Discussion paper on the calibration of *Africana* against selected commercial vessels

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INTRODUCTION

Since April 2012 the *Africana* has been at sea for less than 50 days in total and has managed only 1.5 pelagic surveys – prior to this her average work rate was in the region of 260 sea days per year. If the 2013 demersal surveys of the West Coast in January/February and of the South Coast in April/May, the consequences to the demersal trawl industry are expected to be extremely serious. Therefore it is considered prudent to investigate the possibility of utilising a commercial vessel as an alternative in case of further problems experienced by the *Africana*.

In selecting a potential commercial vessel to undertake a survey, one needs to consider not only whether the vessel will provide a suitable working platform (eg the demersal surveys are 30 to 35 days duration therefore only freezer vessels would be suitable), but whether it will possible to use the biomass index derived from the survey in the assessment model. To this end some sort of "calibration factor" will be required in order to compare the index from the commercial vessel with the historic time series of factors from the *Africana*. The question of which trawl gear to deploy from the commercial vessel is central to the estimation of a calibration factor.

Factors that contribute to the different fishing efficiency between two vessels (the calibration factor) can be divided into those related to differences between the vessels (vessel effect) and those related to differences between the gears (gear effect). The normal way of calibrating two vessels is to conduct comparative trawling experiments. However such experiments cannot be undertaken until the *Africana* is available.

Deploying the *Africana* gear from the commercial vessel

If the commercial vessel deploys the same gear as used on the *Africana*, and fishes that gear in the same way then hopefully there will be minimal or no gear effect leaving only vessel effect. The vessel effect may be relatively minor, especially if the selected commercial vessel is similar to the *Africana*.

In the absence of comparative trawl data, a calibration factor would have to be assumed based on subjective views. If a conservative calibration factor is assumed i.e. assume that the commercial vessel *x*-times more efficient than the *Africana* and assume a value for *x* that is higher than expected, then it is likely that any error will lead to a precautionary TAC. Thus, although the error here is a bias, it will hopefully be positive or at worst slightly negative leading to an estimated abundance index that is more likely to be lower than would have been estimated if the survey had been conducted by the *Africana*.

Deploying the commercial vessel's normal gear

Prof. Butterworth suggested that it may be possible to use historic data for the commercial vessel and for the *Africana* to estimate a calibration factor provided that the commercial vessel deploys its normal gear.

There are a number of data limitations that had to be considered before this approach could be tested.

- The *Africana* uses a 75 mm mesh codend fitted with a 35mm mesh liner whereas commercial vessels use 110mm mesh codend. As a result the minimum size for hake in the *Africana*'s catch is about 5cms whereas in the commercial landings it is about 21cm. The selectivity ogives for the *Africana* gear (Fig. 1) are markedly different from those of the commercial gear (Fig. 2). The contribution of pre-recruits (less than 21cm) to the *Africana*'s catch will be dependent on annual

recruitment. Therefore inclusion of the pre-recruits in the comparison will introduce substantial inter-annual "noise" and decrease the precision of the estimates.
- Freezer vessels report position and effort per trawl, but the catch is recorded as daily tally. Therefore even if the selected vessel fished on the west coast for the whole of January and February, the maximum number of data records available for a single year is 59 (or 60 in leap years).
- The commercial fleet fishes between the 200m and 750m isobaths whereas the *Africana* fishes between the 30m and 500m isobaths (Fig. 3).

The method suggested by Prof. Butterworth entails the following steps.
1. Apply a selectivity curve to convert the hake catch recorded by the *Africana* to what would be expected if she had used 110mm mesh codend, i.e. to "commercial equivalent". We will refer to these data as *Africana* (adjusted).
2. Use GLM methods to estimate the relative fishing efficiency between the *Africana* (adjusted) and the selected commercial vessel. This will estimate the vessel effect component of the calibration factor.
3. Use GLM methods to estimate the relative fishing efficiency between the *Africana* (adjusted) and the *Africana* (standard). This will estimate the gear effect component of the calibration factor

METHOD

Preparation of the *Africana* data
- Although it would be more accurate to apply the selectivity curves estimated from the hake assessment model (Figs 1 & 2), we considered simple length frequency slicing adequate for the purposes of the illustrative fits presented here.
- Use sex-aggregated length frequency data and species-specific length/weight relationship for west coast (Fairweather, 2008) to slice the *Africana* catch per station into four categories: pre-recruits (under 21cm Lt); small (21-44cm); medium (44-65cm) and large (over 65 cm). The length ranges for the three commercial size categories follow Gaylard and Bergh (2004).
- Aggregate the estimated catch weight per size category across species.
- For surveys where the *Africana* deployed the "new" trawl gear the hake catch per station was multiplied by 0.8 to convert to "old" gear equivalent (Rademeyer 2012).
- Only data from "biomass stations" were used.

