Further squid effort calculations, also taking into account the introduction of Small Scale fishers as an additional sector in the squid fishery

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Introduction

A recent update of the squid stock assessment model indicates that the target effort level in the jig fishery should be about 250000 man-days, implying a reduction in the number of men allowed in the fishery given that this is less than the 300000 man-days on which recommendations in previous years have been based.

Anticipating that squid rights are shortly to be allocated for 2014-2020 and furthermore that squid will form part of the "basket of fish" awarded to Small Scale fishers, this document details various calculations performed in order to provide advice for allocations to the respective sectors so as to ensure that the target effort level is not exceeded.

Scenario 1: Removal of under-utilized effort from the existing jig fishery

Not all existing right holders fish optimally at around 200 days per year. For vessels operating over the last 3 seasons (2010-2012), the typical number of days fished annually per vessel has been determined by applying a GLM for the form:

$$\ell n(N_{y,v}) = \mu + \alpha_y + \beta_v + \varepsilon_{y,v} \qquad (1)$$

where:
$N_{y,v}$ is the number of days fished per vessel *v* in year *y*,
μ is the intercept,
α_y is the year effect reflecting annual variation in the overall fishing effort,
β_v is the vessel effect (the extent to which the typical number of days fished annually differs for vessel *v* compared to a reference vessel included in the intercept), and
$\varepsilon_{y,v}$ is the error term, assumed to follow a normal distribution.

Only vessels that fished in all three years were included in the analyses, amounting to 126 vessels.

The typical number of days fished per vessel (N_v) over the last three years was calculated as follows:

$$N_v = e^{\mu+\beta_v+\overline{\alpha_y}} \qquad (2)$$

where $\overline{\alpha_y}$ is the average of the year effects over the three years considered.

N_v was then ordered from largest to smallest and the number of man-days per vessel was calculated as:

$$E_v = N_v \times crew_v \qquad (3)$$

where $crew_v$ is the number of crew allocated to vessel v as advised by Resource Management (T. Tanci, pers. commn) and where in these calculations (as in the past) a maximum crew of 20 was assumed for vessels where crew > 20. E_v is then summed over the ordered N_v values until a total of 250000 man-days is reached, this being the desired target effort level.

Future effort for projection purposes was calculated as follows:

Let:

$$\theta_{y,v} = \varepsilon_{y,v} + \alpha_y - \overline{\alpha_y} \tag{4}$$

where $\varepsilon_{y,v}$, α_y are derived from the GLM of equation (1).

Future effort (E_y) is calculated as:

$$E_y = \sum_v E_v e^{\theta_{y,v}} \tag{5}$$

The evaluation of E_y is restricted to those vessels that contributed to the summation of E_v over the ordered N_v until a total of 250000 man-days was reached.

The following E_y values resulted:

y	**E_y (man-days)**
2010	270495
2011	265263
2012	218321

The squid resource was then projected forward 50000 times utilizing randomly selected future effort values from the three E_y values above for the projection period (2013-2022) for each simulation. Note that this corresponds to each year selecting the vector $\theta_{y,v}$ at random from $\theta_{2010,v}$, $\theta_{2011,v}$ and $\theta_{2012,v}$ to preserve the correlations amongst vessels in days fished each year.

Scenario 2: Removal of under-utilized effort from the existing jig fishery and the introduction of additional closed periods

The extent of the reduction in the number of men in the commercial fishery to ensure that the target effort level of 250000 man-days is not exceeded could be ameliorated by the introduction of additional closed periods. The extent of such possible amelioration was tested by assuming no fishing in the months of April, May, July and August.

The procedure above (Equations (1)-(5)) was applied to data for the period 2010-2012, but omitting data from April, May, July and August.

The applications of Equations (4) and (5) resulted in the following E_y values:

y	E_y (man-days)
2010	257473
2011	264319
2012	238833

The squid resource was then projected forward 50000 times utilizing randomly selected future effort values from the three E_y values above for the projection period (2013-2022) for each simulation.

