DFFE Demersal Research Surveys

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Background

Fishery-independent demersal trawl research surveys have been conducted in South Africa since 1984 (Table 1). The surveys have usually been conducted each year in summer (January – February) on the West Coast (WC) and in autumn (April – May) on the South Coast (SC), although budgetary/operational constraints have resulted in several surveys being cancelled (Table 1). While some winter (June – July) WC and spring (September – October) SC surveys have been completed (Table 1), the last winter survey was in 1991, and no spring surveys have been conducted since 2016. Surveys have generally been conducted using the Department's research vessel *Africana*, but commercial vessels (*Andromeda* and *Compass Challenger*) have been chartered for this purpose when the *Africana* has been unavailable. Prior to 2011, West Coast surveys typically extend from the coast out to the 500-metre isobath (with some exceptions, see Table 1) in the area between the international border with Namibia (Orange River mouth) and Cape Agulhas (20° E), while South coast surveys cover the same depth range between Cape Agulhas and Port Alfred (27° E). From 2011 onwards, the survey areas have (with some exceptions) been extended to the 1 000 m isobath in an effort to encompass the entire distribution of deep-water hake (*Merluccius paradoxus*). Cost and time constraints in recent years have, however, resulted in the 500 – 1 000 m stations not being sampled during some of the surveys (see Table 1), resulting in incomplete coverage of the *M. paradoxus* resource.

The primary objective of the surveys has been to provide fishery-independent abundance indices for the two species of Cape hakes (shallow-water hake *Merluccius capensis* and deep-water hake *M. paradoxus*), as well as other commercially important species (including Agulhas sole, Cape horse mackerel, monkfish, kingklip and chokka squid). Other objectives include routine collection of length frequency data from all fish and squid species caught, biological sampling of key commercial species, collection of hydrographic data using a net-mounted CTD as well as fulfilling sample requests from DFFE and external scientists. Given that the entire catch is sampled, the surveys could be considered as a comprehensive demersal biodiversity survey.

Survey design, sampling procedures and calculation of abundance indices

For each survey, 120 trawl stations are selected (100 stations in the cases of surveys restricted to < 500 m as a result of time/cost constraints) using a pseudo-random stratified sampling design. The survey area is divided into depth strata, and each stratum is further subdivided into 1° latitude substrata on the West Coast and 1° longitude substrata on the South Coast. The number of target stations per substratum is proportional to the area of the substratum, and stations within each substratum are selected at random. Areas of rough ground within the survey area that cannot be sampled using the research demersal trawl gear are excluded from the station selection process, and it is assumed that fish densities in these areas are the same as those in adjacent areas. Sampling (trawling) is conducted only during the day to minimise bias arising from the daily vertical migration of hake, which are known to move off the sea floor and into the water column at night to feed. Examples of typical survey designs for the West and South Coasts are illustrated in Figures 1 and 2.

Surveys conducted on the research vessel *Africana* between 1984 and September 2003 used a 2-panel German 180 ft trawl net with a rope-wrapped chain footrope, 150kg lift and 1500kg WV doors. In 2003, "new" gear was introduced that consisted of a 4-panel German 180 ft trawl net with a modified rockhopper footrope, 150 kg lift and 1 500 kg Morgere multi-purpose doors. The "new" gear has

subsequently been used as standard (with the exception of 2006 and 2010, where the old gear was used to facilitate a gear "cross-calibration").

All organisms in the catch, including benthic invertebrate macrofauna, are identified to species level where possible, in some cases also separated by gender (hake, chondrichthyans and cephalopods), and the catch weight of each species (and gender) is then recorded. The size composition of the catch of each species is measured, and more detailed biological analyses are conducted on sub-samples of commercially important species (hake, kingklip, monkfish, Agulhas sole and chokka squid). Such biological analyses include individual fish length and weight measurements, macroscopic estimation of maturity stage, gonad and liver weight measurements and samples, evaluation of stomach contents and extraction of otoliths for age determination.