Preparation of the data from commercial vessels
- Data preparation was as for the annual GLM-standardisation of the commercial CPUE (see for eg Glazer, 2008). This includes aggregating effort per day to match the daily catch tally, and assigning an average start position for the days fishing.
- Midwater trawl catches were excluded.
- Data were not restricted to hake targeted trawls.

The General Linear Model
The following model was applied to the hake CPUE data (for different size categories):

$$\ln(CPUE) = \alpha + \beta_{year} + \gamma_{depth} + \eta_{area} + \lambda_{vessel} + \varepsilon$$

where: CPUE is the catch of a hake (*Merluccius* spp) per unit of effort,
α is the intercept,
year is a factor with 23 levels (1986-2012) associated with the year effect,
depth is a factor with 2 levels:
*d*1: ≤ 250m
*d*2: 251 - 500m
area is a factor with 2 levels*:*

$a1$: ≤ 33°00' S (Namibian boarder to Cape Columbine)
$a2$: > 33°00' S (south of Cape Columbine)
vessel is a factor associated with each individual vessel in the dataset being analyzed
ε is the error term, assumed to follow a normal distribution.

For these illustrative models stations with zero catch were deleted.

The model was fitted to two different subsets of the hake catch per station. The first subset included only medium and large hake. The pre-recruit and small hake (hake less than 44cm Lt) were excluded because they would be unrepresented (pre-recruits) or under-represented (small) in the commercial catch due to escapement – the selectivity curves fitted to the commercial catch (Rademeyer, 2012) shows that hake are fully selected at about 40 cm (Fig. 2).

There are indications that the *Africana* gear catches relatively fewer large fish than does the commercial gear – it is possible that the reduced water flow through the small meshed codend of the *Africana*'s gear creates a more pronounced pressure wave ahead of the net which could enhance avoidance by large hake. Therefore the model was fitted to the catch of medium hake only as it is possible that this is the only size category that is fully selected by both the *Africana* and commercial gears.

RESULTS

The vessel parameters relative to the *Africana* are presented in Table 1. To standardise the *Africana* against herself, the CPUE-series recorded by the *Africana* for different components of her hake catch were treated as separate "vessels". The parameter values for year, area, depth and "vessel" effects from this model are presented in Table 2. To illustrate the paucity of commercial data, the number of available records per vessel, year, area and depth are presented in Table 3. Seven of the 24 freezer vessels have less than 50 fishing days in total (data points) on the West Coast during January and February over the 26 year time period (Table 3) and they should be excluded from further analyses. These vessels are *Antares Prima, Boronia, Eschalar, Harvest Lindiwe, Khulisa Eyethu, Sandile* and *Toralla*.

DISCUSSION

The suggestion to use commercial gear in favour of the *Africana* gear was made because there will be an bias of unknown magnitude associated with a biomass index derived from a survey by a commercial vessel deploying the *Africana* gear. Further it was assumed that although a calibration factor based on the historic commercial and *Africana* data would probably be very imprecise, it may be unbiased.

However, that view ignored the effect of targeting. The historic commercial data reflect a scenario where the commercial vessel is targeting hot-spots with a specific species mix. Therefore the fishing performance of the commercial vessel when she is conduction a random survey is unlikely to be the same as her performance when fishing commercially. In other words there will be a bias of unknown dimension associated with a calibration factor derived from commercial fishing data. This point is illustrated by the wide range of calibration factors (0.97 to 21.98) in Table 1.

Vessels with calibration factors less than two tend to be vessels with smaller hake allocations and they are likely to target a species mix with higher bycatch levels rather than targeting maximum hake catch rate. It is tempting to assume that there may be less difference in hake catch rates between random fishing and this type of fishing strategy, i.e. less bias, but this is not necessarily the case. This is because the vessel could use different trawl gear when following different fishing strategies, e.g. when

targeting monk vessels use trawls with a lower vertical mouth opening to maximise the monk catch while minimising the hake catch.

