WESTERN PACIFIC REGIONAL FISHERY MANAGEMENT COUNCIL

P* Working Group Meeting

December 11-12, 2013
1:00 pm – 5:00 pm
Council Conference Room
WPRFMC Office

Day 1
Present On Site: Dr. Pierre Kleiber (ret. NMFS PIFSC), Dr. Bob Humphreys (NMFS PIFSC), Mr. Ed Watamura (Advisory Panel Chair), Mr. Roy Morioka (H-FACT), Mr. Ed Ebisui (Council member, Program Planning Chair), Marlowe Sabater (WPRFMC), Dr. Bob Skillman (ret. NMFS PIFSC), Paul Dalzell (WPRFMC)

On the Conference Line: Dr. Erik Franklin (UH HIMB), Dr. Domingo Ochavillo (DMWR, AS), Dr. Todd Miller (DFW, CNMI), Michael Tenorio (DFW, CNMI), Mr. Jarad Makaiau (NMFS – PIRO)

Day 2
Present On Site: Dr. Pierre Kleiber (ret. NMFS PIFSC), Dr. Bob Humphreys (NMFS PIFSC), Mr. Ed Watamura (Advisory Panel Chair), Mr. Roy Morioka (H-FACT), Mr. Ed Ebisui (Council member, Program Planning Chair), Marlowe Sabater (WPRFMC), Paul Dalzell (WPRFMC), Dr. Erik Franklin (UH HIMB), Gerard DiNardo (NMFS PIFSC), Lennon Thomas (NMFS PIFSC)

On the Conference Line: Dr. Domingo Ochavillo (DMWR, AS), Mr. Jarad Makaiau (NMFS – PIRO)

REPORT

Introductions

Mr. Edwin Ebisui chaired the third meeting of the P* Working Group. In attendance were Robert Skillman, Pierre Kleiber, Robert Humphreys, Ed Watamura, Roy Morioka, Jarad Makaiau, Erik Franklin, Domingo Ochavillo, Todd Miller and Michael Tenorio. Marlowe Sabater and Paul Dalzell provided technical and administrative support.

Recommendations from the SSC

Council staff presented on the summary of the recommendations by the Scientific and Statistical Committee from its 114th meeting. The recommendation focuses on the endorsement of the Martell, Froese and Kleiber (MFK) model for management purposes and directed staff to finalize the MSY estimates for P* analysis. In addition, the SSC recommended to reconvene the P* WG and finalize the criteria to determine the appropriate level of risk and associated acceptable biological catch for the fishing year 2015. The SSC also suggested applying the MFK model to fully assessed Tier 1 stocks (e.g., bottomfish) in order to gauge the MFK model's accuracy. Council staff reminded the working group members that it is critical to finalize the P* score in this meeting in order to meet the timeline needed to complete the specification package to utilize the new ABCs for fishing year 2015.

Review of the previous P* WG Meeting

Council staff summarized the accomplishments of the P* WG from the 2 previous meetings, held May 28-29, 2013 and June 12, 2013, respectively. Staff also presented on the action items of the WG from the second meeting and how those action items were addressed. The actions included:

1) Covert the PSA scores from Thomas (2013)[1] to the same scale as what is used in the Productivity-Susceptibility Dimension of the P* Analysis. The converted values were included in the briefing materials (Document 7.0). This would serve as a proxy for the Guam P-S exercise; 2) Finish/refine the P* criteria particularly the scientific information and the stock status. The scientific information was revisited and the approach aspect elements were re-evaluated for changes; 3) Follow-up with SSC members on their P-S scores. All of the P* WG members assigned to provide P-S scores had submitted their scores and was included in the briefing materials; and 4) Finalize the technical paper. The technical paper was included in the briefing materials as the final draft.

Review of the biomass-augmented catch-MSY model

Dr. Pierre Kleiber presented on the results of the comparative analysis suggested by the SSC to determine accuracy of the MSY results from the augmented catch-MSY model. MSY estimates from the MFK model were compared to MSY estimates from two PIFSC bottomfish stock assessments, the 2011 MHI Deep 7 bottomfish stock assessment and the 2012 bottomfish stock assessment for American Samoa, Guam and the CNMI. In two instances, the results of the augmented catch-MSY model were more conservative than the stock assessment results. Specifically, the results for American Samoa showed more conservative results where the augmented catch-MSY model estimated MSY at 51,000 lbs and the stock assessment estimated MSY at 76,000 lbs. Similarly, the results for CNMI from the catch-MSY approach are less than half of the results of the stock assessment (catch-MSY = 100,000 lbs and stock assessment = 173,000 lbs).

For Guam bottomfish and MHI Deep 7 bottomfish, the augmented catch-MSY approach provided less conservative estimates of MSY. Specifically, for Guam bottomfish, the augmented catch-MSY model estimated an MSY of 60,000 lbs while the stock assessment estimated and MSY of 56,000 lbs. For all comparative analysis, the biomass estimates are incorporated to simulate what was done with the augmented catch MSY approach. However, there is some circularity in the approach because the biomass estimates used in the augmented catch-MSY approach came from the biomass generated by the stock assessment. Similarly for MHI Deep 7 bottomfish, the augmented catch-MSY model resulted in MSY estimates that are higher than the MSY estimated in the PIFSC 2011 stock assessment. The data used for the augmented catch-MSY analysis was catch scenario 2/CPUE scenario 1 where the unreported non-commercial landing was assumed to be 1:1 to the reported commercial landing. The resulting MSY estimate for the catch-MSY approach was 1,548,000 lbs whereas the resulting MSY from the stock assessment (using CPUE scenario 1) was 848,000 lbs which is 45% lower that the catch-MSY result. It was hoped that the estimates be more close to each other.

The discrepancy in the Hawaii results may be due to how the augmented catch-MSY model responds to assumptions in stock exploitation relative to stock biomass. Bottomfish fisheries in the territories (with perhaps the exception of Guam) have high biomass and low fishing mortality. However Hawaii has higher fishing mortality and therefore higher population turnover per time step. Too much turnover per time step can cause the underlying population model in the catch-MSY approach to be erratic. This is not a problem inherent in the Schaefer model but

[1] Thomas L. 2013. Assessment of the vulnerability of reef fishes in Guam. Western Pacific Regional Fishery Management Council, Honolulu, HI 96813

rather a problem in way it is currently coded in the catch-MSY software. This could be fixed, though perhaps at the expense of longer running times for the model.

The data also for Hawaii goes all the way back to 1948. Simulation run was also conducted to test for effect of the long catch time series by truncating to the most catch data since 1970. The results were almost the same. Also checked was the r-k density plot to see if there is anything wrong, but the plot does not provide any indication that there is something wrong in the *r-k* algorithm.

The Hawaii data seemed to be anomalous in more than one case. The Chair liked the idea that the model is generating conservative results for data poor stocks. However, in the case for stocks that are exploited there must be some ancillary factors affecting the results that need to be accounted for.

Review and changes to the P* Dimensions and Criteria
Council staff presented the different dimensions of the P* analysis and the criteria under each dimension as revised by the P* WG members from the last 2 meetings. The WG members reviewed the preliminary scores of the Model Information and Uncertainty Characterization Dimensions. The WG members retained the preliminary scores and deemed it applicable for the current methods under Tier 3.

For the Model Information Dimension, the WG deemed the MFK model falls somewhere between 2 and 4 since it aspects captured within this range.

Model Information Description	Score
Highly quantitative probabilistic approach that provides estimates of depletion and biomass status; includes MSY benchmarks; model input parameters include fishery dependent and independent information with limited assumptions	0.0
Quantitative probabilistic approach that provides estimates of depletion and biomass status; includes MSY benchmarks; model input parameters include at least fishery dependent or fishery independent information with additional assumptions;	2.0
Quantitative assessment non-probabilistic approach utilizing bulk estimators providing measures of exploitation or B, proxy reference points, includes MSY benchmarks; some sources of mortality accounted for	4.0
Semi quantitative assessment; utilizes estimators that generate relative measures of exploitation or B, proxy reference points, no MSY benchmarks, absolute measures of stock unavailable	6.0
No benchmark values, but reliable catch history	8.0
Bad. No benchmark values, and scarce or unreliable catch records	10.0

In order to determine exactly where, the WG scored the approach aspect. The scores are as follows:

Approach Aspects (AAs)	Score

Reliable catch history	0
Measure of depletion	1
Species-specific data	1
All sources of mortality accounted for (z)	0.5
Fishery independent information	0.5
Probability distribution available (output)	0
Population/biological parameters (r or k etc.)	0.5
SUM	**3.5**

Using the scaling equivalency table, the score of 3.5 has a scaled equivalent of 3.0.