Abundance indices are calculated from the survey data using the swept-area method. The density ($kg.nm^{-2}$) of a given species at a given station (trawl) is calculated as the total catch weight of the species in the trawl divided by the area swept by the trawl. The mean density of the species within the relevant stratum is then calculated as the average of the densities observed at all stations within that stratum, with the associated standard error of the mean. The abundance of the species within the stratum is then calculated as the product of the mean density and the area of the stratum (with the standard error of the stratum abundance estimate being calculated as the product of the standard error of the mean density and the area of the stratum). Total survey abundance of the species is then computed as the sum of all the stratum abundance estimates (and similarly the standard errors of the abundance estimates per stratum are summed over all strata to yield a survey standard error).

Time series of swept-area abundance estimates for several key species are illustrated in Figure 3.

The importance of demersal surveys

1. Abundance indices derived from the survey data are critical inputs to the assessments (and subsequent management advice) of the two hake species, Agulhas sole, horse mackerel, chokka squid, monkfish, kingklip and various other key species caught as by-catch in SA's demersal fisheries, including line fish and sharks.
2. In the case of hake, the surveys provide a "reality check" on the commercial CPUE indices of abundance (which may provide misleading perceptions of stock abundance due to changes in fishing behaviour or gear, for example) and are consequently used as direct inputs to the hake OMP algorithm that calculates a recommended TAC each year.
3. Considering that the SA hake trawl fishery is currently certified by the Marine Stewardship Council (and the hake longline fishery is working towards MSC certification), the surveys are a critical requirement for ensuring that the assessment and management of the SA hake resource aligns with the MSC Fishery Standard, both in terms of Principle 1 aspects (target stock) as well as contributing to Principle 2 aspects (ecosystem impacts, by-catch species, VMEs and benthic habitats).
4. In the case of monk, kingklip and the other by-catch species, the surveys provide the ONLY abundance information to support the assessments.
5. Stock proportions-at-length data that are important inputs to the current hake and horse mackerel assessments and will be invaluable inputs to future statistical catch at length assessments of other species if/when they are developed.
6. Biological data and samples collected during the surveys from hake, monkfish, kingklip, Agulhas sole and chokka squid yield information on length-weight relationships (important inputs to the

hake and horse mackerel assessments), age and growth (otoliths), size-at-maturity and fecundity (gonad staging and histological analyses) and diet (stomach contents analysis).

7. The surveys are an important source of distribution, abundance and size structure data for more than 1 500 marine species that are not directly managed by the Department. These include both retained and discarded non-target fish, shark, skate and squid species that are caught as incidental by-catch during commercial fishing operations and benthic invertebrates (these latter data have been invaluable in SA's marine biodiversity mapping research). These data have also been critical in Marine Spatial Planning work (including development of MPA networks).
8. The surveys have been used as a source of samples for stock structure research (genetics/genomics, morphometrics, parasitology etc) of a variety of species, including pelagic and line fish species, as well as for species managed by high seas RFMOs (such as SEAFO).
9. The research vessel used for the surveys provides a unique platform for marine research other than the fisheries-related research that is the responsibility of the Department, and for the training of young scientists in various aspects of marine and fisheries science.

Table 1: List of DFFE demersal surveys 1984 – present. Summer (WC) and autumn (SC) surveys are listed in black text while winter (WC) and spring (SC) surveys are in grey text. The gear used (OLD versus NEW), the depth range encompassed by each survey and the vessels used (research vessel Africana = RES -AFR, commercial vessels Andromeda = COM – AND and Compass Challenger = COM – CCH) are also indicated.