Comparing the factors estimated for the Boronia and Blue Bell provides another example of the effect of fishing strategy. These two vessels are sister ships and would be expected to have similar catch rates. But the vessels follow different fishing strategies and their calibration factors relative to the *Africana* are quite different.

Limiting the *Africana* data to use only trawls that were completed on the commercial fishing grounds (Fig. 3) may reduce the impact of targeting, but hake are not homogenously distributed over the commercial grounds and the "hake specialist" vessels will target areas within the trawl footprint with high hake catch rates.

CONCLUDING REMARKS

- If a commercial vessel is used to conduct the West Coast demersal survey in 2013 there will be bias of unknown magnitude associated with the biomass index whether the vessel uses her normal commercial gear or the *Africana* gear.
- If the commercial vessel uses the *Africana* gear then the calibration will be due to vessel effects only, whereas if she uses commercial gear then both vessel and gear effects will apply.
- Using the small mesh codend of the *Africana* gear will have the added advantage that the survey will collect data on the small incidental bycatch species whereas it will not be possible to calculate indies for many of the bycatch species if the vessel uses the commercial gear.

REFERENCES

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Table 1: Vessel parameters (CF) relative to the *Africana* for freezer vessels currently active in the demersal fleet

	medium hake only				hake medium plus hake large			
	Exp(vessel)	SE	t Value	Pr > |t|	Exp(vessel)	SE	t Value	Pr > |t|
Africana	1.000				1.000			
Andromeda	2.681	0.117	8.41	<.0001	2.763	0.114	8.91	<.0001
Antares Prima	5.888	0.339	5.23	<.0001	6.249	0.330	5.55	<.0001
Armana	0.965	0.074	-0.48	0.6309	1.069	0.072	0.93	0.3526
Basani	4.012	0.110	12.6	<.0001	4.631	0.107	14.29	<.0001
Beatrice Marine	7.231	0.083	23.88	<.0001	7.524	0.081	25.07	<.0001
Bluebell	3.221	0.140	8.33	<.0001	4.515	0.136	11.1	<.0001
Boetie Bert	1.526	0.097	4.38	<.0001	1.579	0.094	4.86	<.0001
Boronia	4.882	0.179	8.85	<.0001	3.899	0.155	8.77	<.0001
Codesa 1	4.115	0.108	13.13	<.0001	4.378	0.105	14.09	<.0001
Compass Challenger	6.937	0.128	15.18	<.0001	7.552	0.124	16.3	<.0001
Echalar	11.307	0.283	8.56	<.0001	14.558	0.276	9.71	<.0001
Esra Cruz	1.004	0.092	0.05	0.963	1.078	0.089	0.84	0.3995
Harvest Lindiwe	5.216	0.370	4.46	<.0001	5.808	0.360	4.88	<.0001
Harvest Veronica	5.154	0.086	19.05	<.0001	5.792	0.084	21	<.0001
Khulisa Eyethu	20.313	0.174	17.31	<.0001	21.977	0.169	18.25	<.0001
Lee-Anne	1.488	0.088	4.52	<.0001	1.599	0.085	5.49	<.0001
Lepanto	1.105	0.053	1.87	0.0617	1.289	0.052	4.89	<.0001
Lincoln	2.479	0.108	8.41	<.0001	2.726	0.105	9.56	<.0001
Lucerne	1.325	0.063	4.43	<.0001	1.403	0.062	5.49	<.0001
Portunity	1.651	0.085	5.89	<.0001	1.743	0.083	6.72	<.0001
Realeka	1.410	0.077	4.49	<.0001	1.410	0.074	4.63	<.0001
Sandile	7.936	0.190	10.9	<.0001	8.599	0.185	11.63	<.0001
Sistro	3.839	0.084	15.98	<.0001	3.926	0.082	16.71	<.0001
Toralla	5.069	0.194	8.38	<.0001	5.710	0.189	9.24	<.0001

Table 2: Parameter values for the calibration of *Africana* against herself for three different components of her hake catch: All – the total hake catch; med+lrg – all hake longer than 44cm total length; med – 44cm ≤ hake ≤ 65cm total length

Parameter		Exp(vessel)	S.E.	t Value	Pr > |t|
Hake	med	0.144	0.044	-44.16	<.0001
Hake	med+lrg	0.186	0.044	-38.45	<.0001
Hake	all	1.000			

