Initial OMP candidates for the Nightingale rock lobster fishery

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Summary

The performances of a number of OMP candidates are reported here. Simulation results do not vary much amongst the various candidates. For this and other reasons it is recommended that at this stage CMP3 be adopted as the new OMP. This CMP has a TAC Ceiling of 85 MT. Very little further resource protection (which is in any case already certainly adequate) is provided by a CMP with a lower TAC ceiling. All the CMPs have appropriate feedback, so that if the resource declines in the future, so will the future TAC. An added precautionary feature defines an Ilim catch rate below which TAC can decline faster than the baseline constraint under the occurrence of "Exceptional Circumstances" is also build into the CMPs.

Introduction

In 2013, an OMP (Operational Management Procedure) was developed for the Tristan island rock lobster fishery (Johnston and Butterworth 2013). This OMP was updated in 2016 (Johnston and Butterworth 2016) and used to set the TAC at Tristan for the 2016 and 2017 seasons. OMPs were developed and implemented in 2014 for the Inaccessible and Gough lobster fisheries (Johnston and Butterworth 2014). An OMP has not been developed for Nightingale yet, due to the OLIVA incident in 2011 and subsequent high CPUE values, which have led to considerable uncertainty about the resource dynamics. This resulted in precautionary TACs being set in recent years.

This document reports performances of CMPs (Candidate Management Procedures) for the Nightingale rock lobster fishery, with the intention that the final selected OMP will be used for setting the TAC at Nightingale for the 2017 season and the following three seasons.

The stock assessment of the rock lobster population at Nightingale has recently been updated (Johnston and Butterworth 2017) to take data from the most recent (2016) fishing season into account. This assessment includes updated data from both the commercial fishery and the biomass surveys. The recent (2013-2016) high GLM standardised CPUE values (and biomass survey index values) at the island, which were not initially anticipated, suggest that the impact of the OLIVA on adults may have been overestimated. These high CPUEs indicates that the additional adult mortality in 2011 due to the OLIVA incident was much less than originally assumed. The 2017 RC assessment thus now assumes zero additional adult mortality in 2011 due to the OLIVA incident, but continues to assume an 80% additional juvenile mortality in 2011 due to this incident. Projections suggest that the resource could readily sustain future constant catches at 75 MT, though there may be a brief downturn in catch rates soon if the OLIVA incident led to a high additional mortality of juveniles at that time. The current spawning biomass (*Bsp*) relative to the pristine level (*K*) for Nightingale is estimated to be at healthy values between 66% (RC) and 90% (sensitivity test for only 50% OLIVA induced additional juvenile mortality). This suggests that this population is well above the level at which maximum sustainable yields would be expected to be harvestable (usually a value of around 50% K or lower). As populations approach their carrying capacity (*K*), the productivity of the resource diminishes. For this reason, it is usually recommended that populations at high levels of spawning biomass relative to *K* can be more heavily harvested to reduce their abundances to lower and more productive levels.

As with the Tristan, Inaccessible and Gough OMPs, the management target for Nightingale island is linked to the target catch rates which are considered to be the most desirable in the future. The ultimate aim of using an OMP to manage a resource is to try to reach such a management goal as closely as possible, no matter what eventuates in the future. If the resource declines in the future, this will be seen in the catch rates and TACs will be reduced, and more quickly should those rates fall below threshold levels. For the analyses that follow, TACs are constrained to not increase or decrease by any large amount between each season – here the baseline constraint is 5%. Rules that allow for a TAC decrease greater than 5% if catch rates decline appreciably (below a defined Ilim level) are also incorporated in the OMP for implementation in such Exceptional Circumstances. Unlike the OMPs for the other three islands, the Nightingale OMP also includes an upper “ceiling” in the future annual TACs. Here the range of 75MT to 85 MT is considered for this ceiling.

The impact that the OLIVA had on the resource at Nightingale is modelled by assuming an 80% once off additional mortality of juvenile lobsters aged 1, 2 and 3 years during the 2011 season due to oil induced mortality. Robustness of the CMPs’ performance to this assumption is explored (where lower levels of 2011 additional juvenile mortality are assumed).

