The 2016 updated horse mackerel standardized CPUE and implications for Exceptional Circumstances applying when setting of the TAC for 2016

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Updated Standardized CPUE

A General Linear Model has been applied in the past to standardize the horse-mackerel CPUE data. This index has been updated to include the 2014 Desert Diamond data. The model applied is of the form:

$$\ell n(CPUE_y + \delta) = \alpha + \beta_y + \gamma_{month} + \kappa_{tod} + \varepsilon \tag{1}$$

where

α is the intercept,

y is a factor with 12 levels associated with the year effect (2003-2014),

$month$ is a factor with 6 levels associated with a month effect:

> Jan-Feb, Mar-Apr, May-Jun, Jul-Aug, Sep-Oct, Nov-Dec

tod is a factor with 8 levels associated with a time of day effect:

> tod ≤ 3am
>
> 3am < tod≤-6am
>
> 6am < tod≤ 9am
>
> 9am < tod≤ noon
>
> noon < tod≤ 3pm
>
> 3pm < tod≤ 6pm
>
> 6pm < tod≤ 9pm
>
> 9pm < tod≤ midnight

ε is the error term, assumed to follow a normal distribution.

δ is a small constant added to the CPUE data to allow for the inclusion of zero CPUE in the analyses. It is assumed to be 10% of the average CPUE over the period considered.

For the updated analyses δ was assumed to be the δ value determined in the analyses conducted in 2014.

The resulting standardized CPUE index is shown in Figure 1. Of note is the very low catch rate in 2014, which could be attributed to the fact that 80**%** of the drags contained zero horse mackerel catch (Figure 2). As a result, alternative models were considered, namely:

Model A: GLM on non-zero catch data setting δ to zero.

Model B: The application of a delta-lognormal model where a GLM was applied to the positive catches and a binomial model to the proportion of positive catch (see Appendix A for the equations related to the delta-lognormal model).

The resulting standardized indices are reported in Table 1 and Figure 3. Irrespective of the model applied, the standardized CPUE for 2014 remains very low, even for the model that excludes zero catches. It is recommended that Model B be taken to be the reference case updated standardised CPUE series.

Comparison of updated standardized CPUE with previous series

Table 2 and Figure 4 compare the updated standardized CPUE (CPUE 2015 – Model C) with two previous CPUE data series:

CPUE 2013 –   this is the data series Liam Furman used for the assessment model presented in his Masters thesis, and used for initial OMP development.

CPUE 2014 –   this is the data series which was subsequently updated in 2014 to take into account previously omitted zero catches, and was used to update the final horse mackerel assessment operating model (OM) used in the final OMP tuning (Singh et al. 2014).

Each index has been normalized to its mean over the common period 2003-2012.

Comparison of updated standardized CPUE with predicted values

The horse mackerel operating model was updated with CPUE 2014 and used to tune the final 2014 OMP. This OM provided predicted horse mackerel CPUEs under the selected OMP. Figure 5 reports the observed (CPUE 2014) and estimated CPUE (CPUE_est) as well as the median, 5th and 95th percentiles of predicted CPUE under OMP. The solid black line thus shows the median expected CPUE (Pred_median), with the dotted lines predicted the range of possible CPUE values with 90% CI (Pred_5^{th} and Pred_95^{th}).

The open circles show the recently updated CPUE 2015. It is clear that both the updated 2013 and 2014 CPUE values are outside the range predicted by the OM for the current OMP. Of most concern is the updated 2014 CPUE value which is considerably lower than the lower 5th percentile of predicted CPUE values for 2014.

According to the Exceptional Circumstances (EC) provisions, as described in Furman (2015) (see Appendix B), Exceptional Circumstances will be considered for "CPUE trends that are appreciably outside the bounds predicted in the OMP testing".

Figure 5 would strongly suggest that ECs exist for the horse mackerel OMP implementation for 2016.

Suggestions of analyses to be conducted prior to TAC 2016 setting

The observed recent downturn in CPUE for 2014 could be a result of either

i)   a reduction in catchability, or

ii)   a reduction in survival or decrease in productivity for HM.

The important question is what the impact on the resource will be if either effect continues into the future.