Table 3: Sample size per cell for the model fit to the medium+large hake categories. Note that this represents the maximum sample size per cell

Vessel	Andromeda					Antares Prima					Armana					Basani					Beatrice Marine					Bluebell					Boetie Bert				
Area	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot
Depth	1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2	
1986																																		
1987																																		
1988												9		9																				
1989												10		10																				
1990																																		
1991																																		
1992																																		
1993																																		
1994																					3	2	3	9	17									
1995																							1	7	8									
1996																						3		9	12									
1997																								8	8									
1998												7	13	14	34								2	17	19									
1999												26		6	32							2	5	23	30									
2000												22	4	18	44								4	33	37									
2001												11	4	18	33								9	29	38									
2002												41	1	1	43								1	15	16			24	1	25				
2003												20	1	2	23									4	4							41	1		42
2004																								2	2				1	1		10		1	11
2005			9	12	21								12	5	17									31	31				2	2		36		1	37
2006			11	14	25							1	13	4	18									16	16			1	2	3				
2007		32		4	36							33		3	36		2		2	4				14	14		8		11	19				
2008			12	21	33		1	2	7	10		28	7	8	43		38		5	43				20	20			1	7	8	1	21	3	5	30
2009																5	24		5	34				9	9		4	1	11	16		21		1	22
2010													10	1	11		24	3	7	34			2	8	10							20		12	32
2011			1		1		1		1	2							13	3	4	20			2	9	11				3	3			3	5	8
Total	-	32	33	51	116	-	2	2	8	12	-	189	84	80	353	5	101	6	23	135	3	7	29	263	302	-	12	27	38	77	1	149	7	25	182

Table 3: Cont

Vessel	Boronia				Codesa 1				Compass Challenger				Echalar				Esra Cruz				Harvest Lindiwe				Harvest Veronica			
Area	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot
Depth	1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2	
1986																													
1987																													
1988																													
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1992																													
1993																													
1994																													
1995																													
1996																													
1997																										8		2	22	32
1998		1		25	26																					3		7	21	31
1999		4		5	9																					7		4	21	32
2000				4	4																									
2001				1	1												8			8										
2002							4		7	11														2	2					
2003		1			1		26		3	29				1	1			20		10	30					1	12	1	17	31
2004							24		3	27				2	2			29		2	31			1	1					
2005							10	1	10	21				16	16			21		5	26						5	1	11	17
2006							12		1	13		1		18	19			13			13									
2007				2	2		7		1	8		4		20	24			17		15	32			1	1		5		17	22
2008				6	6		29		1	30				16	16			6		2	8			2	2		2	2	26	30
2009												3	2	5				23		4	27									
2010																17			1	18	6		6	12			3	3		18		28	46
2011														16	16			5		12	17			1	1		2	1	17	20
Total	-	6	-	43	49	-	112	1	26	139	-	5	3	91	99	-	17	-	1	18	-	148	-	56	204	-	-	-	10	10	1	62	18	180	261

Table 3: Cont

Vessel	Khulisa Eyethu				Lee-Anne				Lepanto				Lincoln				Lucerne				Portunity				Realeka			
Area	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot
Depth	1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2	
1986																													
1987												1		1					1	4	5									
1988												11		1	2	14				1		1								
1989												7		29		36		1		1		5		10	1	16				
1990														6	24	30								5	9	14				
1991							1		12	3	16	1	28	2	10	41								6	10	16				
1992												15	24		3	42								1	4	5				
1993												12	25		1	38														
1994												10	18		2	30								3	1	4				
1995													2		31	33								4	1	5				
1996												1	14		14	29								1	2	3				
1997												1	39		4	44					1	9	2	12	24				6	5	2	13
1998												11	30			41						14	6	15	35			1	7			8
1999												1	31		8	40						24		12	36				16		4	20
2000													39		5	44		2		2		20	1	20	41				7		21	28
2001													18		26	44		17	5	22		28	1	7	36							
2002													36		7	43						37		5	42						13	13
2003													38		7	45		3	2	5		22	1	4	27		24		15	39	11	1	23	35
2004							16	1	12	29			27		14	41						4	3	2	9	1	22		4	27	3	2	14	19
2005							13	3	1	17			32	2	7	41		4	2	6		2	11	22	35	5	19	1	11	36	20	1	23	44
2006							4	17	2	23				7	1	8		26		26		2	17	12	31		31			31		6	30	36
2007		14			14		34		4	38			40		6	46		18		5	23		12	9	19	40		16		4	20		44	44
2008		34		1	35		29	12	3	44			47			47		27	11	38		3	26	13	42		17		8	25		37	37
2009							6	11	4	21			17		1	18						28			28		14		8	22		1	31	32
2010								9	2	11		7		12	1	20		5		5			6	2	8		18			18		2		16	18
2011								13	3	16				18	17	35		11		11			22	1	23		19		11	30			15	15
Total	-	48	-	1	49	-	103	78	34	215	52	530	78	191	851	-	18	96	25	139	1	210	137	178	526	6	180	1	61	248	1	72	16	273	362