	WEST COAST					SOUTH COAST				
Year	**Season**	**Cruise#**	**Gear**	**Depths**	**Vessel**	**Season**	**Cruise#**	**Gear**	**Depths**	**Vessel**
1984	Winter	AFR00022	OLD	≤ 500 m	RES - AFR					
1985	Summer	AFR00028	OLD	≤ 500 m	RES - AFR					
	Winter	AFR00033	OLD	≤ 500 m	RES - AFR					
1986	Summer	AFR00039	OLD	≤ 500 m	RES - AFR					
	Winter	AFR00046	OLD	≤ 500 m	RES - AFR	Spring	AFR00048	OLD	≤ 500 m	RES - AFR
1987	Summer	AFR00050	OLD	≤ 500 m	RES - AFR					
	Winter	AFR00054	OLD	≤ 500 m	RES - AFR	Spring	AFR00056	OLD	≤ 500 m	RES - AFR
1988	Summer	AFR00059	OLD	≤ 500 m	RES - AFR	Autumn	AFR00063	OLD	≤ 500 m	RES - AFR
	Winter	AFR00066	OLD	≤ 500 m	RES - AFR					
1989						Autumn	AFR00072	OLD	≤ 200 m	RES - AFR
	Winter	AFR00075	OLD	≤ 500 m	RES - AFR					
1990	Summer	AFR00079	OLD	≤ 500 m	RES - AFR	Autumn	AFR00082	OLD	≤ 200 m	RES - AFR
	Winter	AFR00084	OLD	≤ 500 m	RES - AFR	Spring	AFR00086	OLD	≤ 200 m	RES - AFR
1991	Summer	AFR00088	OLD	≤ 500 m	RES - AFR	Autumn	AFR00093	OLD	≤ 500 m	RES - AFR
						Spring	AFR00095	OLD	≤ 200 m	RES - AFR
1992	Summer	AFR00100	OLD	≤ 500 m	RES - AFR	Autumn	AFR00102	OLD	≤ 500 m	RES - AFR
						Spring	AFR00106	OLD	≤ 200 m	RES - AFR
1993	Summer	AFR00109	OLD	≤ 500 m	RES - AFR	Autumn	AFR00111	OLD	≤ 500 m	RES - AFR
						Spring	AFR00116	OLD	≤ 200 m	RES - AFR
1994	Summer	AFR00118	OLD	≤ 500 m	RES - AFR	Autumn	AFR00122	OLD	≤ 500 m	RES - AFR
						Spring	AFR00125	OLD	≤ 200 m	RES - AFR
1995	Summer	AFR00127	OLD	≤ 500 m	RES - AFR	Autumn	AFR00129	OLD	≤ 500 m	RES - AFR
						Spring	AFR00131	OLD	≤ 200 m	RES - AFR
1996	Summer	AFR00133	OLD	≤ 500 m	RES - AFR	Autumn	AFR00135	OLD	≤ 500 m	RES - AFR
1997	Summer	AFR00139	OLD	≤ 500 m	RES - AFR	Autumn	AFR00144	OLD	≤ 500 m	RES - AFR
1998										
1999	Summer	AFR00150	OLD	≤ 500 m	RES - AFR	Autumn	AFR00152	OLD	≤ 500 m	RES - AFR
2000										

Table 1 (contd.)

	WEST COAST					SOUTH COAST				
Year	**Season**	**Cruise#**	**Gear**	**Depths**	**Vessel**	**Season**	**Cruise#**	**Gear**	**Depths**	**Vessel**
2001						Spring	AFR00160	OLD	≤ 500 m	RES - AFR
2002	Summer	AFR00165	OLD	≤ 500 m	RES - AFR					
2003	Summer	AFR00173	OLD	≤ 500 m	RES - AFR	Autumn	AFR00177	OLD	≤ 500 m	RES - AFR
						Spring	AFR00182	NEW	≤ 500 m	RES - AFR
2004	Summer	AFR00188	NEW	≤ 500 m	RES - AFR	Autumn	AFR00191	NEW	≤ 500 m	RES - AFR
						Spring	AFR00200a	NEW	≤ 500 m	RES - AFR
2005	Summer	AFR00203	NEW	≤ 500 m	RES - AFR	Autumn	AFR00206	NEW	≤ 500 m	RES - AFR
2006	Summer	AFR00214	OLD	≤ 500 m	RES - AFR	Autumn	AFR00217	OLD	≤ 500 m	RES - AFR
						Spring	AFR00224	OLD	≤ 500 m	RES - AFR
2007	Summer	AFR00228	NEW	≤ 500 m	RES - AFR	Autumn	AFR00232	NEW	≤ 500 m	RES - AFR
						Spring	AFR00236	NEW	≤ 500 m	RES - AFR
2008	Summer	AFR00238	NEW	≤ 500 m	RES - AFR	Autumn	AFR00241	NEW	≤ 500 m	RES - AFR
						Spring	AFR00246	NEW	≤ 500 m	RES - AFR
2009	Summer	AFR00249	NEW	≤ 500 m	RES - AFR	Autumn	AFR00252	NEW	≤ 500 m	RES - AFR
2010	Summer	AFR00259	OLD	≤ 500 m	RES - AFR	Autumn	AFR00261	OLD	≤ 500 m	RES - AFR
2011	Summer	AFR00270	NEW	≤ 1 000 m	RES - AFR	Autumn	AFR00273	NEW	≤ 1 000 m	RES - AFR
2012	Summer	AFR00279	NEW	≤ 1 000 m	RES - AFR					
2013	Summer	AND00001	NEW	≤ 1 000 m	COM - AND					
2014	Summer	AND00002	NEW	≤ 1 000 m	COM - AND	Autumn	AND00003	NEW	≤ 1 000 m	COM - AND
2015	Summer	AND00004	NEW	≤ 1 000 m	COM - AND	Autumn	AND00005	NEW	≤ 1 000 m	COM - AND
2016	Summer	CCH00008	NEW	≤ 1 000 m	COM - CCH	Autumn	CCH00009	NEW	≤ 1 000 m	COM - CCH
						Spring	AFR00289	NEW	≤ 1 000 m	RES - AFR
2017	Summer	AFR00291	NEW	≤ 1 000 m	RES - AFR					
2018										
2019	Summer	AFR00296	NEW	≤ 1 000 m	RES - AFR	Autumn	AFR00297	NEW	≤ 1 000 m	RES - AFR
2020	Summer	AFR00300	NEW	≤ 1 000 m	RES - AFR					
2021						Autumn	AFR00303	NEW	≤ 500 m	RES - AFR
2022	Summer	CCH00011	NEW	≤ 1 000 m	COM - CCH					
2023	Summer	CCH00015	NEW	≤ 1 000 m	COM - CCH	Autumn	CCH00016	NEW	≤ 1 000 m	COM - CCH
2024	Summer	AFR00306	NEW	≤ 500 m	RES - AFR	Autumn	AFR00307	NEW	≤ 500 m	RES - AFR
2025										