It is thus proposed that four scenarios are considered:

Current CPUE decrease due to	Continues into the future	Applies only for 2014
Catchability decrease	Scenario 1	Scenario 2
Survival/productivity decrease	Scenario 3	Scenario 4

The current OM will be updated with updated data (CPUE, catches, biomass estimates, RLF). The updated OM will then be projected forwards under the same simulation assumptions as for the OMP development, except that future (2016) TACs will be set at various constant catch (CC) levels for each of the four scenarios above. These results will be considered in making a TAC recommendation for 2016. If the CPUE downturn continues into the next season, a full OMP review will be conducted.

References

Brandão A & Butterworth DS (2004) Delta-lognormal linear models applied to standardized CPUE abundance indices (1994 to 2003) for orange roughy off Namibia. WFWG/WkShop/Mar04/doc1.

Furman, L. 2015. The 2014 Operational Management Procedure for the South African horse mackerel resource. DAFF report, FISHERIES/2015/MAR/SWG-DEM/03. 10pp.

Singh, L, Glazer, J and Fairweather, T. 2014. Updated horse mackerel CPUE trend. DAFF report, FISHERIES/2014/SEPT/SWG-DEM/53. 7PP.

Table 1: Standardized CPUE indices from different model applications.

Year	Model A	Model B
2003	0.731	0.725
2004	0.646	0.632
2005	0.872	0.874
2006	0.991	0.986
2007	1.533	1.516
2008	0.964	0.973
2009	0.874	0.890
2010	1.197	1.206
2011	1.707	1.685
2012	0.919	0.928
2013	1.408	1.448
2014	0.158	0.137

Table 2: Updated standardized CPUE 2015 compared with previous CPUE series.

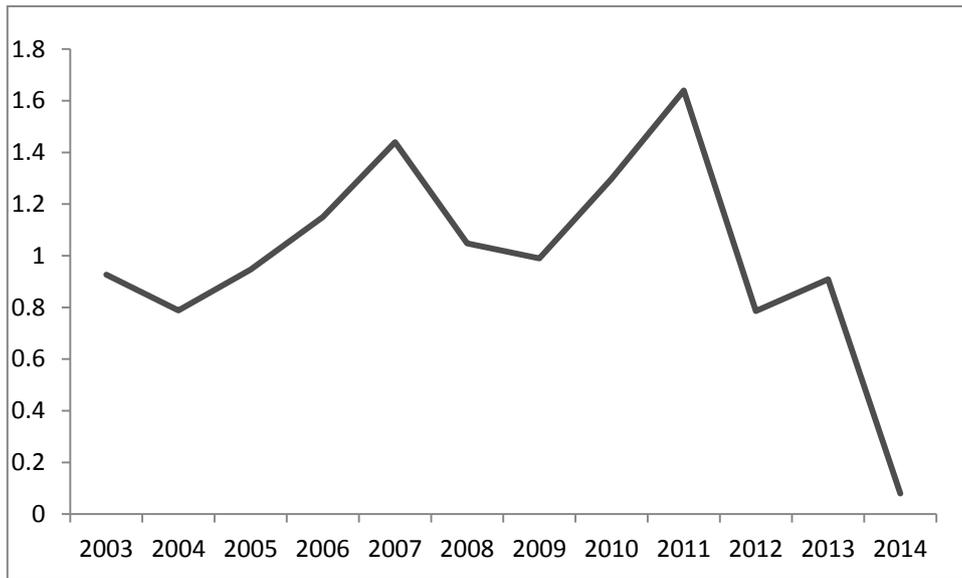|	CPUE 2013	CPUE 2014	CPUE 2015
2003	0.617	0.804	0.696
2004	0.712	0.685	0.607
2005	0.897	0.822	0.839
2006	1.004	0.998	0.947
2007	1.494	1.251	1.456
2008	1.016	0.911	0.934
2009	0.828	0.860	0.855
2010	1.111	1.127	1.158
2011	1.415	1.420	1.618
2012	0.907	0.681	0.891
2013	-	-	1.390
2014	-	-	0.132