Table 3: Continue

Vessel	Sandile					Sistro					Toralla					SAS Africana				
Area	north		south		Tot	north		south		Tot	north		south		Tot	north		south		Tot
Depth	1	2	1	2		1	2	1	2		1	2	1	2		1	2	1	2	
1986																21	22	18	8	69
1987																29	20	19	7	75
1988																25	19	19	5	68
1989																8	9	4		21
1990																32	13	17	6	68
1991																38	17	19	9	83
1992																32	26	20	5	83
1993																18	25	19	8	70
1994																27	25	25	6	83
1995																42	24	23	9	98
1996						7	15		6	28						26	24	17	5	72
1997							18		3	21						21	19	20	9	69
1998							11		1	12										
1999						2	6			8						32	17	18	9	76
2000							19			19										
2001							1		6	7										
2002							3		6	9						32	27	22	8	89
2003							3		6	9				1	1	27	24	19	6	76
2004							31		7	38						32	20	15	9	76
2005														1	1	39	27	19	6	91
2006			2	8	10		11		3	14				1	1	23	22	16	6	67
2007		6	3	7	16		12			12		1		19	20	22	23	15	5	65
2008				2	2		20	6	16	42						30	25	18	7	80
2009			1		1											35	26	13	11	85
2010							4	12	8	24				4	4	24	25	16	10	75
2011			4	7	11			3	1	4			4	8	12	18	25	19	11	73
Total	-	6	10	24	40	9	154	21	63	247	-	1	4	34	39	633	504	410	165	1712

