Spatial aspects of spawning of hakes (*Merluccius capensis and M. paradoxus*) in the BCLME – a review of available information

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1. **Kainge *et al* (2007):**
   - Analysis of gonads (histology coupled with a gonadosomatic index threshold) collected from demersal research surveys and commercial catches between September 1998 and June 2002.
   - Maturing and mature female *M. paradoxus* (GSI > threshold) were observed in the southern areas (Figure 1), but no spawning individuals (macroscopic maturity stage 4) were observed in any of the samples.
   - Maturing and mature female *M. capensis* (GSI > threshold) were observed mainly in the central areas (Figure 2), and several of the samples contained spawning (stage 4) individuals.
   - *M. paradoxus* do not spawn in Namibian waters, but *M. capensis* do.

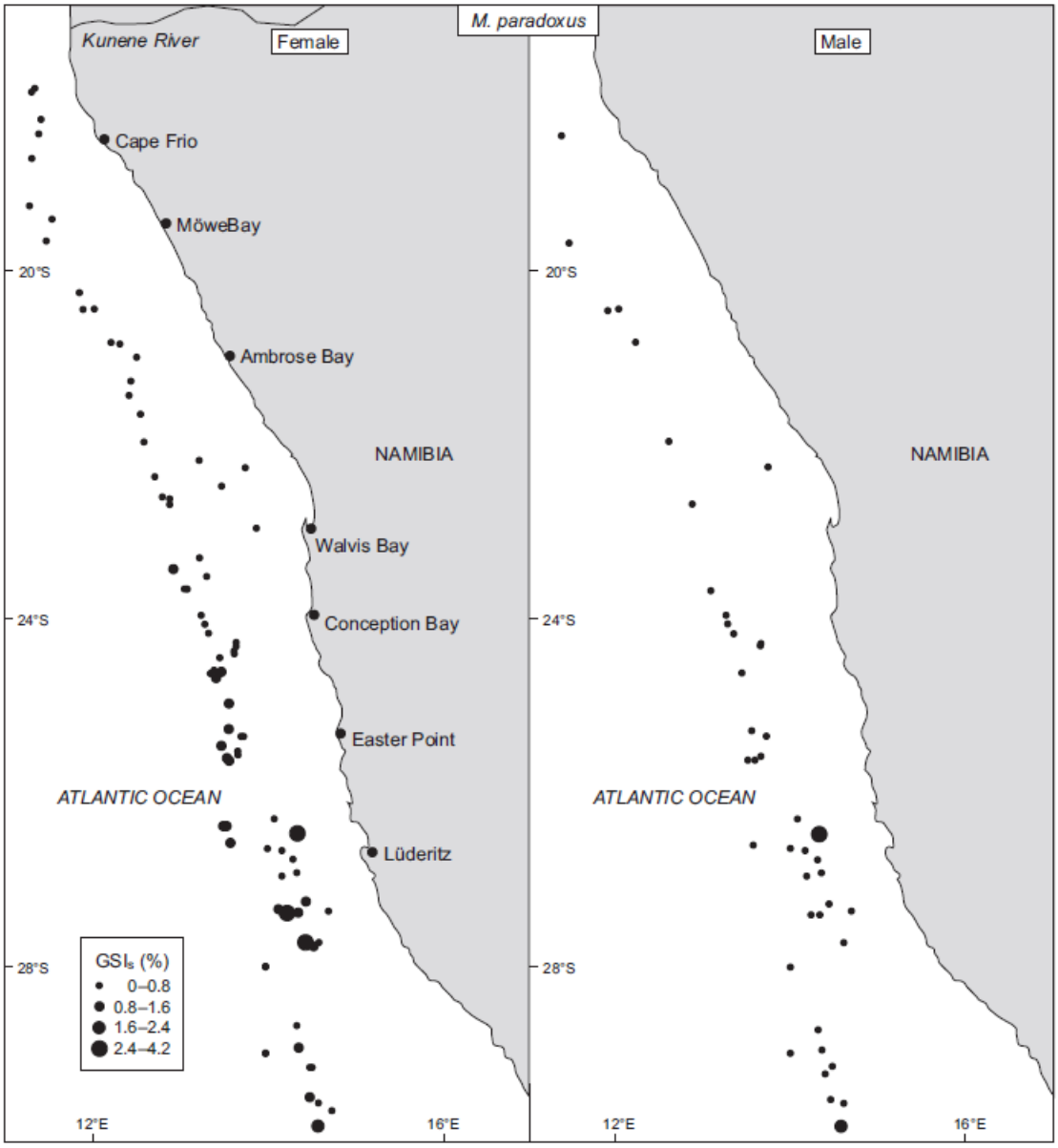

Figure 1: Distribution of GSI values per geographical position for *M. paradoxus* over the Namibian coastal shelf. Females with a GSI > 0.8 were considered to be maturing or mature. Taken from Kainge *et al* (2007).

