



## Report of the Benguela Current Commission – ECOFISH WP1-WP2 Hake Biology Workshop

DAFF Fisheries Research Seminar Room

12 – 13 November 2014

### EXECUTIVE SUMMARY

The ECOFISH project (a collaborative Benguela Current Commission – European Union project) aims to develop regional stock assessments of marine fish resources that may be shared between countries in the Benguela Region (i.e. are of a transboundary nature). The first of the resources being considered by ECOFISH is hake, specifically the two species that may be shared between Namibia and South Africa (shallow-water hake *Merluccius capensis* and deep-water hake *M. paradoxus*). There remains uncertainty concerning the stock structure of these two species. In the absence of definitive information concerning the possible transboundary distribution of stocks of these two species, a workshop was convened from 26 – 28 March 2014 by the Benguela Current Commission with the objective of initiating co-ordinated discussions towards developing hypotheses regarding the stock structure of these two species of hake. A number of plausible hypotheses concerning the stock structure of the two species were developed, but the workshop recommended that a follow-up workshop be convened later in 2014 to review additional genetics data that would then be available and then revise/refine the hypotheses. The follow-up workshop was convened from 12 – 13 November 2014. Additional genetics data arising from updated analyses of microsatellite markers, as well as some hake parasite information were considered during the workshop. Three stock structure hypotheses for *M. paradoxus* resulted, comprised two 2-stock hypotheses (differing in the area of overlap of the two stocks) and a single stock hypothesis. In the case of *M. capensis*, the workshop discarded an initial single stock hypothesis, and proposed four 2-stock hypotheses (again differing in terms of the areas of overlap between the two stocks) and retained the initial 3-stock hypothesis. The workshop also considered the links to the pending December 2014 DAFF/NRF International Stock Assessment Review Workshop, during which a number of dedicated ECOFISH sessions will address the development of transboundary hake stock assessments.

**Rationale:**

Progress on the ECOFISH project, and specifically on Work Package 1 (stock assessment) and Work Package 2 (input to stock assessment models) was reviewed during the annual DAFF/NRF International Stock Assessment Review Workshop convened at the University of Cape Town in December 2013. The International Panel, having reviewed available documentation and information made the following general recommendation:

*“The Panel recommends that the biologists and modellers (South African, Namibian and Danish) collaborate to: (a) identify alternative hypotheses regarding stock structure, (b) test those hypotheses using existing data (i.e. the tests to be undertaken as part of the genetics study should be based on the identified hypotheses to the extent possible), and (c) population models should be implemented for the hypotheses that cannot be rejected given the tests conducted, to ensure that the models used for management reflect the range of plausible stock structure hypotheses.”*

In line with this recommendation, the Benguela Current Commission (BCC) convened a workshop in March 2014 during which key ECOFISH participants met to develop these topics. The available information that was reviewed during the course of the workshop included some results of genetics analyses, data collected during research surveys (primarily spatial patterns in abundance and size structure) that had been analysed using GeoPop techniques, and spatial patterns in spawning, age and growth. Based on these data, a number of alternative hypotheses concerning the stock structure of the two species were developed. In terms of *M. capensis*, three alternative hypotheses were put forward, while two hypotheses of *M. paradoxus* stock structure were proposed. The workshop also recommended several fields of future/continued research on this topic, providing a basis for a second phase of the ECOFISH programme.

It was recognised by that workshop that the hypotheses of hake stock structure developed could only be considered to be preliminary, and would need to be revisited and perhaps revised once further information concerning genetics became available. Scientists conducting the genetics research indicated that further information would be available in November 2014. The BCC consequently convened a second ECOFISH workshop to refine (where possible) the hake stock structure hypotheses in the light of the additional genetics and other data and analyses. This workshop was held at the Fisheries Branch of the Department of Agriculture, Forestry and Fisheries (DAFF) in Cape Town, South Africa, from 12 to 13 November 2014.