Results and Discussion

An initial estimate of the number of men permitted in the fishery given the target effort level of 250000 man-days under Scenario 1 was obtained by dividing the target effort level by the maximum N_v (210 days) to yield 1190 men (the number of men permitted at present is 2422). The summation of E_v over the ordered N_v until a total of 250000 man-days was reached corresponds to a crew complement of 1429 men i.e. the exclusion of the less efficient vessels, together with the imposition of a maximum number of fishing days for each vessel based on past performance, will allow for ~20% more crew in the fishery.

For Scenario 2 the summation of E_v over the ordered N_v until a total of 250000 man-days was reached corresponded to a crew complement of 2238 men i.e. an approximate 57% increase in the number of men allowed if an additional 4 month closed period is invoked for the months indicated, together with the imposition of a maximum number of fishing days for each vessel based on past performance in months other than April, May, July and August.

Results from projecting the resource forward 50000 times utilizing randomly selected future effort values from the three E_y values determined for Scenarios 1 and 2 are presented in Figures 1-4 in the form of $\frac{B_{lowest}}{K}$, $\frac{B_{final}}{K}$, median average catch and average annual variability (AAV) in catches, and these are compared against results for future effort fixed at 250 000 man-days. These statistics are also shown in Table 1 given that the differences are not easily discernible in the plots.

An illustration of possible options for TAE allocations to commercial and Small Scale fishers

The squid resource has been included in the basket of fish that will be allocated to Small Scale fishers from 2014, and cognisance of this needs to be taken into account when allocating effort to the various users so that the target effort level of 250000 man-days is not exceeded. The following three options have therefore been considered for TAE allocations to Small Scale fishers, which would then obviously have consequences for the commercial fishers:

- 0%
- 30%
- 60%

Tables 2-5 present the effort allocation per sector as well as the number of fishers per sector depending on the percentage of effort allocated to each sector and the effort constraints applied. It is clear that by removing inefficient vessels from the commercial fishery and allocating vessel-specific days would allow for more fishers in this particular sector, and even more so if additional closed periods are invoked. Similarly, if Small Scale fishers are also subjected to closed periods the number of fishers allocated to that sector could potentially be increased.

Further Work

It has been suggested that when abundance is higher more effort is expended and *vice versa*. If this is the case then more men might be permitted in the fishery given that this effect would provide some safeguard for the resource in years of low abundance. The relationship between number of days fished and abundance will therefore be modelled as follows:

$$\ln(N_{y,v}) = \mu' + \alpha' B_y^{model} + \beta'_v + \varepsilon'_{y,v} \qquad (6)$$

where B_y^{model} is the begin-year biomass at the joint posterior mode as estimated in the assessment model (Glazer and Butterworth, 2013).

Future effort for projection purposes will be calculated as follows:

$$E_y = \sum_v e^{\mu' + \alpha' B_y^{model} + \beta'_v + \varepsilon^*_{y,v}} \times crew_v$$

where: μ', α' and β'_v are from the fit to the model described in Equation (6), and in each year projected $\varepsilon^*_{y,v}$ is selected at random from the vectors $\varepsilon'_{2010,v}$, $\varepsilon'_{2011,v}$ and $\varepsilon'_{2012,v}$. The summation will be over the same vessels as selected in Scenario 1 above.

Reference:

Glazer, J.P. and D.S. Butterworth. 2013. Further Squid Assessment and Projection Results for a Bayesian Approach to Take Account of Uncertainty in Parameter Values. Unpublished DAFF WG document: FISHERIES/2013/SEPT/SWG-SQ/54. 6pp

Table 1: Median, 5th and 95th percentiles for $\frac{B_{final}}{K}$ and $\frac{B_{lowest}}{K}$ for future effort of 250 000 man-days and for Scenarios 2 and 3 as described in the text.