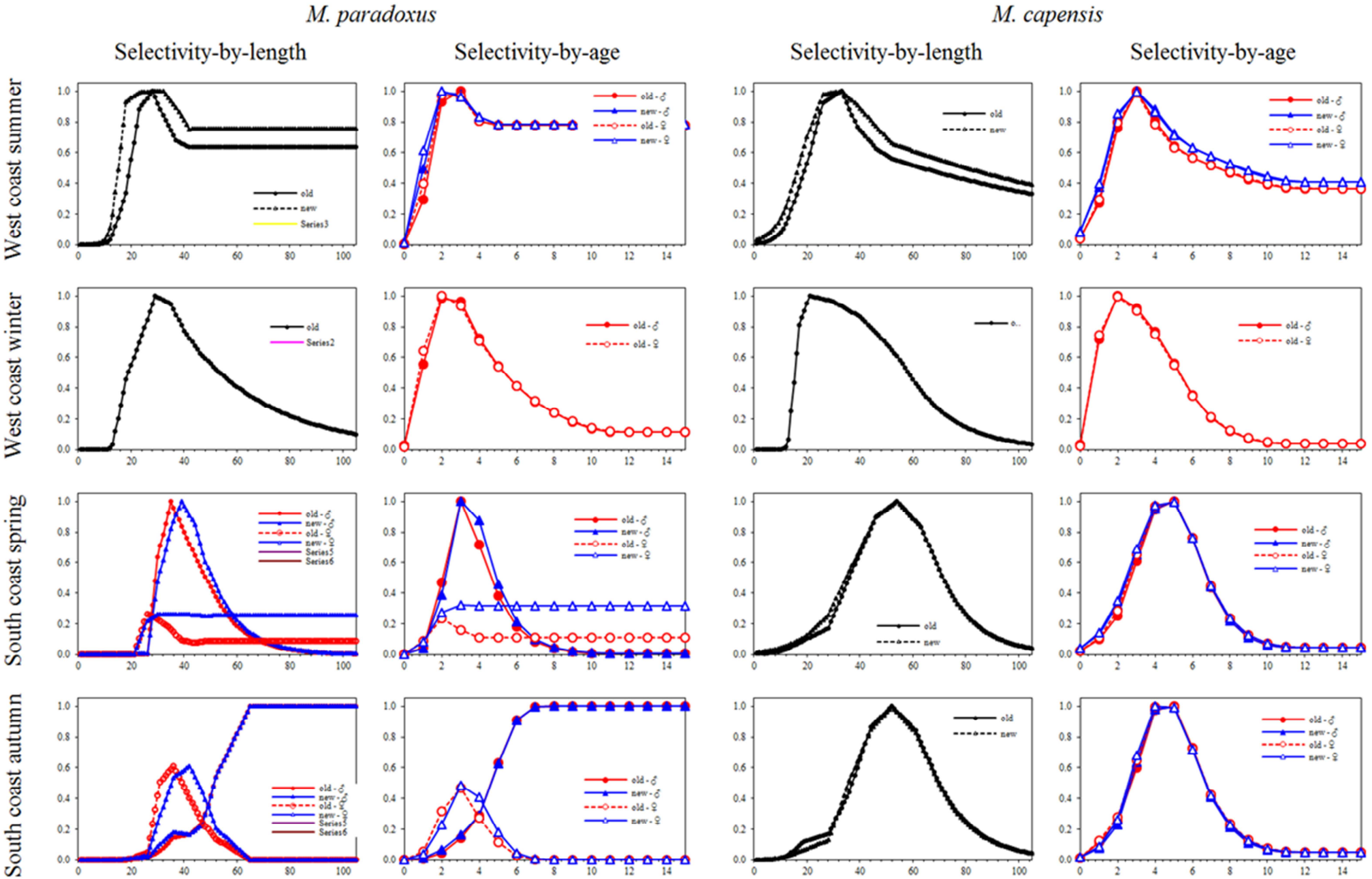

Figure 1: Hake selectivity at length estimates for the *Africana* (from Rademeyer, 2012).

