	0	0.147996696
188	0.00000000	0.180738314	0	0.122609718	0	0.150397053
189	0.00000000	0.183841418	0	0.124531633	0	0.152823332
190	0.00000000	0.186981045	0	0.12647332	0	0.155275672
191	0.00000000	0.190157431	0	0.128434877	0	0.157754217
192	0.00000000	0.19337081	0	0.130416404	0	0.160259105
193	0.00000000	0.196621418	0	0.132417996	0	0.162790479
194	0.00000000	0.199909491	0	0.134439754	0	0.165348479
195	0.00000000	0.203235264	0	0.136481773	0	0.167933246
196	0.00000000	0.206598973	0	0.138544153	0	0.170544922
197	0.00000000	0.210000854	0	0.14062699	0	0.173183647
198	0.00000000	0.213441145	0	0.142730384	0	0.175849562
199	0.00000000	0.216920082	0	0.144854431	0	0.178542809
200	0.00000000	0.220437903	0	0.146999229	0	0.181263528