AAs Score	Scaled equivalent	AAs Score	Scaled equivalent
0.5	2.1	4	3.1
1	2.3	4.5	3.3
1.5	2.4	5	3.4
2	2.6	5.5	3.6
2.5	2.7	6	3.7
3	2.9	6.5	3.9
3.5	3.0	7	4.0

Hence for the **Model Information Dimension the score is 3.0.**

The Uncertainty Characterization Dimension had not been revised since this dimension is applicable for a Tier 1 to Tier 3 stock. The WG maintained the **score of 5** for this model-based approach under this Tier. The group scored this dimension as 5.0 since uncertainties can be adjusted by controlling for the range of r and k as well as the process error of the Schaefer Model (see P* WG second meeting report). By process of elimination it cannot be scored as 7.5 because there is an estimate of MSY and probability distribution around that MSY.

The table for this Dimension is shown below:

Uncertainty Characterization Description	Score
Complete. Key determinant – uncertainty in both assessment inputs and environmental conditions included	0.0
High. Key determinant – reflects more than just uncertainty in future recruitment	2.5
Medium. Uncertainties are addressed via statistical techniques and sensitivities, but full uncertainty is not carried forward in projections	**5.0**
Low. Distributions of Fmsy and MSY are lacking	7.5
None. Only single point estimates; no sensitivities or uncertainty evaluations	10.0

Fishing Level Scoring Session
This model approach provides an estimate of relative sustainable harvest level and has limited information on the stock status. Hence the third dimension had been revised to provide insight of

F/F_{MSY} and not B/B_{MSY}. Council staff presented a summary of the Fishing Level Table (Document 4.0) and explained how the values were derived. Each of the families with MSY estimates were scored based on the criteria constructed by the P* Working Group at its second meeting. The summary of the scoring criteria is shown in the table below. A logical argument in Excel was crafted following the criteria designed by the WG members. In order to determine the final scores for each family, the WG was asked to define and determine 2 parameters:

1) Define catch – would the catch be defined as the point estimate of the most recent year in the time series; or an average of 3 years; or an average of 5 years
2) Determine MSY based on 2 different method in defining the r and k range – here termed as k-revise method A and k-revise method B

Description	Fishing level	Score
Lightly harvested	Catch << 1/3MSY	0.0
Moderately harvested	Catch < MSY	2.5
Fully harvested	Catch ≈ MSY	5.0
Over harvested	Catch > MSY	7.5
Severely Over harvested	Catch > 2x+MSY	10.0

Rationale for using 3 year average:
The WG members defined catch as average catch over a three year period. Using an average of a recent segment of the catch time series addresses short term fluctuation in catches brought about by variability in productivity and fishery dynamics. A three year average allows us to see trends that are occurring recently and is reasonable time frame for management to be reactive to recent changes in the fishery. This also balances random fluctuation in catch as opposed to real stock change which can then be used as point estimate for comparison with MSY reference points.

Rationale for using k-revise method B:

The catch-MSY method examines 30,000 randomly chosen points in a window in r-k space. Each point corresponds to a pair of r and k values. Plausible r-k pairs are identified if a Schaefer model run with those parameter values can generate a biomass time series that accommodates the catch time series as well as any measured values of biomass and satisfies other criteria such as biomass not going below zero or not exceeding k. The plausibility density in r-k space is interpreted as a probability density from which r, k, and hence MSY can be estimated where

$$MSY=rk/4. \qquad (1)$$

At the outset the window in r-k space is determined by ranges of r and k assumed to contain the true values of r and k. These ranges are purposely wide -- perhaps orders of magnitude (particularly for k) -- to minimize the possibility that the true value of either r or k is outside the window. To focus into a region of high density, another set of 30,000 points is then examined from a revised window and MSY estimated. The revised ranges are calculated based on the outcome from the first window.

There are two methods for calculating the revised range for k, method A and method B, and Figures 1 and 2 show plausibility density for method A and B respectively. The dashed lines in the density plots indicate the locus of points corresponding to a constant value for MSY determined by equation (1) above with r and k estimated from the plausible r-k pairs. Ideally the density plots should show a high density ridge with density sloping off on either side and the MSY line associated with that ridge. Good examples are in the siga-a plot in Figure 1 and most of the plots in Figure 2. Some of the plots in Figure 1 indicate that the final window in r-k space was missing the highest density ridge, being located too far below/left (e.g. caran-a) or too far above/right (e.g. holo-a). The scattering of holes in the density plots is another indication that the window was not well located, and the near verticality of the MSY lines in several plots indicates that the range in k values was too narrow and badly located. Mis-located windows are also indicated in truncated density distributions of MSY from method A (Figure 3).

Because k-revise method B was more consistent in finding a good k range, the WG members determined that MSY estimates generated from the k-revise method B is preferred over k-revise method A. However, it was suggested that determination of ranges for r and particularly for k might be improved with a more flexible and perhaps interactive method for final placement of the window in r-k space.

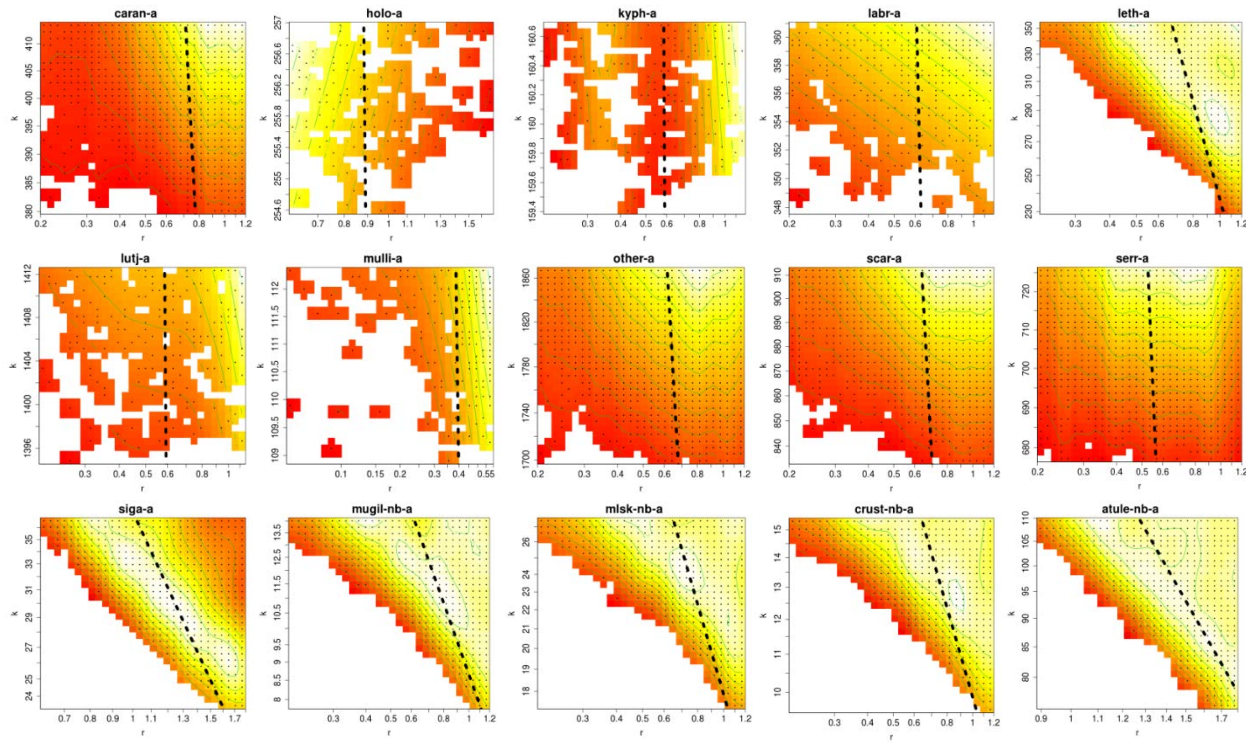

Figure 1. Density of plausible r-k combinations for the different families of reef fish and reef associated organisms using k-revise method A. Dashed lines show the locus of points corresponding to the estimated MSY.