Candidate OMPs (CMPs)

The CMPs presented here are based on the same structure as that for the current Tristan, Inaccessible and Gough OMPs (see Johnston and Butterworth 2013 and 2014). This is a target-based rule based on the recent commercial CPUE, *viz.*

$$TAC_{y+1} = TAC_y + \alpha(I_y^{rec} - I^{tar}) \quad (1)$$

where

I_y^{rec} is the average of the GLM standardized CPUE over the last three years (*y*-2, *y*-1,*y*),

I^{tar} is the CPUE target index (the average GLM standardised 2008-2010 CPUE of 3.689 kg/day is used, although a target value of 5.0 kg/day is also explored), and

α is a tuning parameter which is varied here between 2.5 to 5. The larger the α value, the more "responsive" the OMP will be to changes in the catch rate in the future.

A rule to control the inter-annual TAC variation is also applied. The baseline % TAC change relative to the previous year ("max V%") is restricted to a maximum of either up 5% down 5% (although a maximum of either up 3% down 3% is also explored):

If $TAC_{y+1} < 0.95TAC_y$ then $TAC_{y+1} = 0.95TAC_y$

If $TAC_{y+1} > 1.05TAC_y$ then $TAC_{y+1} = 1.05TAC_y$

Furthermore a ceiling (upper bound) on the TAC is introduced:

If $TAC_{y+1} > TAC_{ceiling}$ then $TAC_{y+1} = TAC_{ceiling}$

As for the other OMPs that have been developed, the addition of a precautionary metarule rule is also incorporated into the OMP, where the 5% TAC decrease constraint is increased to up to 20% if the (catch rate) index drops below a threshold (Ilim) level. Here the baseline Ilim level is set at 3.0 kg/trap. The Ilim is seen as the CPUE level below which "Exceptional circumstances" should apply.

Summary statistics

A number of summary statistics have been developed in order to compare the trade-offs and performances of the alternate CMPs. These are similar to those used for the selection of the Tristan, inaccessible and Gough OMPs.

- CR(2035) = catch rate expected in 2035 (in kg/trap)
- CR(2025) = catch rate expected in 2025 (in kg/trap)

- C_{ave} 10 = average annual catch (in MT) over the next 10 years (2017[1]-2026)
- V10 = average percentage TAC change from the previous year over next 10 years
- The median of *Bsp*(2036)/*K* which is the spawning biomass at the start of 2036 relative to the pristine level (*K*)
- The lower 5%ile of *Bsp*(2036)/*K* which is the spawning biomass at the start of 2036 relative to the pristine level (*K*)

Each candidate CMP was run for 100 simulations. The medians, and the 5th and 95th percentiles of various management quantities of interest are reported.

Future (2014+) stock-recruit residuals are generated as follows

The model estimates stock-recruit residuals for 1990-2013. For 2014+ recruitment is set equal to its expected value given the fitted stock-recruit relationship; to provide mean unbiased results this is multiplied by lognormally distributed error. This relationship $R_y = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{\varepsilon_y - \sigma_R^2/2}$ where $\varepsilon_y \sim N(0, \sigma_R^2)$ and $\sigma_R = 0.8$. This means that the expected recruitment $E[R_y] = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}}$

However, given indications of some temporal auto-correlation in the stock recruit residuals an AR(1) process is assumed. The associated auto-correlation s_R is estimated by:

$$s_R = \sum_{y=1990}^{2012} \hat{\varepsilon}_{y+1} \hat{\varepsilon}_y \Big/ \sum_{y=1990}^{2012} \hat{\varepsilon}_y^2$$

Then instead of generating the ε_y from $N(0, \sigma_R^2)$, we use

$$\varepsilon_{y+1}^s = s_R \varepsilon_y^s + \sqrt{1 - s_R^2}\, \eta_y^s \qquad \eta_y^s \sim N(0, \sigma_R^2)$$

This equation is first applied for *y*=2014 to provide ε_{2014}^y with an input of $\varepsilon_{2013}^s = \hat{\varepsilon}_{2013}$, i.e. the value estimated in the assessment.