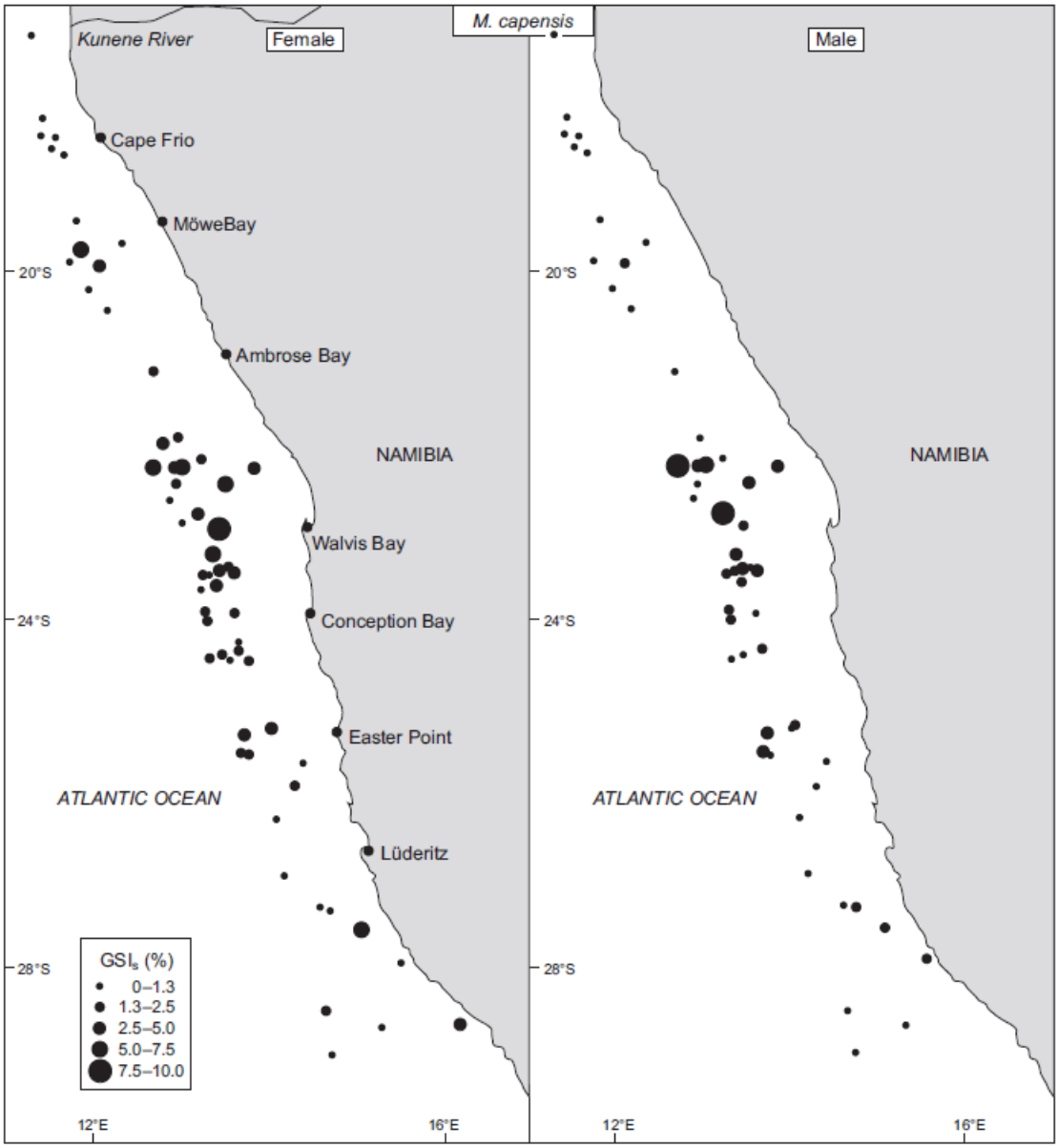

Figure 2: Distribution of GSI values per geographical position for *M. capensis* over the Namibian coastal shelf. Females with a GSI > 1.3 were considered to be maturing or mature. Taken from Kainge *et al* (2007).

2. Grote *et al* (2007):

- Analysis of ichthyoplankton (eggs and larvae) collected using mini bongo nets during bimonthly SARP cruises (sampling of stations along a transect extending south west from the Cape Peninsula) conducted from August 1995 to July 2003.
- Samples of hake ichthyoplankton could not be identified to the species level.
- *Merluccius spp*. eggs were most abundant in austral winter and early spring (June to October).
- Mean abundance of *Merluccius spp*. larvae was highest in August and October.
- The western Agulhas Bank appears to be an important spawning area for both hake species (inferred from back tracking the origin of the larvae using current vectors).