Figure 1: Standardized CPUE indices obtained from the application of Equation (1) for all data setting δ to the value determined in 2014.
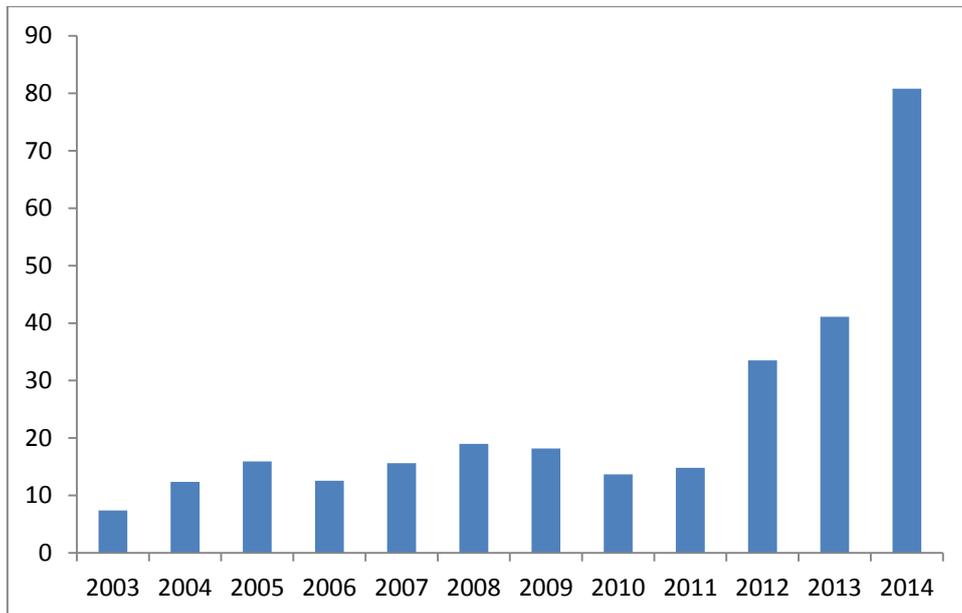

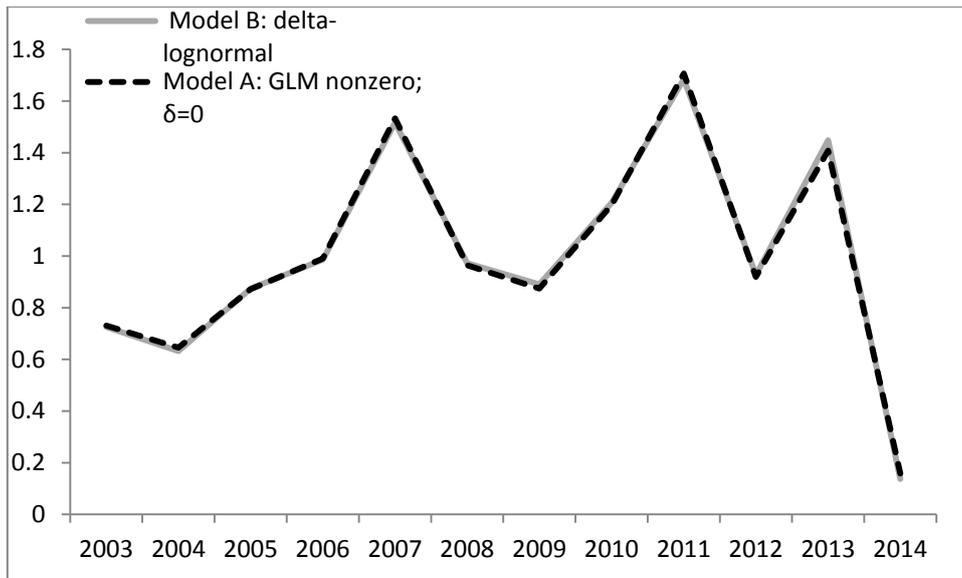**Figure 2: Percentage of zero catch per year.**