Future (2017+) CPUE values are generated with noise as follows

Future CPUE values need to be generated. For each assessment model there is a model estimate for $CPUE_y$ for past years. Projected into the future, the model provides expected $CP\hat{U}E_y$ values for each year. Future (2017+) CPUE values for simulation *s* are generated from:

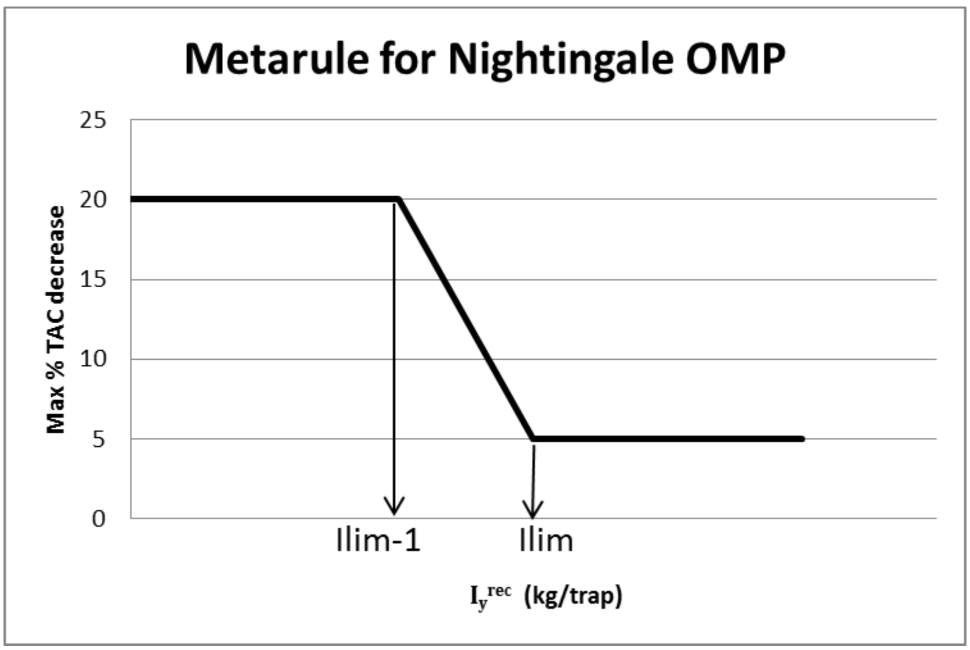
[1] The split season is referred here by the first year, i.e. 2013 refers to 2013/14 season.

$$CPUE_y^s = CP\hat{U}E_y^s \exp(\varepsilon_y^s) \qquad \varepsilon_y^s \sim N(0,(\sigma_{CPUE})^2))$$

where the σ_{CPUE} value is as estimated in the corresponding assessment.

Metarule

A metarule that allows for the TAC to decrease further than the usual maximum 5% TAC decrease, under "Exceptional Circumstances", is shown in the figure below. "Ilim" is the threshold catch rate level below which the metarule would be invoked. The baseline Ilim level is 3.0 kg/trap. Sensitivity to this value may be explored at a later stage.



Results

Results for 10 candidate CMPs are reported here (the first two are simply constant future catches at either 75MT or 80 MT). The CMP control parameter values which are explored are:

Itar: The target CPUE level set at a baseline level of 3.689 kg/day (the average of the three years prior to the OLIVA event, and an Itar value of 5.0 kg/day is also explored.

α: a tuning parameter is set to either 2.5 or 5. The larger the α value, the more "responsive" the CMP will be to changes in the catch rate in the future.

$TAC_{ceiling}$: the maximum annual TAC value allowed (values of 75 MT, 80 MT and 85 MT are explored, as well as no limit).

Ilim: the threshold catch rate level below which the metarule for Exceptional Circumstances is invoked (and TAC may fall more than 5% per annum).

Max V%: The % TAC change relative to the previous year ("max V%") is restricted to a maximum of either up 5% down 5% (baseline) although a maximum of either up 3% down 3% is also explored.

Table 1 compares simulation results of various initial CMPs expected performance results for the RC assessment model (assumes an 80% additional juvenile mortality in 2011 due to the OLIVA event). All statistics reported are median values unless otherwise stated, and values **bolded** indicate changes from CMP1 selections.

Figure 1 shows the standardized Nightingale CPUE, and also indicates three levels for Itar and one for Ilim (3 kg/trap).

Figure 2 shows the simulation results for CMP1, CMP2, CMP3 and CMP9, as well as CC trajectories of 75 MT or 80 MT. Median values only are shown.