- *Merluccius spp.* larvae have two potential spawning grounds on the western Agulhas Bank. One is closer inshore in the vicinity of the Cape of Good Hope, at approximately 100–300m depth. The other spawning ground is farther offshore above a bottom depth of 400–1000 m.

3. Stenevik *et al* (2008):

- Analysis of ichthyoplankton (eggs and larvae) collected using Hydrobios multinet sampler during the September - October 2005 cruise of the *Dr. Fridtjof Nansen*.
- Sampling covered the shelf and slope between Cape Agulhas on the South African south coast and southern Namibia on the west coast.
- Sub-samples of hake ichthyoplankton were identified to the species level (genetics analyses).
- Main hake spawning grounds are south of 32° S (no eggs found north of that latitude – Figure 3).
- Clear differences in cross-shelf distribution of eggs and larvae between the two hake species (Figure 4). The average bottom depth over which *M. paradoxus* and *M. capensis* eggs were found was 855 m and 228 m respectively, whereas larvae were found over average bottom depths of 250 m (*M. paradoxus*) and 181 m (*M. capensis*).
- The differential cross-shelf distribution would most likely lead to species-specific drift routes (the coastal jet current splits into offshore and inshore branches north of Cape Columbine) which could explain why the two species seem to have different nursery areas.

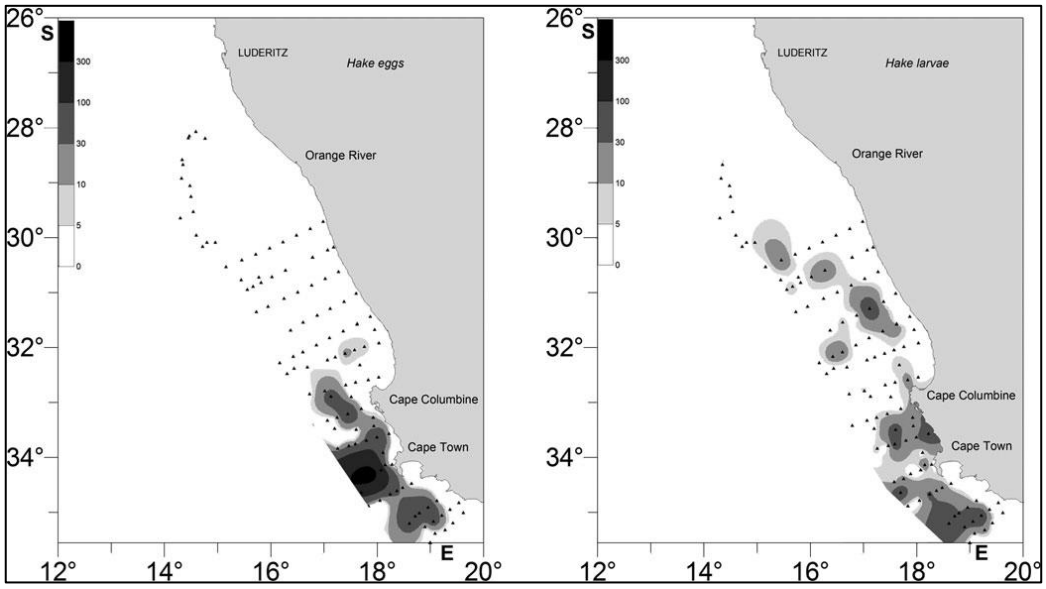

Figure 3: Station map showing the distribution of eggs (left) and larvae (right) of Cape hakes (both species combined). Numbers per 10 m^2. Taken from Stenevik *et al* (2008).