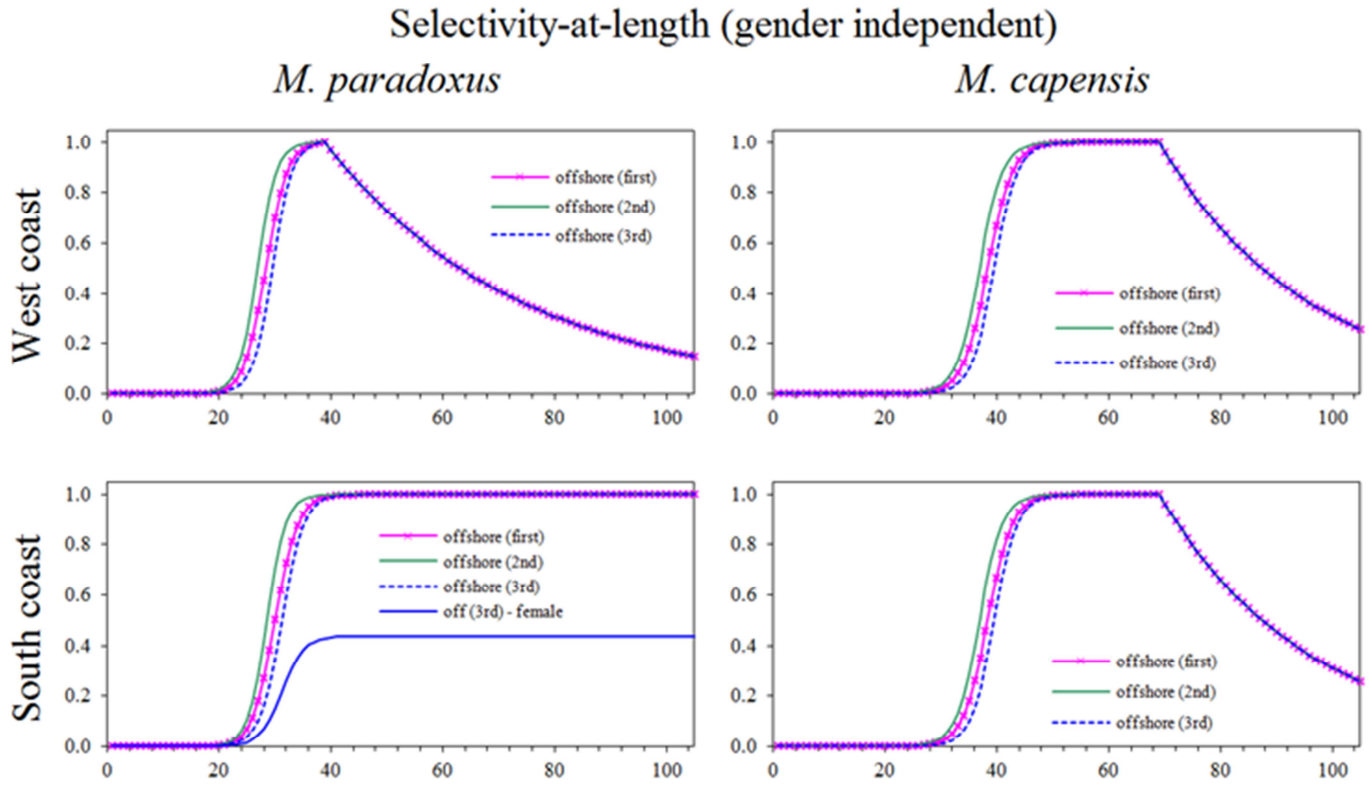

Figure 2: Hake selectivity at length for the commercial catches (from Rademeyer, 2012).

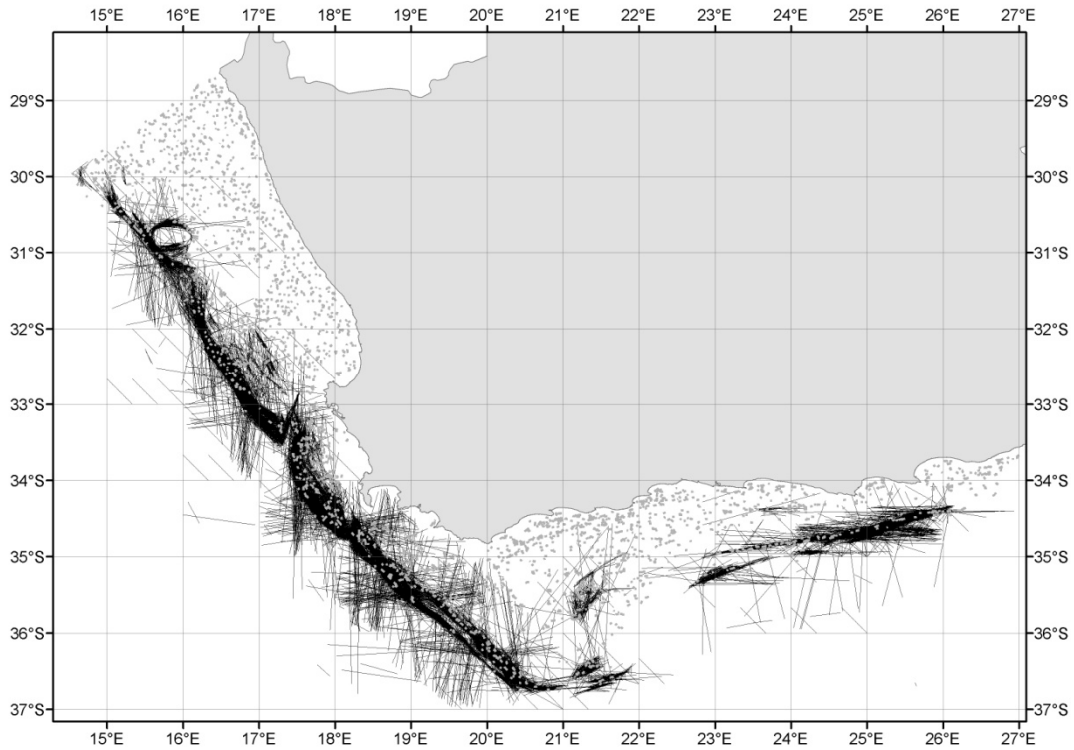

Figure 3: Trawl tracks (black lines) of offshore freezer vessels targeting hake between 2000-2009 in the months coinciding with demersal surveys (Jan, Feb, Apr & May), compared to research survey trawls (grey lines) completed since 1985.