Figure 3 shows simulation results comparing CMP3 (Ceiling of 85 MT, Itar = 3.369) and CMP9 (Ceiling of 75 MT; Itar = 5.0) where not only is the median shown, but also the 5^{th} and 95^{th} percentile values.

Discussion

The Nightingale resource is currently at a healthy state with current spawning biomass at 62%-87% of K (see Johnston and Butterworth 2017).

The Table and Figures reported here show clearly that the Nightingale resource is able to accommodate a TAC Ceiling of 85 MT in the future. There is little difference in performance over most of the CMPs reported. Even if no ceiling is set, the median final spawning biomass is a healthy 75% of K.

The OMPs will reduce the TACs (by 5% per annum) should the resource start to decline and if the resource were to suddenly "crash" producing catch rates below 3 kg/day then the metarule would allow for much faster TAC reductions. Given that this OMP is to be in place for four years only, it is unlikely the three year catch rate (which is input into the OMP) will decline to any very low level.

Further work should check robustness of these CMPs to more challenging OMs.

Management Recommendations

The MARAM recommended OMP is CMP3 which allows for a TAC Ceiling of 85 MT in the future as the resource continues to increase in a positive way as observed recently. The annual 5% TAC increase constraint still applies. The Itar is set at the level of three years prior to the OLIVA event (3.689 kg/day). The value for α has little difference in performance for the scenarios considered here; α=2.5 is recommended as this is the value used for the Inaccessible OMP.

An alternate possibility is that CMP9 be considered the preferred OMP; this allows for a TAC Ceiling of 75 MT. The Itar is slightly higher at 5.0 kg/day.

References

Johnston, S.J. and Butterworth, D.S. 2013. An operational management procedure for the Tristan da Cunha rock lobster fishery. MARAM/TRISTAN/2013/OCT/14.

Johnston, S.J. and Butterworth, D.S. 2014. Initial OMP candidates for the Inaccessible and Gough rock lobster fisheries. MARAM/TRISTAN/2014/FEB/03.

Johnston, S.J. and Butterworth, D.S. 2016. Initial results in the development of a new OMP 2016 for Tristan da Cunha island rock lobster. MARAM/TRISTAN/2016/MAY/07.

Johnston, S.J. and Butterworth, D.S. 2017. Updated 2017 Nightingale island assessment. MARAM/TRISTAN/2017/MAY/07.

Table 1: Comparison of **Nightingale** initial CMP's expected performance results for the RC assessment model (assumes an 80% additional juvenile mortality in 2011 due to the OLIVA event). All statistics reported below are median values unless otherwise stated. Values **bolded** **i**ndicate changes from CMP1 selections.

CMP	I^{tar} (kg/trap)	α	$TAC_{ceiling}$ (MT)	Ilim (kg/trap)	Max V%	CR(2025) (kg/trap)	CR(2035) (kg/trap)	C_{ave} 10 (MT)	Lower 5%ile C_{ave} 10	V10 (%)	Median *Bsp*(2036/K)	Lower 5%ile *Bsp*(2036/K)
CC 75MT	CC = 75 MT	-	-	-	-	8.92	9.94	75	75	0.13	0.839	0.511
CC 80MT	CC = 80 MT	-	-	-	-	8.67	9.69	80	80	0.53	0.834	0.505
CMP1	3.689	2.5	75	3	+5%,-5%	9.19	9.94	75	75	0.13	0.840	0.525
CMP2	3.689	2.5	**80**	3	+5%,-5%	8.67	9.69	80	80	0.53	0.834	0.521
CMP3	3.689	2.5	**85**	3	+5%,-5%	8.43	9.40	84	84	1.14	0.829	0.519
CMP4	3.689	2.5	**None**	3	+5%,-5%	7.46	4.64	100	99	5.00	0.753	0.439
CMP5	3.689	2.5	75	3	**+3%,-3%**	8.92	9.94	75	75	0.13	0.839	0.522
CMP6	3.689	2.5	**80**	3	**+3%,-3%**	8.68	9.69	80	80	0.52	0.840	0.520
CMP7	3.689	**5**	75	3	+5%,-5%	7.54	8.22	75	75	0.13	0.839	0.529
CMP8	3.689	**5**	**80**	3	+5%,-5%	7.27	8.04	80	80	0.52	0.834	0.535
CMP9	**5.000**	2.5	75	3	+5%,-5%	7.54	8.26	75	74	0.13	0.840	0.532
CMP10	**5.000**	2.5	**85**	3	+5%,-5%	7.06	7.92	84	83	1.14	0.832	0.522

Figure 1: The standardized Nightingale CPUE showing Itar (3.368 kg/trap) and Ilim (3 kg/trap).