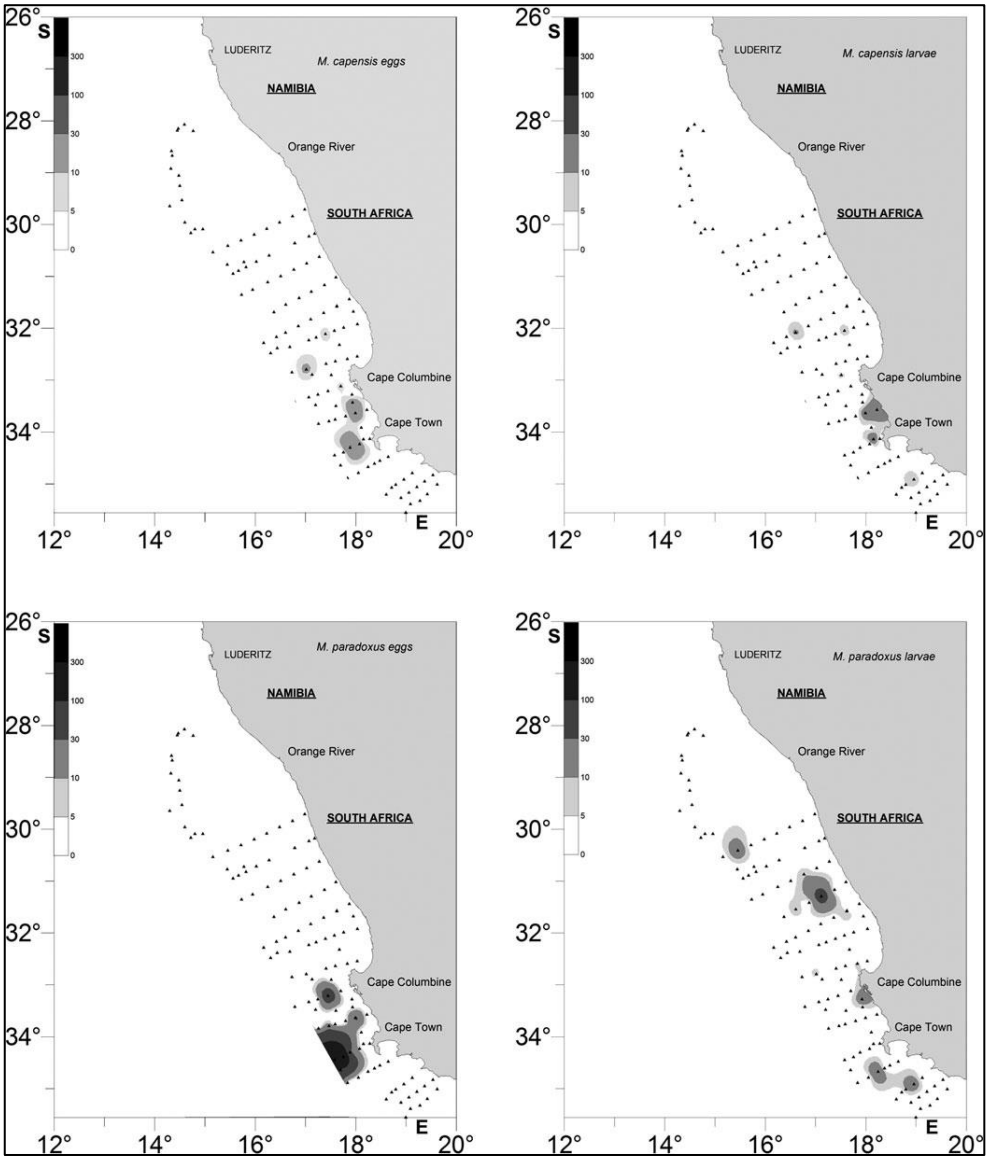

Figure 4: Distribution of eggs (left) and larvae (right) of *M. capensis* (upper) and *M. paradoxus* (lower). Numbers per 10 m^2. Taken from Stenevik *et al* (2008).

4. Strømme *et al* (2015):

- Evaluated the spatial distribution of different size classes of *M. paradoxus* observed during several research surveys by the *Dr Fridtjof Nansen* and other intercalibrated vessels over the period 2000 – 2012. With the exception of a survey in 2010 (which covered the area between the Kunene River and Port Alfred), the surveys encompassed the area between Cape Agulhas and the Kunene River.
- Juveniles (fish < 15 cm) restricted to the area between Cape Agulhas and the Orange River (Figure 5), none were observed in Namibian waters or on the South African South Coast between Cape Agulhas and Port Alfred.
- Large adults (fish > 60 cm) were observed mainly in the area between the Orange River and the southern parts of the Agulhas Bank, with some also observed in central Namibia and off Port Elizabeth (Figure 5).
- Concluded that *M. paradoxus* spawn largely between the Western Agulhas Bank and Elands Bay on the SA West Coast (with a smaller spawning ground off Port Elizabeth). Fish then migrate northwards into Namibia as they grow and then return to the main spawning grounds in SA to spawn.