**Objectives:**

- Finalise alternative hake stock structure hypotheses (i.e. number of stocks, possible overlap and movements during the year) for both *M. capensis* and *M. paradoxus* off Namibia and South Africa in the light of further results of hake genetics research to be reviewed by the December Workshop.
- Consider recommendations arising from the May 2014 modelling workshop held at DTU.
- Address an information request from Robin Waples (panellist for the December 2014 International Stock Assessment Review workshop) regarding hake biology.
- Decide on research priorities for further funding of regional stock assessment related research for the period 2015 – 2019 (to be incorporated into the BCC application for a grant from the Norwegian Ministry of Foreign Affairs).

**Participation:**

Hashali Hamukuaya (BCC)	Deon Durholtz (DAFF) – Chair
Monica Thomas (BCC)	Rob Leslie (DAFF)
Sylvi Nsiangango (INIP)	Jean Glazer (DAFF)
Paulus Kainge (MFMR)	Tracey Fairweather (DAFF)
Sarah Paulus (MFMR)	Larvika Singh (DAFF)
Jan Beyer (DTU)	Rob Cooper (DAFF)
Neils G. Andersen (DTU)	Johann Augustyn (SADSTIA)
Doug Butterworth (MARAM/UCT)	Mike Bergh (OLRAC)
Conrad Matthee (US)	Robert Landman (I&J)
Romina Henriques (US)	Larry Hutchings (UCT)

Appendix 1 describes the workshop programme and lists the presentations and documents.

## WORKSHOP OUTCOMES

### Updated results of genetics research:

Results from analyses of microsatellite markers suggest:

- *M. paradoxus* is a single genetic stock shared between Namibia and South Africa.
- *M. capensis* comprises multiple stocks in Southern Africa, with one stock in Namibia and at least one stock in South Africa. Extensive migration appears to occur both within and between stocks. The Orange River may reflect a biogeographical break between the Namibian and South African populations. The area of overlap between the Namibian and SA populations is currently estimated to be in the region of 28 and 32° S. The uncertainty in this range is a reflection of sampling limitations rather than uncertainty relating to inter-annual changes in the position of the boundary.
- Hybridization is not a sufficiently large issue that it requires further consideration in terms of developing regional hake assessment models.

Further points arising from discussion of this topic:

- Future sampling efforts to address the range of overlap of *M. capensis* stocks should be conducted quarterly (4 times per annum) over at least a 2-year period, incorporate all size groups (not just fish > 40 cm) and be conducted at a finer spatial resolution in the region between Cape Town and Walvis Bay. Observations of eye colour should be recorded (a possible species identification characteristic).
- For December IWS: It would be useful to have as much information as possible to clarify/resolve the discrepancy between the 2005/06 mitochondrial DNA *M. paradoxus* structure indication and current microsatellite “no structure” result.
- For December IWS: “Geographical structure” plots at the proper spatial level (alongshore) would be useful to clarify/illustrate boundaries and overlap.

### Parasites as biotags:

The full Reimer (1993) paper had been obtained and was tabled. The evidence for separate stocks of both hake species in Namibia was considered to be reliable by Dr. Ken MacKenzie (an independent fisheries parasitologist), and the workshop agreed that the information should be included in the reconsideration of the hake stock structure hypotheses. The paper indicates a boundary at about 25.5°S (i.e. just north of Luderitz). Unfortunately, sampling limitations precluded any conclusions regarding possible overlap of the proposed stocks.

### Spawning patterns:

A key point of evidence for the *M. paradoxus* single stock hypothesis has been the indication that this species does not appear to spawn in Namibian waters. The paper by Sundby *et al.*

(2001) is frequently used to support the observation that *M. paradoxus* does not spawn in Namibia. The assumption of Sundby *et al* that no *M. paradoxus* eggs and larvae were present during three cruises by the *Dr. Fridtjof Nansen* (1995, 1997 and 1998) was based on the absence of mature *M. paradoxus* in trawl catches made near where newly spawned hake eggs were found. The presence of mature *M. capensis* in the same trawl catches was therefore the basis for the assumption that all hake eggs found in these studies originated from *M. capensis*. More recently, Kainge *et al* 2007 document no indication of spawning activity by *M. paradoxus* in Namibian waters during a study covering the period 1998 - 2001, with only small numbers of maturing fish being observed in the southern areas between Luderitz and the Orange River mouth.