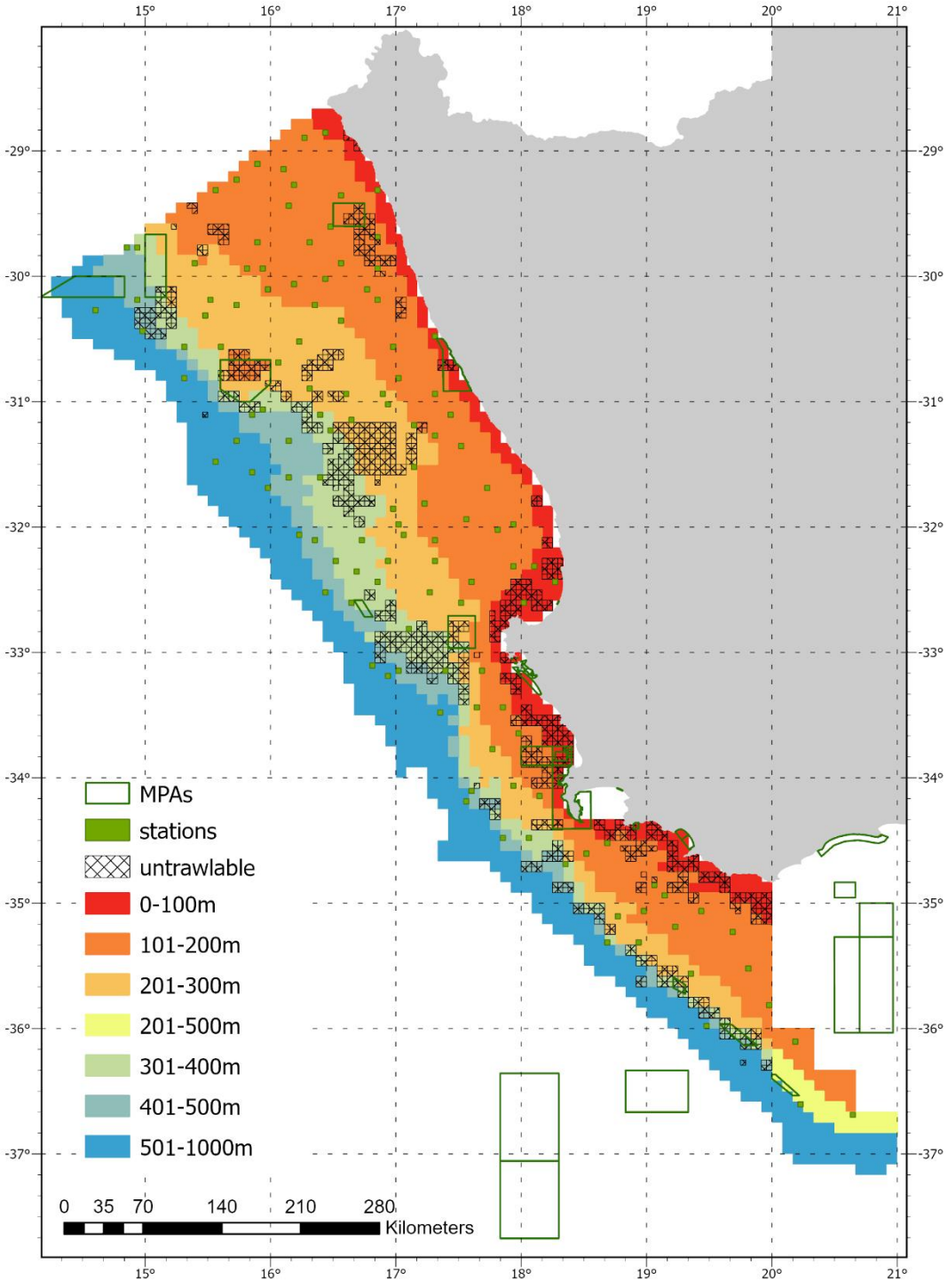

Figure 1: An example of a typical West Coast demersal survey design.