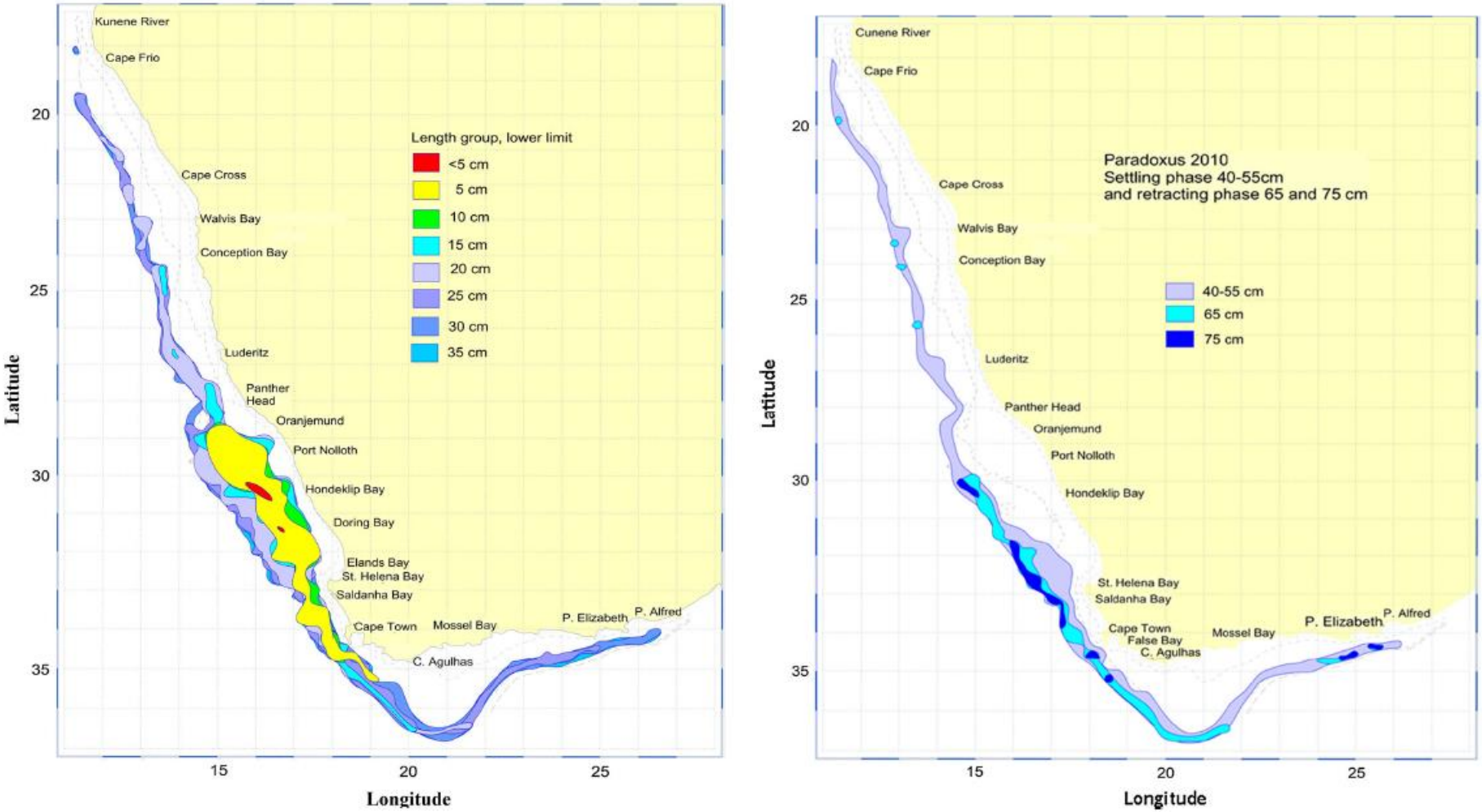

Figure 5: Transboundary distribution of *M. paradoxus* in January – February 2010. Left panel: small and medium size classes (smaller size classes are overlaid on the larger size classes). Right panel: large size classes (the larger size classes are overlaid on the smaller size classes). Taken from Strømme *et al* (2015).

5. Jansen *et al* (2015):

- Used gonadosomatic indices (with a threshold to identify spawning individuals) from samples collected during Namibian and SA national demersal surveys over the period 1991 – 2013.
- *M. capensis* spawning generally appears to occur in shallower water (about 100 m) than does *M. paradoxus* (250 – 650 m).
- Highest proportions of spawning female *M. capensis* were observed in central Namibia (24 - 26°S), two areas off the SA West Coast (31 – 32.5°S and 34.5 - 36°S) and relatively evenly distributed over the SA South Coast east of 20°E (Figure 6).
- *M. capensis* also appear to show seasonal differences in spawning activity, with peak spawning in Namibia being July – September, in summer (around January) on the SA South Coast, and both summer and winter spawning peaks on the SA West Coast.
- Spawning *M. paradoxus* females were observed in southern Namibia as far north as 25°S (in August), and in two areas in SA waters (34.5 – 36.5°S on the West Coast and 23 – 26.5°E on the South Coast).
- *M. paradoxus* spawning in SA appears to occur throughout the year, with increased intensity around March and August – October.
- Results suggest multiple stocks (reproductive units).