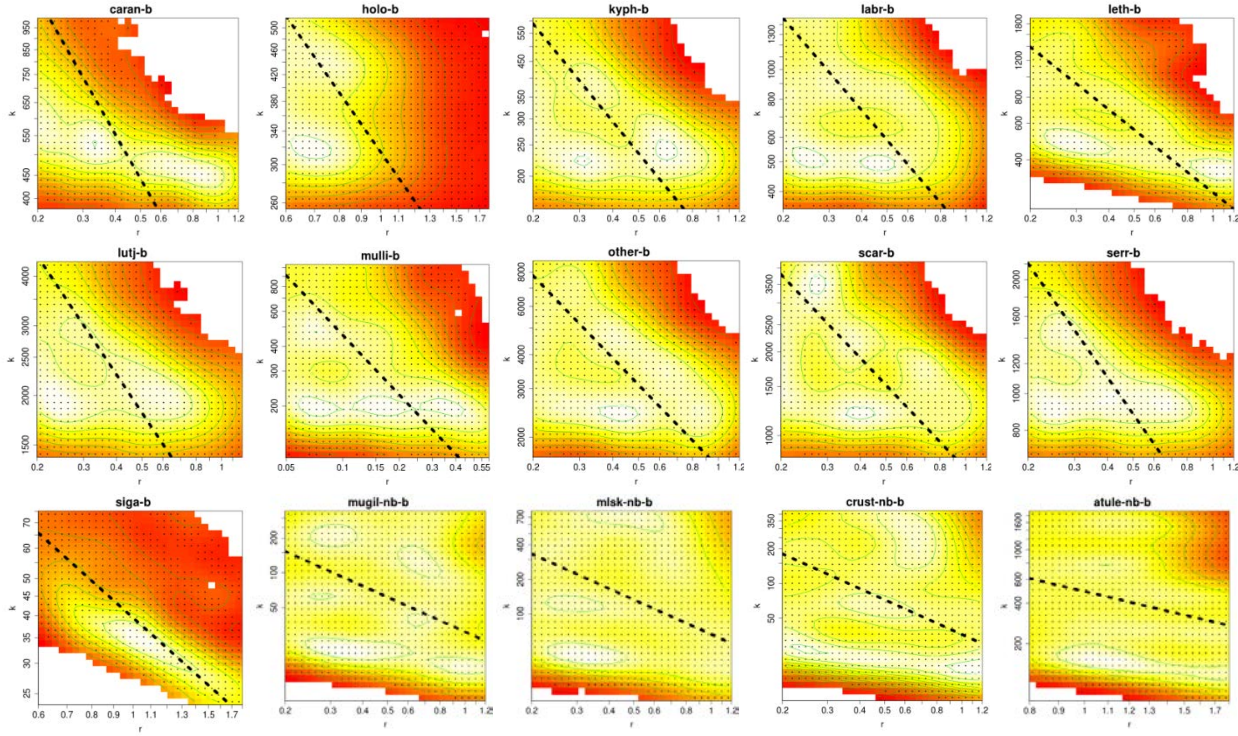

Figure 2. Density of plausible r-k combinations in r-k space for the different families of reef fish and reef associated organisms using k-revise method B. Dashed lines show the locus of points corresponding to the estimated MSY.

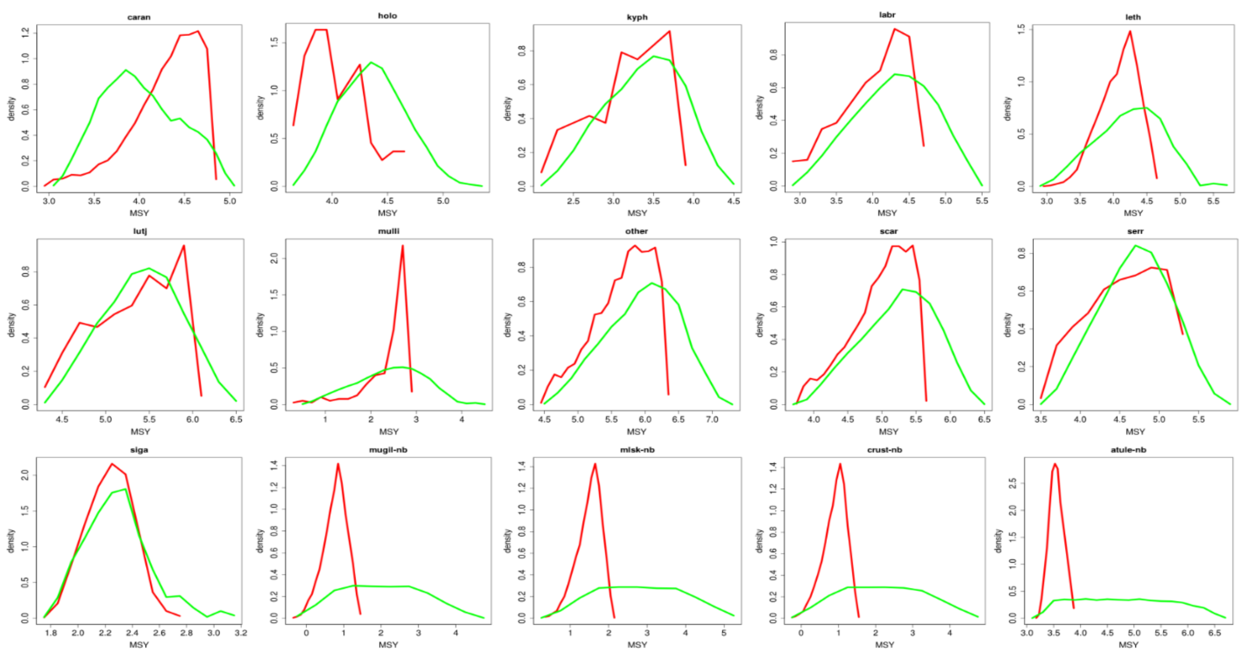

Figure 3. Density distributions of MSY values estimated by k-revise method A (red) and method B (green).

Productivity and Susceptibility Scoring Session

P* Working Group Members were requested to provide a score on the productivity and susceptibility for species that dominates the catch under each of their respective family grouping. When multiple species are scored under each family, the scores were averaged across species to represent the final score.

Productivity and Susceptibility Description	Score
Low risk. High productivity, susceptibility low.	0.0
Low/Medium	2.5
Medium risk. Moderate productivity, and susceptibility	**5.0**
Medium/High	7.5
High risk. Low productivity, high susceptibility	10

Hawaii – Bob Humphreys presented a summary of the Productivity Susceptibility scores (in collaboration with Ed DeMartini) for the coral reef MUS for Hawaii. The scores were given for species that make up the 90% of the coral reef catch. The productivity scores were based on the life history characteristics (e.g. age and growth, longevity, L_{inf} etc.) available from local studies or from the literature. Susceptibility scores were based on the type of fishery it was harvested as well as proximity of the habitat to human presence. If there is no information then a default risk score of 5 is assigned. Details of the PS scores are found in Appendix 1.