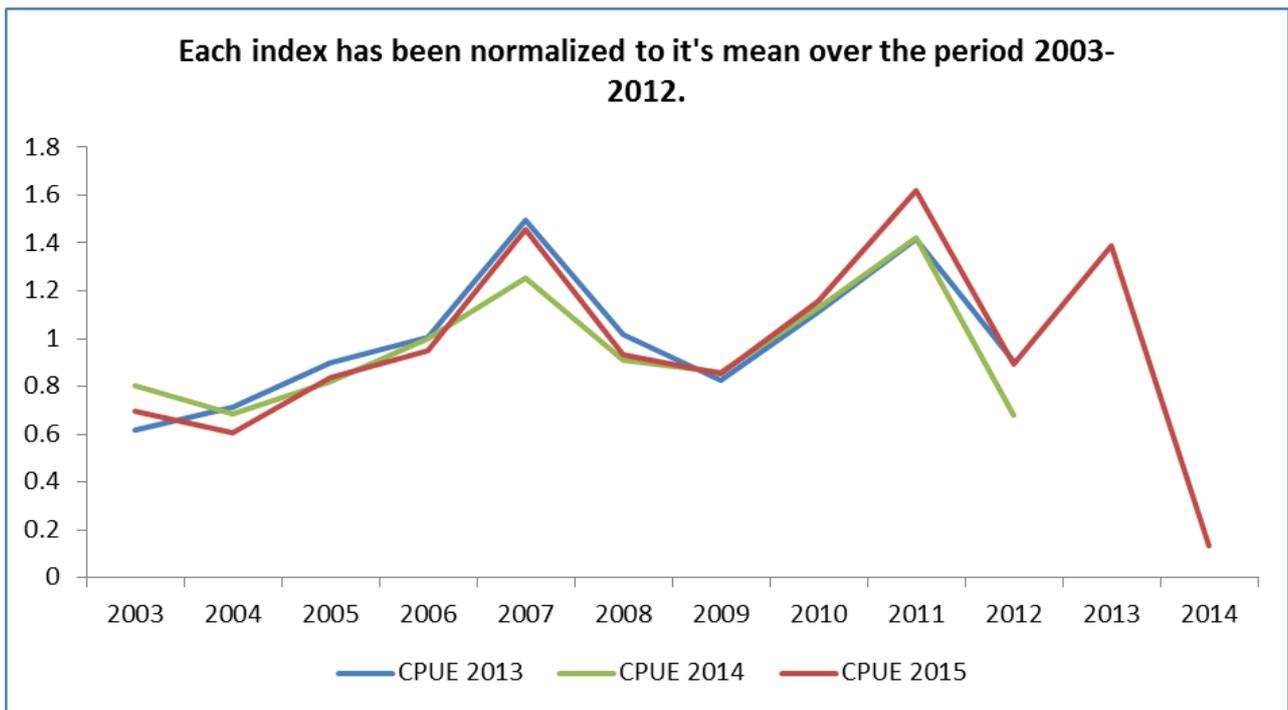**Figure 3: Standardized CPUE data using the two different model applications.**

Figure 4: Comparison of the updated standardized CPUE (CPUE 2015) with two previous CPUE data series:
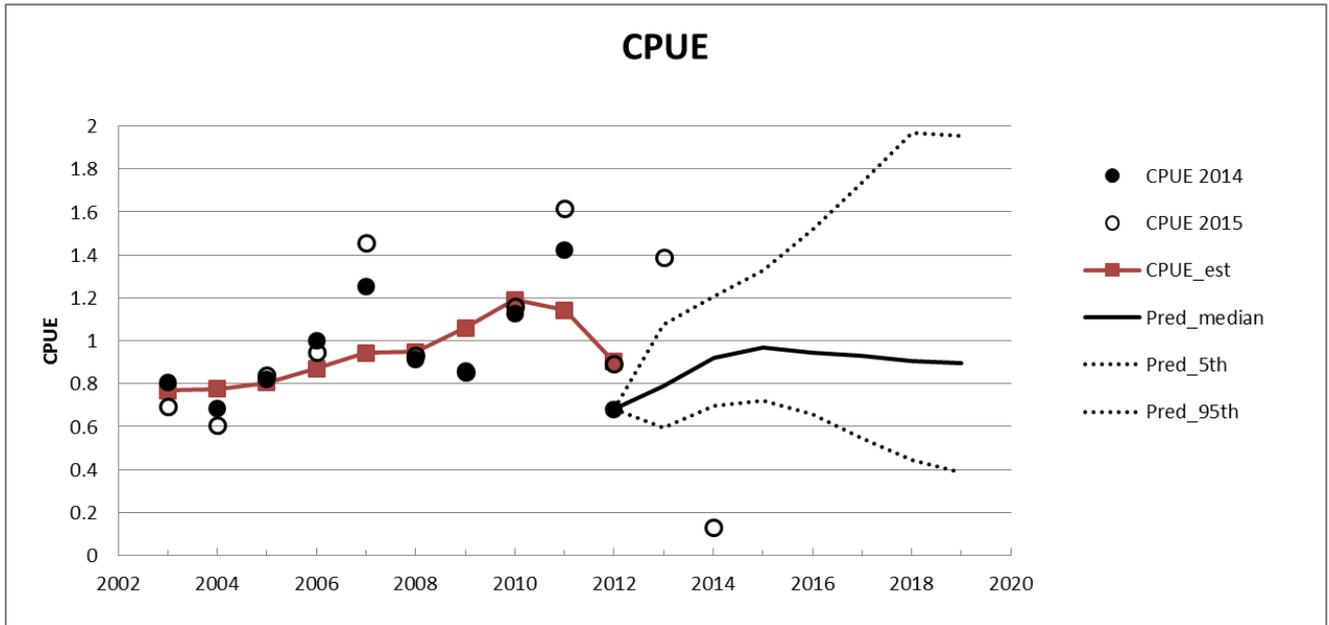
Figure 5: Updated CPUE 2015 compared with predicted CPUE range. The observed CPUE 2014 (to which the OM was fitted to) and the OM estimated CPUE (CPUE_est) are shown. The solid black line shows the median expected CPUE (Pred_median), with the dotted lines predicted the range of possible CPUE values with 90% CI (Pred_5th and Pred_95th). The open circles show the recently updated CPUE 2015.