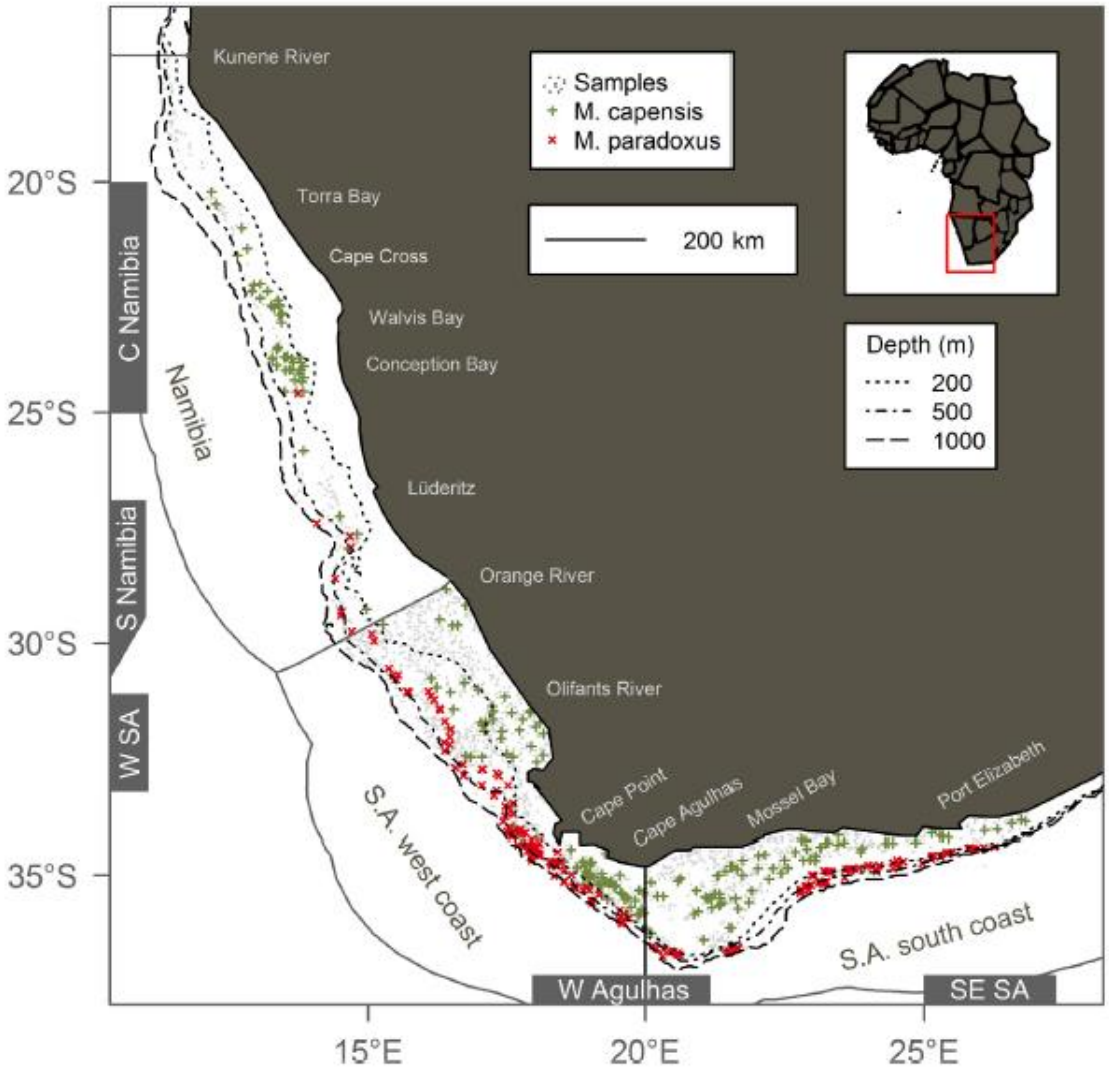

Figure 6: Sample locations and observations of spawning female *M. capensis* (GSI > 10%) and *M. paradoxus* (GSI > 9%). Taken from Jansen *et al* (2015).

6. SA demersal surveys (unpublished data):

- Spatial distribution of stage 4 ("ripe and running" – about to spawn) and stage 5 ("spent" – just spawned) female *Merluccius capensis* and *M. paradoxus* as determined from biological data collected from sub-samples of catches made during fishery-independent swept area surveys conducted in SA waters in summer (West Coast) and autumn (South Coast) over the period 1986 – 2019.
- Sub-sampling was directed at otolith collection for Age Length Key purposes, so the maturity stage data were not reflective of the entire catch, but rather a "presence-absence" per trawl.
- *Merluccius capensis* (Figure 7): Observed across the entire shelf in waters shallower than 400 m, with a tendency for stage 4 females to occur closer inshore than stage 5 females. Conforms to the general perception of an inshore movement of adult females to spawn.
- *Merluccius paradoxus* (Figure 8): Observed along the shelf edge around the entire coast in waters of about 400 m and deeper, but most commonly observed along the entire West Coast from the Namibian border to about 36°S and on the South Coast between Mossel Bay and Port Elizabeth. No clear spatial patterns in stage 4 versus stage 5 females are apparent.