Guam – Lennon Thomas presented on the Productivity Susceptibility Analysis for the Guam coral reef MUS. The analysis utilized the expanded creel survey data and focused on 33 species that comprised more than 50% of the catch (Thomas 2013). These species represents the families of reef fishes that have ACLs. Six life history attributes were used to evaluate productivity: 1) Maximum age; 2) Maximum size; 3) Age at maturity; 4) Von Bertalanffy growth coefficient; 5) Natural mortality; and 6) Trophic level; were used to evaluate productivity. On the other hand, the four attributes used to evaluate susceptibility were: 1) Fishery value; 2) Vertical range; 3) Geographic distribution; and 4) Behavior and relationship to catchability; were used to evaluate susceptibility. All attributes were scored on a range of 1 to 3 where 1 is low, 2 is moderate, and 3 is high. The vulnerability of each species was then calculated which is the Euclidean distance from the *xy* orgin of a scatterplot. However, for the purposes of the P* analysis, only the final scores for the productivity and susceptibility were used. The final productivity and susceptibility scores were rescaled to the 0-10 scale of the P* PSA with 2.5 increments. The conversion table is shown below.

DESCRIPTION	PSA_scale	P_scale	S_scale
LOW	1	10	0
	1.1	9.5	0.5
	1.2	9	1
	1.3	8.5	1.5
	1.4	8	2
	1.5	7.5	2.5

	1.6	7	3
	1.7	6.5	3.5
	1.8	6	4
	1.9	5.5	4.5
MODERATE	2	5	5
	2.1	4.5	5.5
	2.2	4	6
	2.3	3.5	6.5
	2.4	3	7
	2.5	2.5	7.5
	2.6	2	8
	2.7	1.5	8.5
	2.8	1	9
	2.9	0.5	9.5
HIGH	3	0	10

To ensure compatibility with the study results, the converted scores for the P* PSA and the vulnerability scores were compared. Details of the PS scores are found in Appendix 2.

CNMI – Todd Miller presented on the summary of the Productivity Susceptibility scores (in collaboration with Michael Tenorio, Sean MacDuff and John Gourley) for the coral reef MUS for CNMI. The basis for the scoring was from its commonness or predominance in the underwater census surveys, creel survey, market survey and BioSampling program. For the productivity scores this was based on the frequency of sighting in the underwater surveys. The susceptibility scores were based on whether the species are targeted and its commonality in the commercial and non-commercial landing. Details of the PS scores are found in Appendix 3

American Samoa – Domingo Ochavillo presented the summary of the Productivity Susceptibility scores for the coral reef MUS for American Samoa. The scoring was based on the available life history characteristics for the productivity criteria. Scoring for the susceptibility was based on dominance in the coral reef fish catch. Details of the PS scores are found in Appendix 4.

P* for the Western Pacific Coral Reef Management Unit Species

Summing all the dimension scores yields the total uncertainties and when deducted from the 50% risk of overfishing will result in the P*. If accepted by the SSC, the level of catch associated with P* as provided in Sabater and Kleiber (2013) will correspond to the acceptable biological catch. Since the P* values in Sabater and Kleiber (2013) are presented in 5% increment, the SSC may consider rounding P* values up or down depending on the scores proximity to the incremental value.

Table 1. Summary of the dimension scores and the resulting P* for the Hawaii management unit species with ACLs for fishing year 2015.

Hawaii Grouping	M.I.	U.C	S.S	P.S	∑	P*

Acanthuridae – surgeonfish	3	5	0	5.8	13.8	36.2
Atule - *Selar crumenophthalmus*	3	5	2.5	2.5	13.0	37.0
Carangidae – jacks	3	5	0	2.5	10.5	39.5
Carharhinidae – reef sharks	3	5				
Crustaceans – crabs	3	5	5	5	18.0	32.0
Holocentridae – squirrelfish	3	5	2.5	6.3	16.8	33.3
Kyphosidae - rudderfish	3	5	0	5	13.0	37.0
Labridae - wrasses	3	5	0	5	13.0	37.0
Lethrinidae - emperors	3	5	0	5	13.0	37.0
Lutjanidae – snappers	3	5	0	1.2	9.2	40.8
Mollusks – turbo snails; octopus	3	5	5	5	18.0	32.0
Mugilidae – mullets	3	5	2.5	6.6	17.1	32.9
Mullidae – goatfish	3	5	2.5	5.6	16.1	33.9
Opelu - *Decapterus macarellus*	3	5	2.5	5	15.5	34.5
Other CREMUS	3	5	0	6	14.0	36.0
Scaridae – parrotfish	3	5	0	7.5	15.5	34.5
Serranidae - groupers	3	5	0	0	8.0	42.0
Spiny lobster	3	5	0	5	13.0	37.0

Table 2. Summary of the dimension scores and the resulting P* and associated ABCs for the Guam management unit species with ACLs for fishing year 2015.

Guam Grouping	M.I.	U.C	S.S	P.S	∑	P*
Acanthuridae – surgeonfish	3	5	2.5	3.9	14.4	35.6
Algae	3	5	0	5	13	37
Selar crumenophthalmus	3	5	7.5	4.3	19.8	30.2
Carangidae – jacks	3	5	5	5.7	18.7	31.3
Carcharhinidae – reef sharks	3	5				
Crustaceans – crabs	3	5	0	5	13	37
Holocentridae – squirrelfish	3	5	0	4.8	12.8	37.2
Kyphosidae – rudderfish	3	5	2.5	5.6	16.1	33.9
Labridae – wrasses	3	5	0	7.5	15.5	34.5
Lethrinidae – emperors	3	5	0	6.3	14.3	35.7
Lutjanidae – snappers	3	5	0	7.4	15.4	34.6
Mollusks – turbo snail; octopus	3	5	0	5	13	37
Mugilidae – mullets	3	5	0	5.8	13.8	36.2
Mullidae – goatfish	3	5	0	3.8	11.8	38.2
Other CREMUS	3	5	0	5	13	37
Scaridae – parrotfish	3	5	2.5	5.8	16.3	33.7
Serranidae – groupers	3	5	0	6.7	14.7	35.3

Siganidae – rabbitfish	3	5	0	4.1	12.1	37.9
Spiny lobster	3	5	0	5	13	37

Table 3. Summary of the dimension scores and the resulting P* and associated ABCs for the CNMI management unit species with ACLs for fishing year 2015.

CNMI Grouping	**M.I.**	**U.C**	**S.S**	**P.S**	**∑**	**P***
Acanthuridae – surgeonfish	3	5	0	4.3	12.3	37.7
Selar crumenophthalmus	3	5	0	2.5	10.5	39.5
Carangidae – jacks	3	5	0	4.2	12.2	37.8
Crustaceans-crab	3	5	0	5	13	37
Holocentridae - squirrelfish	3	5	0	4.8	12.8	37
Kyphosidae – rudderfish	3	5	0	5.6	13.6	36
Labridae – wrasses	3	5	0	7.5	15.5	35
Lethrinidae – emperors	3	5	2.5	4.9	15.4	34.6
Lutjanidae – snappers	3	5	0	3.2	11.2	38.8
Mollusks – turbo snail; octopus	3	5	0	3.2	11.2	38.8
Mugilidae – mullets	3	5	0	4	12	38
Mullidae – goatfish	3	5	0	4	12	38
Other CREMUS	3	5	0	4.8	12.8	37.2
Scaridae – parrotfish	3	5	0	6	14	36
Serranidae – groupers	3	5	0	5.3	13.3	36.7
Siganidae – rabbitfish	3	5	2.5	4	14.5	35.5
Spiny lobster	3	5	0	5	13	37

Table 4. Summary of the dimension scores and the resulting P* and associated ABCs for the American Samoa management unit species with ACLs for fishing year 2015.