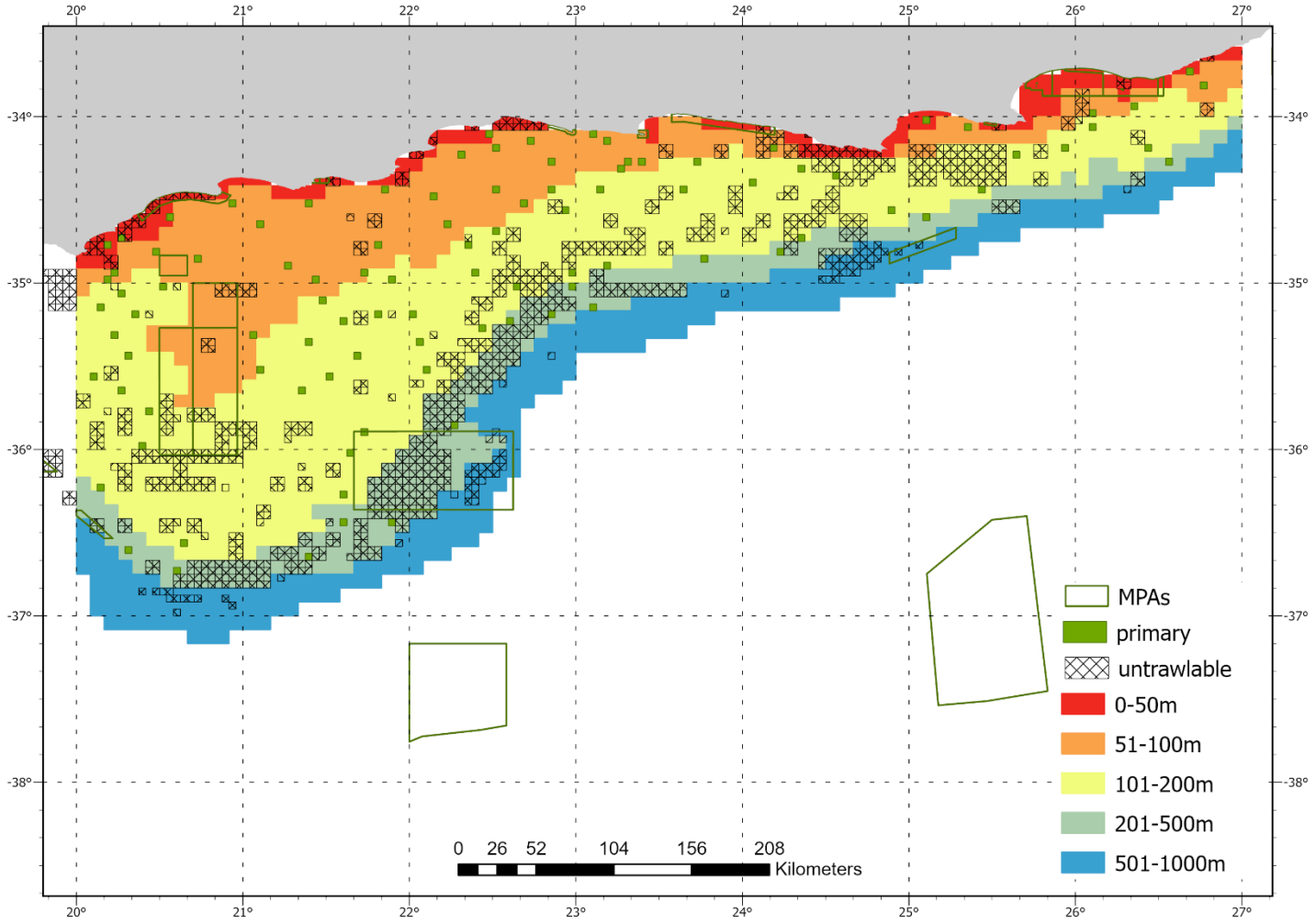

Figure 2: An example of a typical South Coast demersal survey design.