7. Concluding comments:

- Early work on hake biology and population dynamics (1960s and 1970s) is compromised by the relatively late (1970s) recognition that hake in Southern Africa were in fact two species (disregarding a third species, *Merluccius polli*, which occurs largely in Angola and northwards).
- The results of these early studies (particularly with regard to whether or not spawning *M. paradoxus* occur in Namibia) should perhaps also be considered within the context of severely depleted hake resources (particularly in Namibia) following the over-exploitation during the 1960s and 1970s.
- More recent biological research is also subject to the "snapshot" approach implicit in the annual research surveys, and relatively few (and temporally fragmented) dedicated studies of spawning and early life history.

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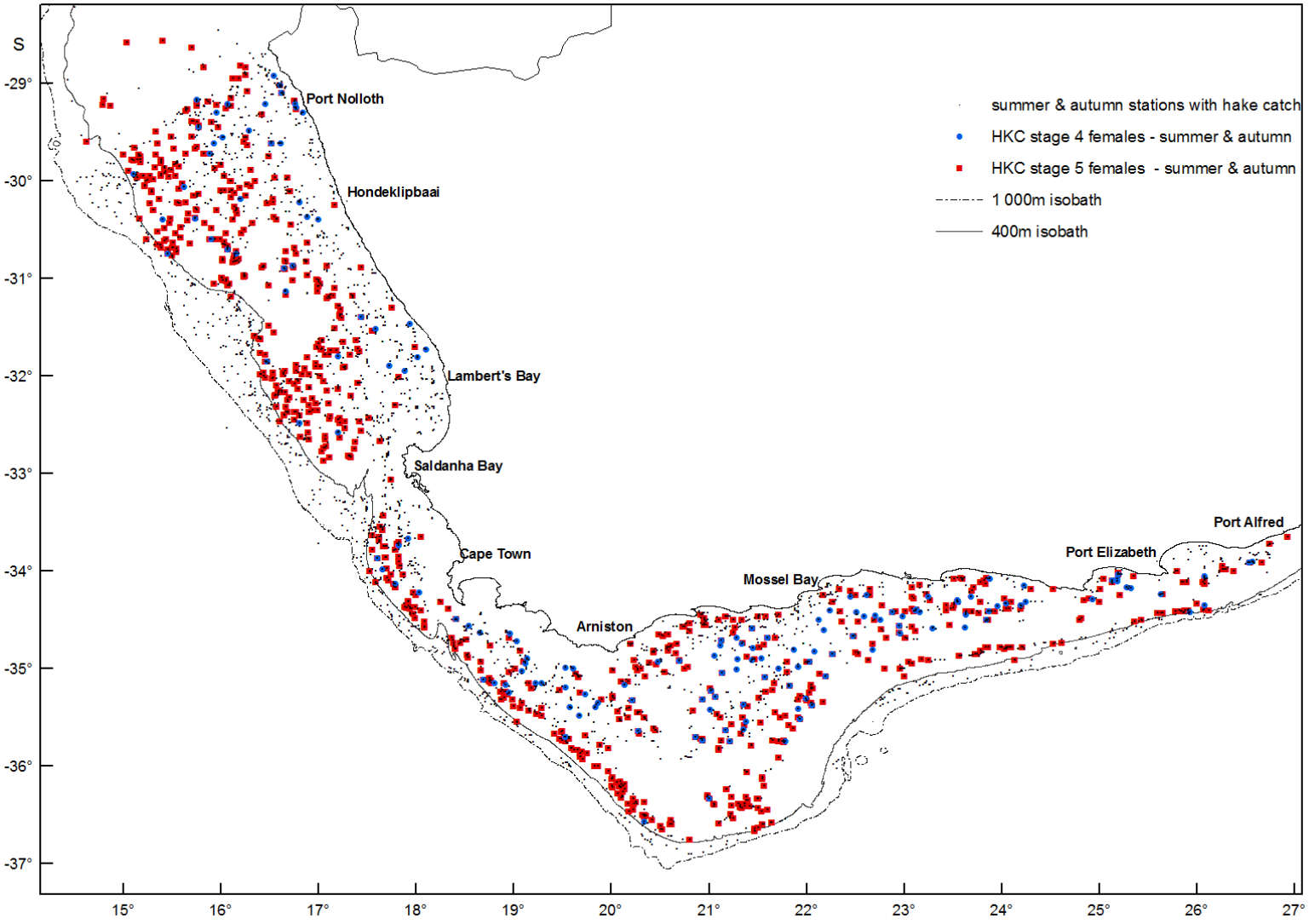

Figure 7: The locations of demersal trawls that contained stage 4 (blue dots) and 5 (red squares) female *Merluccius capensis*. The trawls (black dots) were conducted during routine annual fishery-independent demersal surveys conducted in summer (West Coast) and autumn (South Coast) from 1986 to 2019.