American Samoa Grouping	**M.I.**	**U.C**	**S.S**	**P.S**	**∑**	**P***
Acanthuridae – surgeonfish	3	5	0	3.3	11.3	38.7
Selar crumenophthalmus	3	5	0	2.5	10.5	39.5
Carangidae – jacks	3	5	0	5	13	37
Carcharhinidae – reef sharks	3	5				
Crustaceans – crabs	3	5	5	6.3	19.3	30.8
Holocentridae – squirrelfish	3	5	0	6.3	14.3	35.8
Lethrinidae – emperors	3	5	0	5	13	37
Lutjanidae – snappers	3	5	0	7.5	15.5	34.5
Mollusks – turbo snail; octopus	3	5	0	7.5	15.5	34.5
Mugilidae – mullets	3	5	0	5	13	37
Kyphosidae – rudderfish	3	5	0	5	13	37
Labridae – wrasses	3	5	0	5	13	37

Mullidae – goatfish	3	5	0	5	13	37
Siganidae – rabbitfish	3	5	0	2.5	10.5	39.5
Other CREMUS	3	5	0	5	13	37
Scaridae – parrotfish	3	5	0	5	13	37
Serranidae – groupers	3	5	0	3.8	11.8	38.3
Spiny lobster	3	5	0	5	13	37

Rationale for the species grouping
In the initial 2012 ACL specifications, the different coral reef management unit species were grouped by family and ACLs were specified only for groups that comprised 90% of the total catch. This was done to reduce the number of species that would require ACLs as well as include all families that are harvested in large amounts in the fishery. The rest of the families were grouped as the bottom 10% of the catch and assumed not to be significant in terms of total landings.

The data used in the initial 2012 ACL specification was all available catch data up to 2008 for the territories and through 2009 for Hawaii. In the re-analysis of the data to be used in the model based approach, the data was updated to include all available catch through 2012. Catch data for the Territories was from the creel surveys (proxy for total catch to include shore-based and boat-based catch with varying levels of non-commercial catches from multiple gear) and dealer reports (commercial catch). The Hawaii data was only from commercial catch reports filed by fishermen with Commercial Marine Licenses. Non-commercial catch was not included. In the process of identifying the top 90%, the results yield a different grouping compared to the initial specification. This has legal ramifications because the National Standard 1 requires stocks subject to ACL specification be identified. This should be a static list to ensure consistent monitoring of each group over time. Process-wise this will result in the re-calculation of the top 90% every time new data is available otherwise it is not utilizing the best scientific information available. Shifting species groups that require ACLs is hard to monitor and will result in inconsistencies in the specification that ultimately will confuse the stakeholders. The species groupings that result from incorporating data through 2012 are the groups being monitored by the Archipelagic Plan Team and described in the Council annual reports. By using these fixed groupings into the future, it will enable consistent monitoring of catches and groups that would require ACLs should new data become available.

Rationale for the P* values
The assumption behind the tiered system approach is that the scientific uncertainties increase from a data-rich tier (e.g. Tier 1) to a catch-only tier (e.g. Tier 5). So in situations where less information is available regarding stock status as well as the fishery that harvests the stock, a larger buffer is needed to ensure that the stock is not going to be subject to overfishing or being overfished. This follows the precautionary principle in data poor situations. In the case for most of the Western Pacific stocks (e.g. coral reefs) where the current ACLs are based on catch-only information, the uncertainties were reduced when the augmented catch-MSY approach was used to estimate MSY. Incorporating biomass from underwater census surveys into the model and some information regarding resilience and assumptions on carrying capacity enabled the Council

to enhance the ACL specification from the catch-only approach. The critical factor is the biomass because this parameter is commonly estimated by using CPUE as a proxy in most surplus production models, yet these approaches are treated as a Tier 1.

Determining the appropriate level of scientific risk varies between regions. Other Regional Fishery Management Councils had specified either default P* values for each tier and a range of P* with a P*max. Currently, the omnibus amendment does not prescribe a range of P* values for each tier. Each tier is comprised of varying level of scientific information and model reliability. Tier 3 utilizes model based approaches where the uncertainty of OFL (in this case probability distribution around MSY as a proxy for OFL) can be estimated using Monte-Carlo simulation. The criteria for Tier 3 P* analysis was tweaked from the Tier 1 P* analysis applied to western Pacific bottomfish recognizing that the Tier 3 approach is not a real model based stock assessment. The model and scientific information are based on the merits and demerits of parameters and information that fits the Tier 3 methods. Hence a direct comparison between a Tier 1 P* score and a Tier 3 P* score is not feasible. Although intuitively based on the Tiered approach principle, the P* scores in Tier 3 should not exceed or be equal to the Tier 1 P* score. However, in this case, they do. Specifically, P* values for Hawaii CREMUS ranged from 32-42%. Species groups that exceeded or equaled the Tier 1 MHI Deep 7 Bottomfish (P*=40.8) were the families Lutjanidae and Serranidae from Hawaii at 40.8 and 42, respectively. These families are comprised of taape (*Lutjanus kasmira*) and roi (*Cephalopholis argus*) which are non-native species in Hawaii and considered invasive. There are some eradication efforts being conducted (on roi) by local fishing clubs to maintain ecological balance hence limiting catches for these species is not a priority for the Council.

The P* values for MUS groupings from all other jurisdiction falls generally below the P* values for the Tier 1 Territory Bottomfish (American Samoa 41%; Guam 40%; CNMI 39%). The stocks we analyzed and the Territory bottomfish stocks (majority of which are considered reef fish as well) both showed similar characteristics in which biomass levels are high relative to what is currently being harvested[2]. Based on Tables 1-4 above, the P* range for CREMUS in each island area should be follows:

American Samoa - 30.8-39.5%
Guam – 30.2-37.9%
CNMI – 34.6-39.42%
Hawaii – 32-42%

A more detail comparison between the dimensions in the Tier 1 and the Tier 3 accounted for the scientific uncertainties by using a Tier 3 approach. Table 5 shows the comparative scores between assessments versus the augmented catch-MSY approach

[2] Luck D, Dalzell P. 2010. Western Pacific Region Reef Fish Trends. A Compendium of Ecological and Fishery Statistics for Reef Fishes in American Samoa, Hawai'i and the Mariana Archipelago, in Support of Annual Catch Limit (ACL) Implementation. Western Pacific Regional Fishery Management Council, Honolulu. 43p.

Table 5. Comparative analysis of the dimension scores between Tier 1 and Tier 3.

Model	Tier level	D1 score	D2 score	D3 score	D4 score
MHI Deep 7 Bottomfish[3]	1	1.3	0	3	4.9
Am. Samoa shallow/deep BF[4]	1	1.6	5.0	0	1.95
Guam shallow/deep BF	1	1.6	5.0	0	4.45
CNMI shallow/deep BF	1	1.6	5.0	0	4.61
Biomass augmented catch_MSY	3	3.0	5.0	0-7.5	0-7.5

The tier 3 had higher reduced scores for dimension 1 (assessment information) accounting for the lower quality and less quantity of scientific information utilized in the augmented catch-MSY approach. For dimension 2 (uncertainty characterization), the augmented catch-MSY score is similar to the Territory Bottomfish. The territory bottomfish assessment and the augmented catch-MSY approach had uncertainties around the OFL estimates via the probability distribution around the MSY estimate. These uncertainties were not carried forward to future projections for the augmented catch-MSY approach but were accounted for in the Territory bottomfish assessment. In hindsight, the Territory bottomfish assessment should have been scored with a 2.5 instead of 5.

Hawaii Non-Deep 7 Bottomfish

The previous ACL specification of the Hawaii non-deep 7 bottomfish was based on a model result averaging between: 1) the analog approach with the MHI Deep 7 bottomfish; 2) the 75th percentile of the catch; and 3) the average of the past 3 years of catch. Concerns were raised regarding this method of model result averaging for this was not based on any simulation or re-sampling method but simply took an average of three point estimates. This also did not generate any probability distribution around the mean value. In order to be consistent with the current effort to standardize the ACL specification process using the tier 3 approach, the biomass-augmented catch-MSY approach was applied to the updated catch time series of the non-deep 7 and applied the MHI biomass estimate of *Aprion virescens* (locally known as uku) which makes up more than 87% of the non-deep 7 complex.

There were previous recommendations to remove uku from the non-deep 7 complex because of recent changes in the fishery whereby uku is no longer a substitute fish when the MHI deep 7 bottomfish fishery closes. The uku fishery had evolved on its own and is now a regular targeted fishery. If a separate ACL were to be specified for uku, an FEP amendment is required to establish uku as a different management unit. The working group members agreed to keep uku under the non-deep 7 but to also to treat uku as an indicator species to be monitored as a separate species and as a complex.