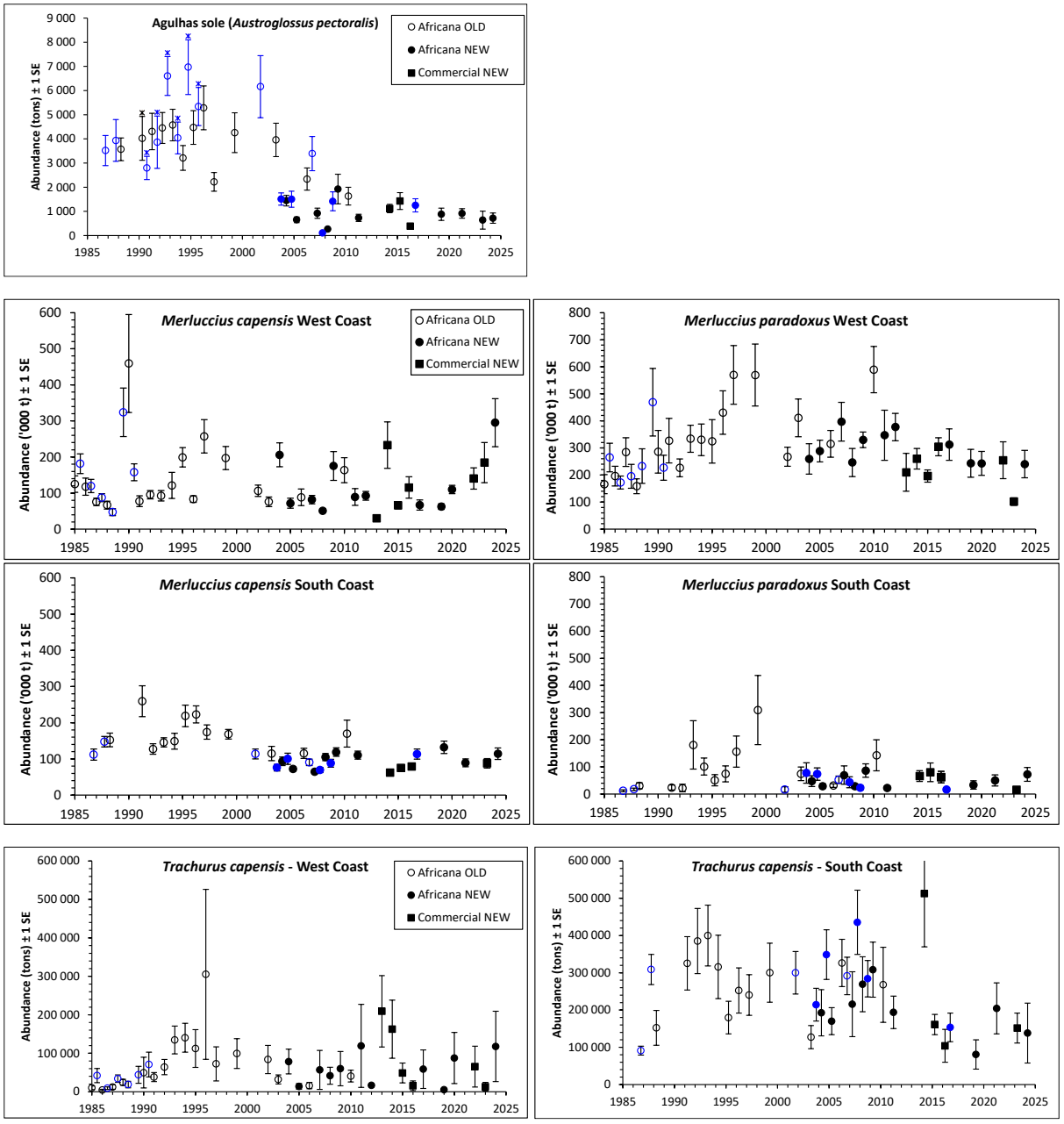

Figure 3: Swept area abundance indices for key demersal species derived from the DFFE demersal surveys. Abundance estimates are illustrated for the various vessel-gear combinations (*Africana* = circles/dots, commercial vessels = squares/blocks). Summer West Coast and autumn South Coast surveys are indicated with black