	B(final)/K		
Future Effort	**p95**	**median**	**p05**
250000	0.65736	0.37894	0.20133
vary E (S1)	0.657	0.37648	0.19917
vary E (S2)	0.64931	0.37315	0.19715
	B(lowest)/K		
Future Effort	**p95**	**median**	**p05**
250000	0.31646	0.20489	0.12532
vary E (S1)	0.31503	0.20395	0.12399
vary E (S2)	0.31397	0.203058	0.12388

Table 2: Scenario 0 - assuming that both commercial and Small Scale fishers have the potential to attain 210 days per annum, TAE allocations to each sector would be as follows:

Allocation to Small Scale	Commercial effort (man-days)	Small Scale effort (man-days)	Commercial effort (number of fishers)	Small Scale effort (number of fishers)
0%	250000	0	1190	0
30%	175000	75000	833	357
60%	100000	150000	476	714

Table 3: Scenario 1 - assuming that under-utilized existing effort has been removed from the commercial fishery and that vessel-specific effort is applied (based on past performance over the period 2010-2012 and monitored, for example, via VMS) and that Small Scale fishers have the potential to attain 210 days per annum, TAE allocations to each sector would be as follows:

Allocation to Small Scale	Commercial effort (man-days)	Small Scale effort (man-days)	Commercial effort (number of fishers)	Small Scale effort (number of fishers)
0%	250000	0	1429	0
30%	175000	75000	958	357
60%	100000	150000	524	714

Table 4: Scenario 2a - assuming that under-utilized existing effort has been removed from the commercial fishery and that vessel-specific effort is applied (based on past performance over the period 2010-2012 and monitored, for example, via VMS), and that the commercial fishery is further restricted by a 4 month closed season (April, May, July and August) and that Small Scale fishers have the potential to attain the maximum effort over the period of 210 days per annum, TAE allocations to each sector would be as follows:

Allocation to small scale	Commercial effort (man-days)	small scale effort (man-days)	Commercial effort (number of fishers)	Small scale effort (number of fishers)
0%	250000	0	2238	0
30%	175000	75000	1408	357
60%	100000	150000	771	714

Table 5: Scenario 2b - assuming that under-utilized existing effort has been removed from the commercial fishery and that vessel-specific effort is applied (based on past performance over the period 2010-2012 and monitored, for example, via VMS), and that the commercial fishery is further restricted by a 4 month closed season (April, May, July and August) and that Small Scale fishers have the potential to attain the maximum effort over the period of 147 days per annum, TAE allocations to each sector would be as follows:

Allocation to small scale	Commercial effort (man-days)	small scale effort (man-days)	Commercial effort (number of fishers)	Small scale effort (number of fishers)
0%	250000	0	2238	0
30%	175000	75000	1408	510
60%	100000	150000	771	1020

Figure 1: B_{lowest}/K with 5th and 95th percentiles. The "vary" label on the horizontal axis applies to the projections where future annual effort was randomly selected from E_y^*. S1 includes data from all months (including the normal closed season in October-November) and S2 excludes the months of April, May, July and August. To aid interpretation, dashed horizontal lines at depletions of 0.1 and 0.2 are also shown.

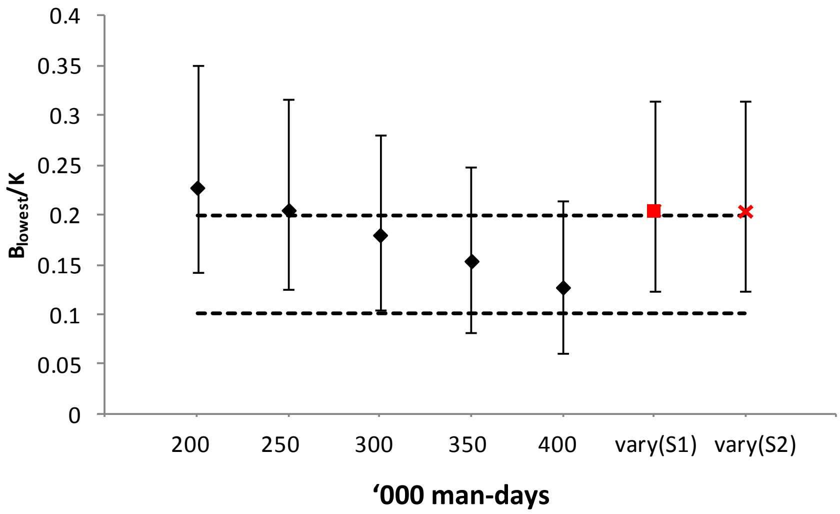

Figure 2: B_{final}/K with 5th and 95th percentiles. The "vary" label on the horizontal axis applies to the projections where future annual effort was randomly selected from E_y^*. S1 includes data from all months (including the normal closed season in October-November) and S2 excludes the months of April, May, July and August. To aid interpretation, dashed horizontal lines at depletions of 0.1 and 0.2 are also shown.