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[3] Brodziak, J., D. Courtney, L. Wagatsuma, J. O'Malley, H. Lee, W. Walsh, A. Andrews, R. Humphreys, and G. DiNardo. (2011). Stock assessment of the main Hawaiian Islands deep 7 bottomfish complex through 2010. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Center

[4] Brodziak, J. J. O'Malley, B. Richards, and G. DiNardo. (2012). Stock Assessment Update of the Status of Bottomfish Resources of American Samoa, the Commonwealth of the Northern Mariana Islands and Guam, 2010. National Marine Fisheries Service Pacific Islands Fisheries Science Center, Internal Report IR-12-022. Honolulu, 126 pp.

Using the biomass-augmented catch-MSY approach, the method-B MSY estimate for the non-deep 7 bottomfish is 265,000 lbs. Applying the same stock status determination methodology in the P* analysis, the stock status dimension score is 2.5. The P-S dimension yields a score of 7.5 (see table below for details). Combining all the dimension scores yield a score of **18** and a corresponding P* value of **32**. The risk table is shown below.

Hawaii Coral Reef Ecosystem (Mullidae-Goatfish) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
UKU	Aprion virescens	7.5	7.5	15	7.5	Long lived (26 years); slow growing; highly targeted; takes 5 years to reach maturity; average length 50 cm from an Lmax of 81 cm

Risk table for the non-deep 7 bottomfish

risk table – k-revise b									
5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
112.2	129.9	144.5	158.1	172.3	187.1	203.7	221.2	239.9	259.2

Next Step

1. SSC review of the P* score
2. SSC decide which ABC to take given that the risk table is in 5% increment (round up or down)

Appendix 1. Hawaii PSA scores

Hawaii Coral Reef Ecosystem (Mullidae-Goatfish) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
KUMU	Parupeneus porphyreus	5	10	15	7.5	P: t(max)=~ 6 yr, k=0.538, L(50fem) unknown but at least 238 mm FL; L(max)=470 mm FL (Moffitt 1979); S: Esteemed food fish highly targeted by recreational & commercial fishermen (Longnecker et al. 2008))
MOANA	Parupeneus spp.	5	7.5	12.5	6.25	Moana=Parupeneus multifasciatus; P:t(max)=> 2 yr., L(50fem)=145 mm FL, L(max)=300 mm FL; S: 7 in. size limit well over female size at maturity (145 mm); targeted by recreational and commercial fishermen (Longnecker et al. 2008)
WEKE (MISC.)	Mullidae	5	7.5	12.5	6.25	P: No available life history vital rates for most mullid species in HI; S: high catch for various components of the family Mullidae in HI
WEKE NONO	Mulloidichthys pflugeri	5	7.5	12.5	6.25	P: L(max)=546 mm, no available life history vital rates for HI and on FishBase, ; S: high catch in HI; (FishBase scores Resilence as medium & Vulnerability as moderate)
WEKE-ULA	Mulloidichthys vanicolensis	5	7.5	12.5	6.25	P: No available life history vital rates for HI, L(mat-fem)=240 mm, L(max)=380mm (FishBase); S: high catch in HI; (FishBase scores Resilence as medium & Vulnerability as low)

Hawaii Coral Reef Ecosystem (Acanthuridae-Surgeonfish) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
KALA	Naso annulatus	7.5	5	12.5	6.25	P: No available life history vital rates for HI; S: high catches in HI (L(inf)=626 mm, k=0.213, t(max)=23 yr (Choat & Robertson 2006)); (FishBase scores Resilence as low & Vulnerability as moderate to high)
KALA	Naso brevirostris	7.5	5	12.5	6.25	P: No available life history vital rates for HI, L(inf)=304 mm, k=0.402, t(max)=25 yr (Choat & Robertson 2006)); S: high catches in HI; (FishBase scores Resilence as medium & Vulnerability as low to moderate)
KALA	Naso unicornus	7.5	5	12.5	6.25	P: long lifespan (>50 yrs.), slower growth, mature at 7-8 yr; S: popular food fish, nets target schools (Eble 2009 Hawaii Fishing News)

KOLE	Ctenochaetus strigosus	5	5	10	5	P: L(1st mat-fem)=100 mm TL, L(50 fem)=?, L(max)=240 mm TL, t(max)=18 yr; S: probably greater longevity that realized, important in commercial and aquarium catch Longnecker et. al. 2008)
MANINI	Acanthurus triostegus	2.5	5	7.5	3.75	P: L(50-fem)=164 mm FL, L(max-fem)= 223 mm FL, t(max)> 4 yr.; S: 5 in. size limit < L(50-fem), schooling fish; shallow water inhabitant easily accessible to fishermen (Longnecker et al. 2008)
NAENAE	Acanthurus olivaceus	7.5	5	12.5	6.25	P: No available life history vital rates for HI (in Australia k=1.066, L(inf)=210 mm, t(max)=33 yr. (Choat & Robertson 2006)); S: high catches in HI; (FishBase scores Resilence as medium & Vulnerability as low to moderate)
PALANI	Acanthurus dussumieri	7.5	5	12.5	6.25	P: No available life history vital rates for HI, (k=0.296, L(inf)=308 mm, t(max)=28 yr, no L(50-fem) estimate, vital rates for Australia (Choat & Robertson)); S: high catches in HI; (FishBase scores Resilence as low & Vulnerability as moderate)
PUALU	Acanthurus blochii,	7.5	5	12.5	6.25	P: No available life history vital rates for HI, (k=0.25, L(inf)= 276 mm SL, t(max)=35 yr, no L(50-fem) estimate, vital rates for Australia (FishBase)); S: high catches in HI; (FishBase scores Resilence is low & Vulnerability is moderate)
PUALU	Acanthurus xanthopterus	7.5	5	12.5	6.25	P: No available life history vital rates for HI, (k=0.287, L(inf)= 426 mm SL, t(max)=34 yr, no L(50-fem) estimate, vital rates for Australia (FishBase)); S: high catches in HI; (FishBase scores Resilence is low & Vulnerability is moderate)

Hawaii Coral Reef Ecosystem (Lutjanidae-Snapper) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
TAAPE	Lutjanus kasmira	2.5	0	2.5	1.25	P: t(50-fem) not available, t(max)~6 yr, k=0.29, L(50-fem) not available, L(inf)=34.0 cm TL; have expanded range since introduction throughout HI Archipelago (Morales-Nin & Ralston 1990)

Hawaii Coral Reef Ecosystem (Holocentridae-Squirrelfish) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification

MENPACHI	Myripristis spp.	5	5	10	5	Based on Myripristis amaena: P: t(1st mat)=6 yrs, t(max)=14 yr, L(max)=215 mm SL, no L(50), k=0.239; typically not mass caught but by spear and hook&line, Myripristis spp. among highest catches (Dee and Radtke 1989)

Hawaii Coral Reef Ecosystem (Mugilidae-Mullet) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
AMAAMA	Mugil cephalus	5	5	10	5	P: No available life history vital rates for wild fish in HI, (k=0.11-0.82, L(mat)= 300-340 mm TL, T(mat)=2-6 yr, t(max)=16 yr (FishBase)); S: high catches in HI; (FishBase scores Resilence is medium & Vulnerability is moderate)

Hawaii Coral Reef Ecosystem (Mollusks) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
OLEPE	Albula glossodonta	7.5	7.5	15	7.5	P: No available life history vital rates for wild fish in HI or on FishBase; S: high recreational catches in HI; (FishBase scores Resilence as medium & Vulnerability as high)

Hawaii Coral Reef Ecosystem (Scaridae-Parrotfish) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
PANUHUNUHU	Scarus spp.	5	10	15	7.5	P: Little vital rate info for HI, in Australia typically k>0.5, t(max) typically <11 yrs (Choat & Robertson (2006); S: popular food fish in Hawaii, very susceptible to night spear-fishing