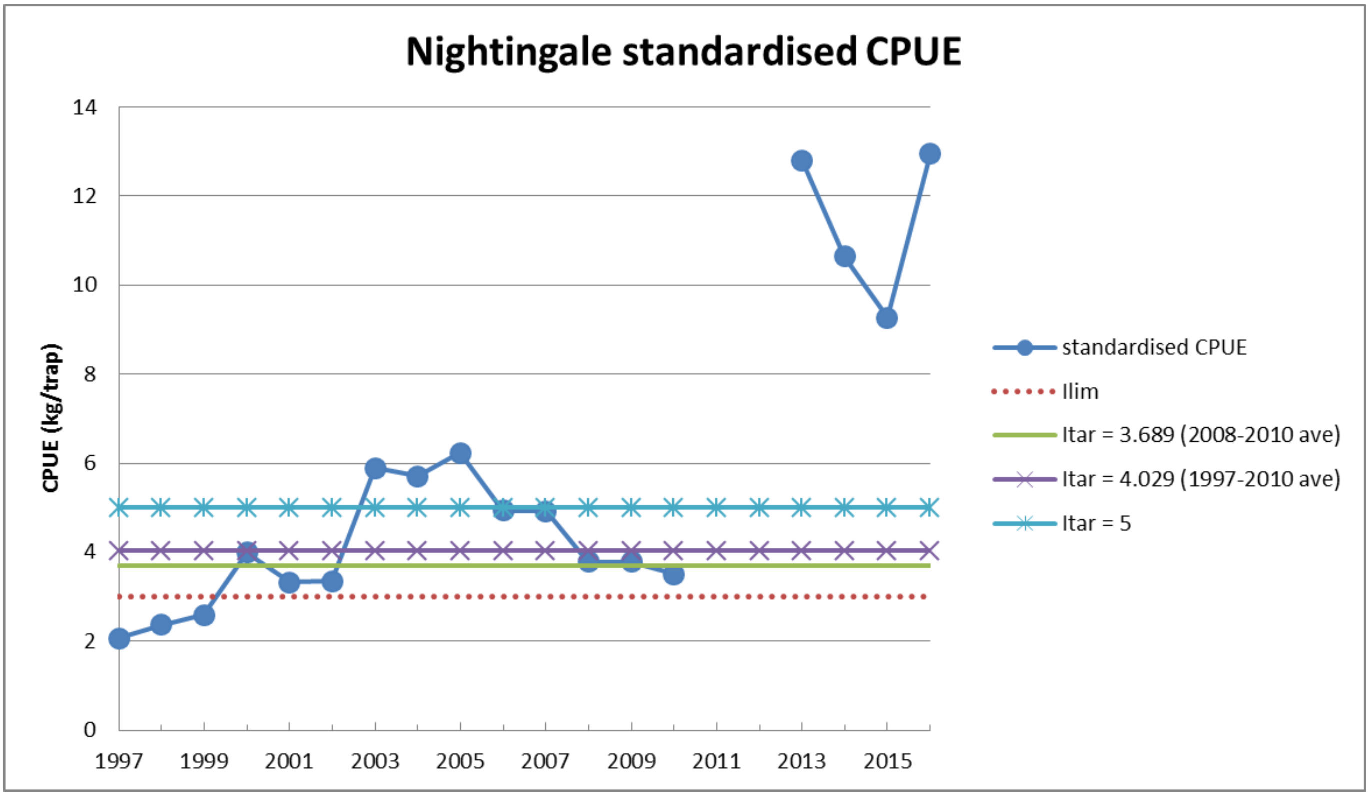
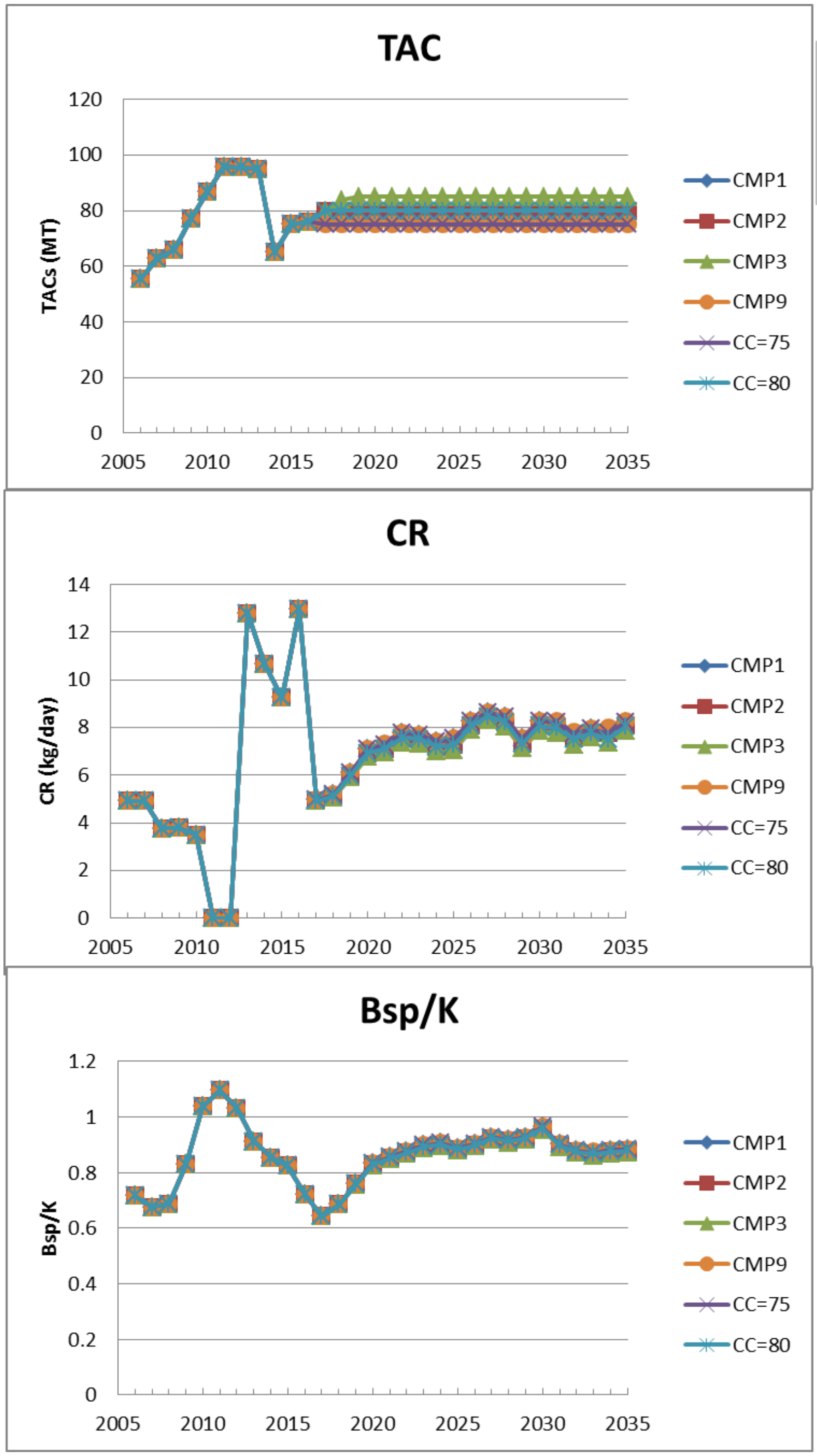


Figure 2: Simulation results for CMP1, CMP2, CMP3 and CMP9, as well as CC trajectories of 75 MT or 80 MT. Median values only are shown.



CMP1: Ceiling 75 MT; Itar = 3.689
CMP2: Celing 80 MT; Itar = 3.689
CMP3: Ceiling 85 MT; Itar = 3.689
CMP9: Ceiling 75 MT; Itar = 5.0

Figure 3: Simulation results comparing CMP3 (Ceiling of 85 MT, Itar = 3.369) and CMP9 (Ceiling of 75 MT; Itar = 5.0) where the median, 5th and 95th percentiles values are shown.