APPENDIX A: The delta-lognormal model

In the application of the delta-lognormal model two linear models are fit to the data: (i) a GLM to estimate the standardized CPUE for records with positive horse mackerel catches and (ii) a model to estimate the proportion of records for which there is positive catch.

The GLM applied to the data with positive catches is of the form:

$$\ell n(CPUE^{+ve}) = \alpha + \beta_{year} + \kappa_{month} + \gamma_{time\ of\ day} + \varepsilon \tag{1}$$

where the error distribution is assumed to be normal.

The model applied to the proportion of data with positive catches assuming binomially distributed errors is of the form:

$$prop^{+ve} = \alpha' + \beta'_{year} + \kappa'_{month} + \gamma'_{time\ of\ day} + \xi \tag{2}$$

The following equation is applied to obtain standardized indices from modelling the positive catches (GLM), noting that the bias correction applied by Brandão and Butterworth (2004) is not applied here:

$$\widehat{CPUE}^{+ve}_{year,month} = e^{\widehat{\alpha}+\widehat{\beta}_{year}+\widehat{\kappa}_{month}+\widehat{\gamma}_{standard\ time\ of\ day}} \tag{3}$$

The following equation is applied to obtain standardized indices from modelling the proportion positive catches (assuming a binomial error distribution):

$$\widehat{Prop}^{+ve}_{year,month} = \frac{\exp\left(\widehat{\alpha}'+\widehat{\beta}'_{year}+\widehat{\kappa}'_{month}+\widehat{\gamma}'_{standard\ time\ of\ day}\right)}{1+\exp\left(\widehat{\alpha}'+\widehat{\beta}'_{year}+\widehat{\kappa}'_{month}+\widehat{\gamma}'_{standard\ time\ of\ day}\right)} \tag{4}$$

The standard time of day is selected to be the time of day category which contains most of the data.

The overall standardized CPUE is then the product equations (3) and (4):

$$\widehat{CPUE}_{year} = \sum_{month}(\widehat{CPUE}^{+ve}_{year,month} \times \widehat{Prop}^{+ve}_{year,month})/\sum_{month} 1 \tag{5}$$

Appendix B

Procedures for deviating from OMP output for the recommendation, and for initiating an OMP review

Metarule Process

Metarules can be thought of as "rules" which pre-specify what should happen in unlikely, exceptional circumstances when application of the TAC/PUCL generated by the OMP is considered to be highly risky or inappropriate. Metarules are not a mechanism for making small adjustments, or 'tinkering' with the TAC/PUCL from the OMP. It is difficult to provide firm definitions of, and to be sure of including all possible, exceptional circumstances. Instead, a process for determining whether exceptional circumstances exist is described below (see Figure B1). The need for invoking a metarule should be evaluated by the DAFF BRANCH FISHERIES [Demersal or Pelagic (as appropriate)] Scientific Working Group (hereafter indicated by WG), but only provided that appropriate supporting information is presented so that it can be reviewed at a WG meeting.