Hawaii Coral Reef Ecosystem (All Other CREMUS Combined) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
AHOLEHOLE	Kuhlia sandvicensis	2.5	7.5	10	5	P: k=0.33, L(max)=305 mm FL, L(inf)=215mmSL, no L(50-fem) estimate, Benson & Fitzsimmons (2002); S: popular netted food fish, according to FishBase Resilence is high and Vulnerability is low to moderate
AWEOWEO	Heteropriacanthus cruentatus	5	5	10	5	P: No available life history vital rates for HI or on FishBase; S: high recreational catches in HI; (FishBase scores Resilence as high & Vulnerability as low to moderate)

MOI	Polydactylus sexfilis	7.5	10	17.5	8.75	P: L(50-fem)~360 mm, first male then female; growth rate undetermined in HI; highly sought after fish, however FishBase scores for Resilence: medium & Vulnerability: low to moderate)
NENUE	Kyphosus bigibbus,	5	5	10	5	is Kyphosus sandwicensis (Randall 2007). P: No life history vital rates for this species in HI or on Fishbase; S: FishBase scores are for Resilence: undetermnined and for Vulnerability: moderate
NENUE	Kyphosus cinerescens	5	5	10	5	is Kyphosus cinerascens (Randall 2007). P: No life history vital rates for this species in HI, L(inf)=480 mm FL and k=0.25 for Papua New Guinea (recorded in Fishbase); S: FishBase scores are for Resilence: medium and for Vulnerability: moderate
LAENIHI	Xyichthys pavo	5	10	15	7.5	is Iniistius pavo (FishBase). P: No life history vital rates for this species in HI or in FishBase; S: Highly sought after food fish, FishBase scores are for Resilence: medium and for Vulnerability: moderate

Hawaii Coral Reef Ecosystem (Selar crumenophthalmus-Akule) FSSI

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
Big eye scad	Selar crumenophthalmus	0	5	5	2.5	Highly productive stock; medium targeted species; schooling behavior results in moderate vulnerability

Hawaii Coral Reef Ecosystem (Decapterus spp.-Opelu) FSSI

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
Opelu	Decapterus spp.	5	5	10	5	Slightly less productive than akule; moderately targeted; schooling behavior results in moderate vulnerability

Hawaii Coral Reef Ecosystem (Carangidae-Jacks) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
OMILU	Caranx melampygus	2.5	2.5	10	2.5	
SASA	Caranx sexafaciatus	2.5	2.5	10	2.5	

Hawaii Coral Reef Ecosystem (Crustacean-Crabs) (non-FSSI)

Species Name	Scientific Name	Prod.	Susc.	Sum	Ave	Justification
Reef crabs etc		5	5	10	5	default value used since no data available

Appendix 2. Guam PSA scores

No	Family	Species	Prod	Susc	Vuln	P_P* scale	S_P*scale	PSA_SCORE	V-equivalent	Delta
3	Lutjanidae	Aprion virescens	1.0	2.7	2.6	10.0	8.0	9.0	8.7	0.3
32	Serranidae	Variola louti	1.2	2.7	2.48	9.5	8.0	8.8	8.3	0.5
7	Labridae	Cheilinus trilobatus	1.8	2.8	2.17	6.0	9.0	7.5	7.2	0.3
18	Lethrinidae	Lethrinus rubrioperculatus	1.7	2.7	2.13	7.0	8.0	7.5	7.1	0.4
28	Scaridae	Scarus schlegeli	1.5	2.5	2.12	7.5	7.5	7.5	7.1	0.4
33	Kyphosidae	Kyphosus vaigiensis	1.3	2.3	2.08	8.5	6.0	7.3	6.9	0.3
21	Lethrinidae	Monotaxis grandoculis	1.3	2.2	2.03	8.5	5.5	7.0	6.8	0.2
14	Scaridae	Hipposcarus longiceps	1.5	2.3	2.01	7.5	6.5	7.0	6.7	0.3
12	Serranidae	Epinephelus merra	1.7	2.3	1.89	7.0	6.5	6.8	6.3	0.5
24	Acanthuridae	Naso unicornis	1.2	1.3	1.86	9.5	1.5	5.5	6.2	-0.7
26	Holocentridae	Sargocentron spiniferum	1.2	1.0	1.83	9.5	0.0	4.8	6.1	-1.4
8	Scaridae	Chlorurus microrhinos	1.5	2.0	1.8	7.5	5.0	6.3	6.0	0.3
10	Mugilidae	Ellochelon vaigiensis	1.3	1.7	1.8	8.5	3.0	5.8	6.0	-0.3
17	Lethrinidae	Lethrinus obsoletus	1.8	2.4	1.8	6.0	6.5	6.3	6.0	0.3
19	Lutjanidae	Lutjanus fulvus	2.0	2.3	1.67	5.0	6.5	5.8	5.6	0.2
4	Carangidae	Caranx ignobilis	1.5	1.3	1.54	7.5	1.5	4.5	5.1	-0.6
31	Siganidae	Siganus spinus	1.8	2.0	1.54	6.0	5.0	5.5	5.1	0.4
6	Carangidae	Caranx sexfasciatus	1.7	1.7	1.49	7.0	3.0	5.0	5.0	0.0
9	Scaridae	Chlorurus sordidus	2.5	2.3	1.42	2.5	6.5	4.5	4.7	-0.2
5	Carangidae	Caranx melampygus	1.0	2.0	1.41	10.0	5.0	7.5	4.7	2.8
20	Lutjanidae	Lutjanus kasmira	1.0	2.0	1.41	10.0	5.0	7.5	4.7	2.8
23	Acanthuridae	Naso lituratus	1.7	1.3	1.37	7.0	1.5	4.3	4.6	-0.3
25	Mullidae	Parupeneus barberinus	1.7	1.3	1.37	7.0	1.5	4.3	4.6	-0.3
29	Atulai	Selar crumenophthalmus	2.7	2.3	1.37	2.0	6.5	4.3	4.6	-0.3
11	Serranidae	Epinephelus fasciatus	1.8	1.7	1.34	6.0	3.0	4.5	4.5	0.0
16	Lethrinidae	Lethrinus harak	1.8	1.7	1.34	6.0	3.0	4.5	4.5	0.0

27	Scaridae	Scarus psittacus	2.8	2.3	1.34	1.0	6.5	3.8	4.5	-0.7
1	Acanthuridae	Acanthurus lineatus	1.8	1.7	1.32	6.0	3.0	4.5	4.4	0.1
15	Kyphosidae	Kyphosus cinerascens	2.0	1.7	1.2	5.0	3.0	4.0	4.0	0.0
22	Mullidae	Mulloidichthys flavolineatus	2.8	2.2	1.18	1.0	5.5	3.3	3.9	-0.7
13	Gerridae	Gerres longirostris	2.7	2.0	1.05	2.0	5.0	3.5	3.5	0.0
30	Siganidae	Siganus argenteus	2.5	1.7	0.83	2.5	3.0	2.8	2.8	0.0
2	Acanthuridae	Acanthurus triostegus	2.4	1.0	0.57	3.0	0.0	1.5	1.9	-0.4
							AVERAGE	5.5	5.4	0.1

Appendix 3. CNMI PSA scores

CNMI Coral Reef Ecosystem (Lethrinidae-Emperors) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Bigeye Emperor	Monotaxis grandoculus	5	6	11	5.5
Blackspot Emperor	Lethrinus harak	3	5	8	4
Yellowstripe Emperor	Lethrinus obsoletus	4	6	10	5
Yellowtail Emperor	Lethrinus atkinsoni	4	6	10	5

CNMI Coral Reef Ecosystem (Carangidae-Jacks) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Bluefin Trevally	Caranx melampygus	4	6	10	5
EE: Juvenile Jacks	Caranx sp.	2	5	7	3.5

CNMI Coral Reef Ecosystem (Acanthuridae-Surgeonfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Bluebanded Surgeonfish	Acanthurus lineatus	3	4	7	3.5
Bluespine Unicornfish	Naso unicornis	5	5	10	5
Orangespine Unicornfish	Naso lituratus	5	4	9	4.5

CNMI Coral Reef Ecosystem (Selar crumenophthalmus-Atulai) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Bigeye Scad	Selar crumenopthalmus	1	4	5	2.5