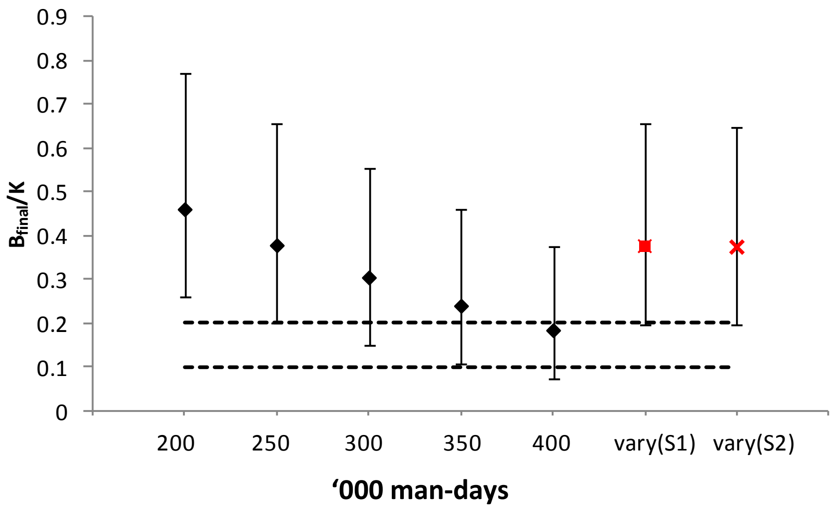

Figure 3: Median average catch with 5th and 95th percentiles. The "vary" label on the horizontal axis applies to the projections where future annual effort was randomly selected from E_y^*. S1 includes data from all months (including the normal closed season in October-November) and S2 excludes the months of April, May, July and August.

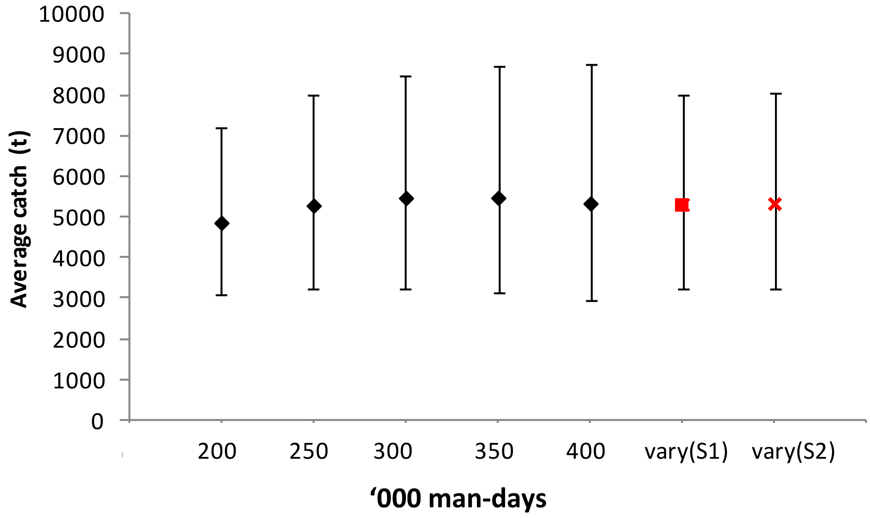

Figure 4: AAV and 5th with 95th percentiles. The "vary" label on the horizontal axis applies to the projections where future annual effort was randomly selected from E_y^*. S1 includes data from all months (including the normal closed season in October-November) and S2 excludes the months of April, May, July and August.