Description of Process to Determine Whether Exceptional Circumstances Exist

While the broad circumstances that may invoke the metarule process can be identified, it is not always possible to pre-specify the data that may trigger a metarule. If a WG Member or Observer, or DAFF BRANCH FISHERIES Management, is to propose an exceptional circumstances review, then such person(s) must outline in writing the reasons why they consider that exceptional circumstances exist, and must either indicate where the data or analyses are to be found supporting the review, or must supply those data or analyses in advance of the WG meeting at which their proposal is to be considered.

Every year the WG will:

- Review population and fishery indicators, and any other relevant data or information on the population, fishery and ecosystem, and conduct a simple routine updated assessment (likely no more than the core Reference Case model used in the OMP testing refitted taking a further year's data into account).

- On the basis of this, determine whether there is evidence for exceptional circumstances.

Examples of what might constitute an exceptional circumstance in the case of [horse mackerel] include, but are not necessarily limited to:

- [Survey estimates of abundance that are appreciably outside the bounds predicted in the OMP testing.

- CPUE trends that are appreciably outside the bounds predicted in the OMP testing.]

Every two years the WG will:

- Conduct an in depth stock assessment (more intensive than the annual process above, and in particular including the full Reference Set of assessment models and conducting of a range of sensitivity tests).

- On the basis of the assessment, indicators and any other relevant information, determine whether there is evidence for exceptional circumstances.

The primary focus for concluding that exceptional circumstances exist is if the population assessment/indicator review process provides results appreciably outside the range of simulated population

and/other indicator trajectories considered in OMP evaluations. This includes the core (Reference case or set of) operating models used for these evaluations, and likely also (though subject to discussion) the operating models for the robustness tests for which the OMP was considered to have shown adequate performance. Similarly, if the review process noted regulatory changes likely to effect appreciable modifications to outcomes predicted in terms of the assumptions used for projections in the OMP evaluations (e.g. as a result, perhaps, of size limit changes or closure of areas), or changes to the nature of the data collected for input to the OMP beyond those for which allowance may have been made in those evaluations, this would constitute grounds for concluding that exceptional circumstances exist in the context of continued application of the current OMP.

(Every year) IF the WG concludes that there is no or insufficient evidence for exceptional circumstances, the WG will:

- Report to the Chief Director Research, DAFF BRANCH FISHERIES that exceptional circumstances do not exist.

IF the WG has agreed that exceptional circumstances exist, the WG will:

- Determine the severity of the exceptional circumstances.

- Follow the "Process for Action" described below.

Specific issues that will be considered annually (regarding Underlying Assumptions of the Operating Models (OMs) for the OMP Testing Process)

The following critical aspects of assumptions underlying the OMs for [horse mackerel] need to be monitored after OMP implementation. Any appreciable deviation from these underlying assumptions may constitute an exceptional circumstance (i.e. potential metarule invocation) and will require a review, and possible revision, of the OMP:

- [Whether survey or CPUE estimates of abundance are appreciable outside the bounds predicted in the OMP testing.

- Whether selectivities-at-length for the major fisheries differ substantially from assumptions made to generate operating model projections.

- Whether future recruitment levels are within the bounds projected by the RS operating models.

- Whether updates of major data sets indicate substantial differences from what were used to condition the operating models for the OMP testing.

- Whether there have been a series of substantial differences between TACs allocated and the catches subsequently made.

- Whether fishing regulations and/or strategies have changed substantially, and in a manner such that continuing use of the agreed GLM-standardisation procedures would likely introduce substantial bias in resource abundance trend estimates based on CPUE indices.]

Description of Process for Action

If making a determination that there is evidence of exceptional circumstances, the WG will with due promptness:

- Consider the severity of the exceptional circumstances (for example, how severely "out of bounds" are the recent CPUEs and survey abundance estimates or recruitment estimates).

- Follow the principles for action (see examples below).

- Formulate advice on the action required (this could include an immediate change in TAC, a review of the OMP, the relatively urgent collection of ancillary data, or conduct of analyses to be reviewed at a further WG meeting in the near future).

- Report to the Director Research, DAFF BRANCH FISHERIES that exceptional circumstances exist and provide advice on the action to take.