CNMI Coral Reef Ecosystem (Serranidae-Groupers) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Flagtail Grouper	Cephalopholis urodeta	5	4	9	4.5
Honeycomb Grouper	Epinephelus merra	6	6	12	6
	Variola louti	6	5	11	5.5

CNMI Coral Reef Ecosystem (Lutjanidae-Snappers) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Humpback Snapper	Lutjanus gibbus	5	4	9	4.5
Red Snapper	Lutjanus bohar	4	0	4	2

CNMI Coral Reef Ecosystem (Mullidae-Goatfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Dash & Dot Goatfish	Parupeneus barberrinus	5	4	9	4.5
Goatfish (juvenile-misc)	Mullidae	3	4	7	3.5

CNMI Coral Reef Ecosystem (Scaridae-Parrotfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Parrotfish (misc.)	Scarus sp.	6	6	12	6

CNMI Coral Reef Ecosystem (Mollusks) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Octopus	Octopus sp.	1	2	3	1.5
Squid	Teuthida	5	1	6	3
Trochus	Trochus sp.	5	0	5	2.5
Clam/bivalve	Bivalvia	6	6	12	6

CNMI Coral Reef Ecosystem (Mugilidae-Mullets) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Mullet	Mugilidae	4	4	8	4

CNMI Coral Reef Ecosystem (Siganidae-Rabbitfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Rabbitfish (sesjun)	Siganus spinus	3	4	7	3.5
	Siganus argenteus	4	5	9	4.5

CNMI Coral Reef Ecosystem (All Other CREMUS Combined) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave
Squirrelfish	Holocentridae	4	4	8	4
Soldierfish (misc.)	Holocentridae	4	4	8	4
Tripletail Wrasse	Cheilinus trilobatus	5	5	10	5
Sea Cucumber	Cucumariidae	4	8	12	6

Appendix 4. American Samoa PSA scores

American Samoa Coral Reef Ecosystem (Acanthuridae-Surgeonfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Blue-banded surgeonfish	Acanthurus lineatus	2.5	2.5	5	2.5	life history information for AS; long lived; high growth rate and low M; age of maturity 2-3 years; S - susceptibility highly abundant fish; lots of alogo
Bluespine unicornfish	Naso unicornis	2.5	7.5	10	5	life history information for AS; long lived; high growth rate and low M; age of maturity 2-3 years; S is 7.5; low abundance; highly targeted by spearfisherman;
Striped bristletooth	Ctenochaetus striatus	2.5	2.5	5	2.5	life history information for AS; long lived; high growth rate and low M; age of maturity 2-3 years; S - susceptibility highly abundant fish; lots of alogo

American Samoa Coral Reef Ecosystem (Lutjanidae-Snappers) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Brown jobfish	Aphareus furca	7.5	7.5	15	7.5	long lived; large sized fish and slow growing; M is low; S - hi because highly targeted and the reef area it is found is small
Humpback snapper	Lutjanus gibbus	7.5	7.5	15	7.5	long lived; large sized fish and slow growing; M is low; S - hi because highly targeted and the reef area it is found is small
Black snapper	Macolor niger	7.5	7.5	15	7.5	long lived; large sized fish and slow growing; M is low; S - hi because highly targeted and the reef area it is found is small

American Samoa Coral Reef Ecosystem Species (Selar crumenophthalmus-Atule) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Bigeye scad	Selar crumenophthal mus	2.5	2.5	5	2.5	high productivity; fast growing high turn-over and short life cycle; low susceptibility due to the life history characteristics

American Samoa Coral Reef Ecosystem (Mollusks) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Giant clam	Tridacna sp.	7.5	7.5	15	7.5	slow growing; few numbers; easily accessible from shore and highly targeted by fishermen; low recruitment

American Samoa Coral Reef Ecosystem (Carangidae-Jacks) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Bluefin trevally	Caranx melampygus	2.5	7.5	10	5	highly targeted species in the fishery; high productivity

American Samoa Coral Reef Ecosystem (Lethrinidae-Emperors) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Goldenline bream	Gnathodentex aureolineatus	5	5	10	5	information was taken from other areas; assumed that the life history characteristics is similar; low growth rate; medium S - not highly targeted;
Bigeye emperor	Monotaxis grandoculis	5	5	10	5	information was taken from other areas; assumed that the life history characteristics is similar; low growth rate; medium S - not highly targeted;

American Samoa Coral Reef Ecosystem (Scaridae-Parrotfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Parrotfishes (misc)	S rubro, oviceps, japanenesis, microrhinos	2.5	7.5	10	5	highly growth rate; highly targeted by the spear fishermen

American Samoa Coral Reef Ecosystem (Serranidae-Groupers) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Honeycomb grouper	Epinephelus merra	2.5	5	7.5	3.75	dominant species being caught in the fishery; has fast growth rate and short lived; S - not highly targeted;
One-bloch grouper	Epinephelus melanostigma	2.5	5	7.5	3.75	
Peacock grouper	Cephalopholis argus	2.5	5	7.5	3.75	
White-edged lyretail	Variola albimarginata	5	2.5	7.5	3.75	slower growing and lived longer; caught by multiple gear and through bottomfishing

American Samoa Coral Reef Ecosystem (Holocentridae-Squirrelfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Big scale soldierfish	Myripristis berndti	5	7.5	12.5	6.25	combination of low and high productivity; long lived; high growth coefficient; low M; small sized; reach productivity at young age; based on Hawaii data; S - highly targeted by Samoans; schooling and easy to collect in high numbers;

Blotch eye soldierfish	Myripristis murdjan	5	7.5	12.5	6.25	combination of low and high productivity; long lived; high growth coefficient; low M; small sized; reach productivity at young age; based on Hawaii data; S - highly targeted by Samoans; schooling and easy to collect in high numbers;
Bluelined squirrelfish	Sargocentron tiere	5	7.5	12.5	6.25	combination of low and high productivity; long lived; high growth coefficient; low M; small sized; reach productivity at young age; based on Hawaii data; S - highly targeted by Samoans; schooling and easy to collect in high numbers;
Brick soldierfish	Myripristis amaena	5	7.5	12.5	6.25	combination of low and high productivity; long lived; high growth coefficient; low M; small sized; reach productivity at young age; based on Hawaii data; S - highly targeted by Samoans; schooling and easy to collect in high numbers;

American Samoa Coral Reef Ecosystem (Mugilidae-Mullet) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Fringelip mullet	Mullets	5	5	10	5	Borrowed information - medium productivity and S - medium; targeted but does not show up in the catch

American Samoa Coral Reef Ecosystem (Crustaceans-Crabs) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Seven-11 crab	Carpilius maculatus	7.5	5	12.5	6.25	low productivity; slow growing; small sized; early age of maturity; medium S; not dominant in the catch

American Samoa Coral Reef Ecosystem (All other CREMUS combined) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Assorted species	n/a	5	5	10	5	default value was used = 5

American Samoa Coral Reef Ecosystem (Labridae-Wrasses) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Triple tail wrasse	Cheilinus trilobatus	5	5	10	5	
Harlequin tuskfish	Cheilinus fasciatus	5	5	10	5	

American Samoa Coral Reef Ecosystem (Mullidae-Goatfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Yellowstripe goatfish	Mulloidichthys flavolineatus	5	5	10	5	
Yellowfin goatfish	Mulloidichthys vanicolensis	5	5	10	5	
Dash-and-dot goatfish	Parupeneus barberinus	5	5	10	5	
Parupenus insularis	Parupeneus insularis	5	5	10	5	
Multi-barred goatfish	Parupeneus multifasciatus	5	5	10	5	

American Samoa Coral Reef Ecosystem (Siganidae-Rabbitfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susc	Sum	Ave	Justification
Forktail rabbitfish	Siganus aregenteus	2.5	2.5	5	2.5	
Scribbled rabbitfish	Siganus spinus	2.5	2.5	5	2.5	

American Samoa Coral Reef Ecosystem Kyphosidae-Rudderfish) (non-FSSI)

Species Name	Scientific Name	Prod	Susceptibility	Sum	Ave	Justification
Rudderfish (cinerascens)	Kyphosus cinerascens	5	5	10	5	