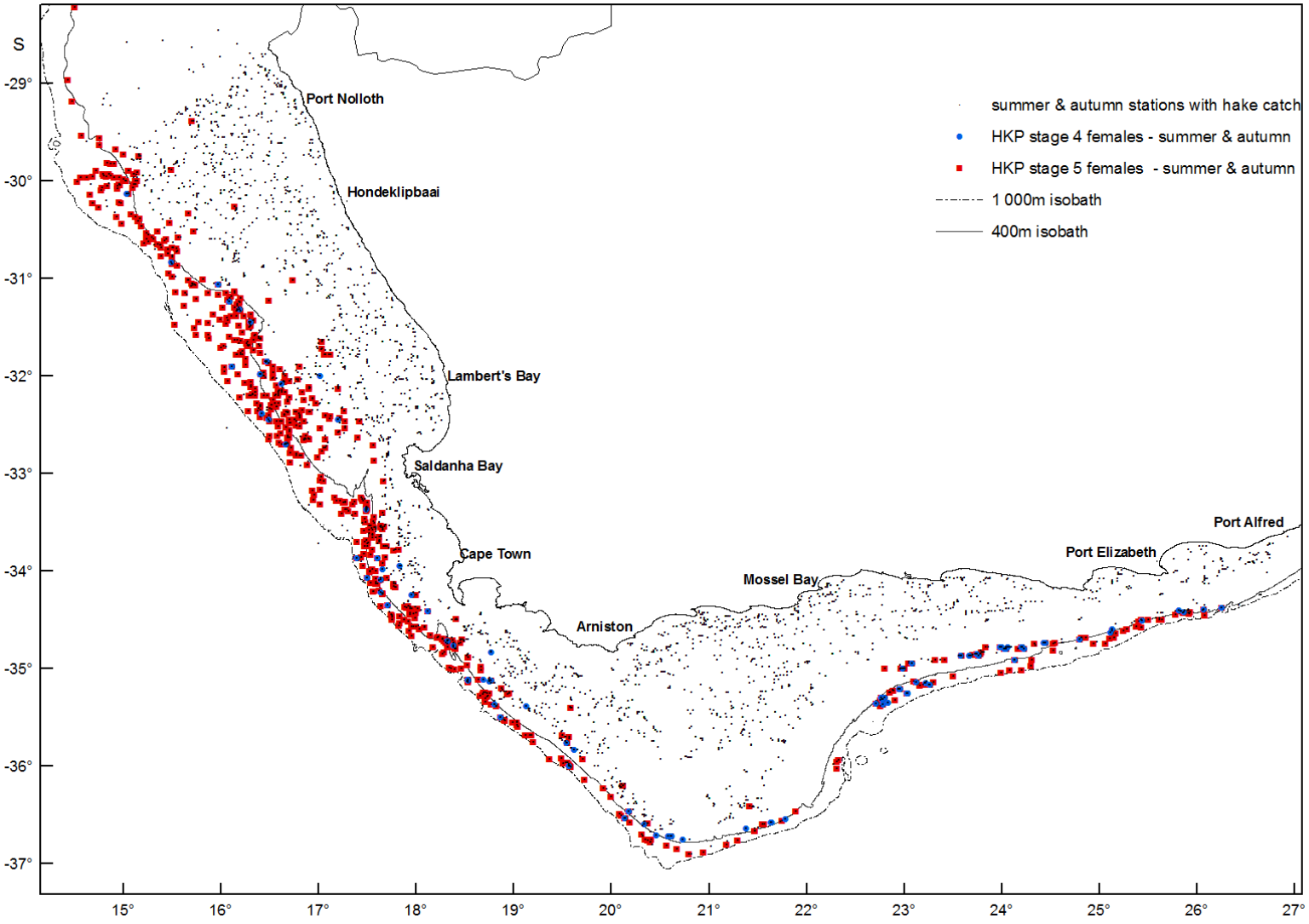

Figure 8: The locations of demersal trawls that contained stage 4 (blue dots) and 5 (red squares) female *Merluccius paradoxus*. The trawls (black dots) were conducted during routine annual fishery-independent demersal surveys conducted in summer (West Coast) and autumn (South Coast) from 1986 to 2019.