The Chief Director Research, DAFF BRANCH FISHERIES will:

- Consider the advice from the WG.

- Decide on the action to take, or recommendations to make to his/her principals.

Examples of 'Principles for Action'

If the risk is to the resource, or to dependent or related components of the ecosystem, principles may be:

- The OMP-derived TAC/PUCL should be an upper bound.

- Action should be at least an x% decrease in the TAC/PUCL output by the OMP, depending on severity.

If the risk is to socio-economic opportunities within the fishery, principles may be:

- The OMP-derived TAC/PUCL should be a minimum.

- Action should be at least a y% increase in the TAC/PUCL output by the OMP, depending on severity.

For certain categories of exceptional circumstances, specific metarules may be developed and pre-agreed for implementation should the associated circumstances arise (for example, as has been the case for OMP's for the sardine-anchovy fishery where specific modified TAC algorithms come into play if abundance estimates from surveys fall below pre-specified thresholds). Where such development is possible, it is preferable that it be pursued.
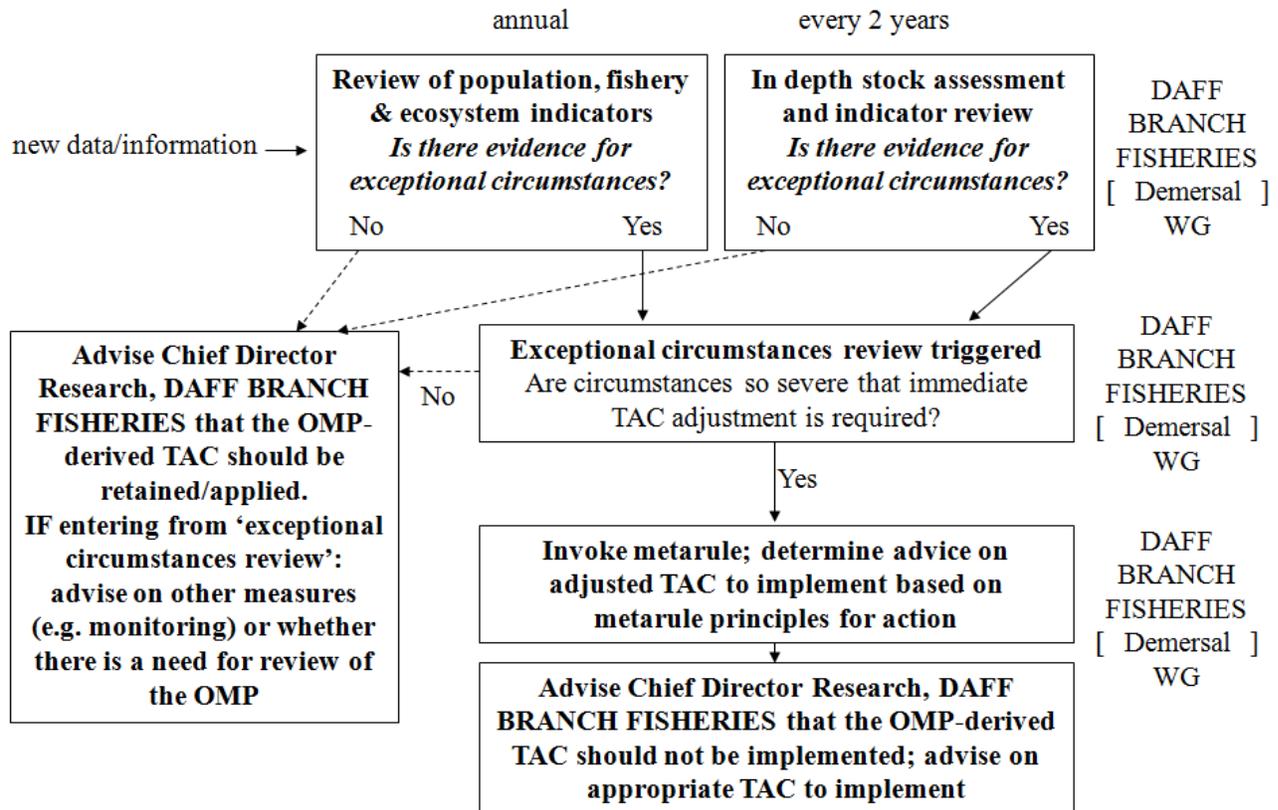
annual | every 2 years

| Review of population, fishery & ecosystem indicators | In depth stock assessment and indicator review | DAFF BRANCH FISHERIES [Demersal] WG |

new data/information →

Review of population, fishery & ecosystem indicators
Is there evidence for exceptional circumstances?
No   Yes