symbols, while winter West Coast and spring South Coast surveys are indicated with blue symbols. Surveys that only extended to the 200 m isobath have been included in the Agulhas sole plot (indicated with an asterisk) given that this species is largely restricted to the South Coast at depths of less than 200 m.

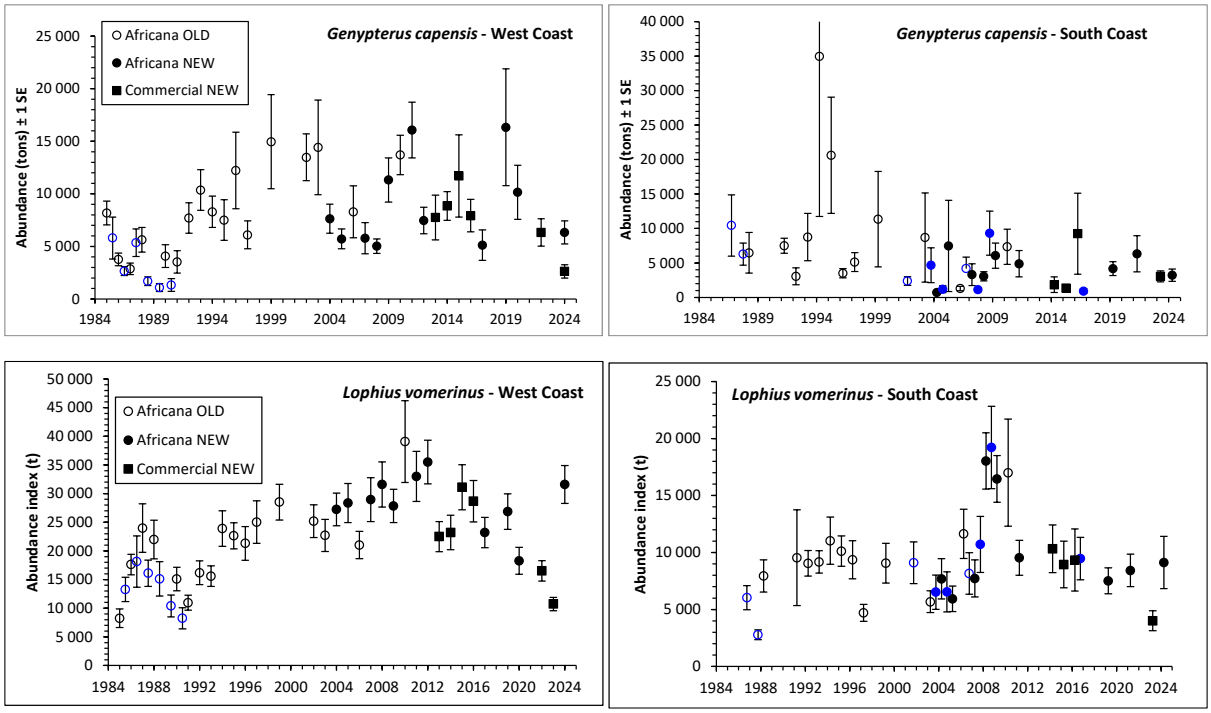

Figure 3 (contd.)