In depth stock assessment and indicator review
Is there evidence for exceptional circumstances?
No   Yes

DAFF BRANCH FISHERIES [Demersal] WG

Advise Chief Director Research, DAFF BRANCH FISHERIES that the OMP-derived TAC should be retained/applied.
IF entering from 'exceptional circumstances review':
advise on other measures (e.g. monitoring) or whether there is a need for review of the OMP

No ←

Exceptional circumstances review triggered
Are circumstances so severe that immediate TAC adjustment is required?

DAFF BRANCH FISHERIES [Demersal] WG

Yes

Invoke metarule; determine advice on adjusted TAC to implement based on metarule principles for action

DAFF BRANCH FISHERIES [Demersal] WG

Advise Chief Director Research, DAFF BRANCH FISHERIES that the OMP-derived TAC should not be implemented; advise on appropriate TAC to implement

Figure B1: Flowchart for Metarules Process

Regular OMP Review and Revision Process

The procedure for regular review and potential revision of the OMP is the process for updating and incorporating new data, new information and knowledge into the management procedure, including the operating models (OMs) used for testing the procedure. This process should happen on a relatively long time-scale to avoid jeopardising the performance of the OMP, but can be initiated at any time if the WG consider that there is sufficient reason for this, and that the effect of the revision would be substantial. During the revision process the OMP should still be used to generate TAC recommendations unless a metarule is invoked.

Description of Process for Regular Review (see Fig.D2)

Every year the WG will:

- Consider whether the procedure for Metarule Process has triggered a review/revision of the OMP. Note that if proposals by a WG Member or Observer, or DAFF BRANCH FISHERIES Management, for an exceptional circumstances review include suggestions for an OMP review and possible revision, they must outline in writing the reasons why they consider this necessary, and must either indicate where the data or analyses are to be found supporting their proposed review, or must supply those data

or analyses in advance of the WG meeting at which their proposal is to be considered. This includes the possibility of a suggested improvement in the manner in which the OMP calculates catch limitation recommendations; this would need to be motivated by reporting results for this amended OMP when subjected to the same set of trials as were used in the selection of the existing OMP, and arguing that improvements in anticipated performance were evident.

Every two years the WG will:

- Conduct an in depth stock assessment and review population, fishery and related ecosystem indicators, and any other relevant data or information on the population, fishery and ecosystem.

- On the basis of this, determine whether the assessment (or other) results are outside the ranges for which the OMP was tested (note that evaluation for exceptional circumstances would be carried out in parallel with this process; see procedures for the Metarule Process), and whether this is sufficient to trigger a review/revision of the OMP.

- Consider whether the procedure for the Metarule Process triggered a review / revision of the OMP.

Every four years since the last revision of the OMP the WG will:

- Review whether enough has been learnt to appreciably improve/change the operating models (OMs), or to improve the performance of the OMP, or to provide new advice on tuning level (chosen to aim to achieve management objectives).

- On the basis of this, determine whether the new information is sufficient to trigger a review/revision of the OMP.

In any year, IF the WG concludes that there is sufficient new information to trigger a review/revision of the OMP, the WG will:

- Outline the work plan and timeline (e.g. over a period of one year) envisaged for conducting a review.

- Report to the Chief Director Research, DAFF BRANCH FISHERIES that a review/revision of the OMP is required, giving details of the proposed work plan and timeline.

- Advise the Chief Director Research, DAFF BRANCH FISHERIES that the OMP can still be applied while the revision process is being completed (unless exceptional circumstances have been determined to apply and a metarule invoked).

In any year, IF the WG concludes that there is no need to commence a review/revision of the OMP, the WG will:

- Report to the Chief Director Research, DAFF BRANCH FISHERIES that a review/revision of the OMP is not yet required.

The Chief Director Research, DAFF BRANCH FISHERIES will:

- Review the report from the WG.

- Decide whether to initiate the review/revision process.

Figure B2: Flowchart for Regular Review and Revision Process