### Revised/refined hake stock structure hypotheses:

The discussions of hake stock structure conducted during the March 2014 ECOFISH Hake biology workshop yielded four hypotheses for *Merluccius capensis*, and two for *M. paradoxus* (illustrated in Figure 1 and summarised below for reference purposes).

#### *M. capensis*

- 1A One stock:** Distributed through the entire Benguela-Agulhas region.
- 1B Two stocks:** Winter spawners in the Northern Benguela extending southwards to 27°S, and summer spawners in the southern Benguela and Agulhas distributed southwards and eastwards from 25°S. The stocks consequently overlap in the area 25–27°S.
- 1C Two stocks:** Winter spawners in the Northern Benguela extending southwards to 33°S, and summer spawners in the southern Benguela and Agulhas extending from 31°S southwards and eastwards. The stocks overlap in the area 31–33°S.
- 1D Three stocks:** A northern Benguela stock extending southwards to 27°S; a central (SA-Namibian) stock distributed between 25°S and 33°S, and a southern stock extending southwards and eastwards from 31°S. The northern and central stocks overlap in the area 25-27°S, while the central and southern stocks overlap in the area 31-33°S.

#### *M. paradoxus*

- 2A One stock:** Distributed through the entire Benguela-Agulhas region.
- 2B Two stocks:** A northern stock extending southwards to 33°S and a southern stock extending southwards and eastwards from 31°S. The two stocks overlap in the area 31-33°S.

These hypotheses were reconsidered in the light of the updated genetics results described above (as well as information tabled previously), and the workshop agreed on a number of revisions to the suite of hypotheses.

1. *M. capensis* single stock hypothesis (1A): This hypothesis should be discarded. All available evidence indicates multiple stocks of *M. capensis* in the Benguela-Agulhas system.
2. On the basis of the updated genetics analyses and the information contained in the hake parasites paper (Reimer 1993), two additional *M. capensis* two-stock hypotheses should be added, differing from initial hypotheses 1B and 1C in regard to the areas of overlap of the two stocks.
3. The remaining *M. capensis* stock hypotheses (1B, 1C and 1D) should be retained pending the availability of data to enable further refinements/exclusions.
4. On the basis of the hake parasites paper (Reimer 1993); an additional *M. paradoxus* two-stock hypothesis should be added, differing from hypothesis 2B (which should be retained) in regard to the boundary area between the two stocks.

The revised hypotheses are summarised below and illustrated in Figures 2 and 3 (with links to the supporting evidence illustrated in Figures 4 -11).

***Merluccius paradoxus:***

- P1: 1 stock distributed throughout the Benguela-Agulhas region (corresponds to initial hypothesis 2A). Evidence: Microsatellites (see Figure 4) and data from the *Nansen – Blue Seas* surveys
- P2a: 2 stocks – a northern stock extending southwards to 33°S and a southern stock extending southwards and eastwards from 31°S. The two stocks overlap in the area 31-33°S (corresponds to initial hypothesis 2B). Evidence: GeoPOP (see Figure 5)
- P2b: 2 stocks separated at 25.5°S, i.e. just north of Luderitz (new hypothesis based on parasite information). Evidence: Parasites (see Figure 6)

***Merluccius capensis:***

- C2a: 2 stocks – a northern stock in Namibian waters extending southwards to 27°S, and a southern stock in the southern Benguela and Agulhas distributed southwards and eastwards from 25°S. The stocks consequently overlap in the area 25–27°S (corresponds to initial hypothesis 1B). Evidence: GeoPOP (see Figure 7)
- C2b: 2 stocks – a northern stock in Namibian waters extending southwards to 33°S, and a southern stock in the southern Benguela and Agulhas distributed southwards and eastwards from 31°S. The stocks overlap in the area 31–33°S (corresponds to initial hypothesis 1C). Evidence: GeoPOP (see Figure 8)
- C2c: 2 stocks - a northern stock in Namibian waters extending southwards to 32°S, and a southern stock in the southern Benguela and Agulhas distributed southwards and eastwards from 28°S. The stocks overlap in the area 28–32°S (new hypothesis based on microsatellite analyses). Evidence: Microsatellites (see Figure 9)
- C2d: 2 stocks separated at 25.5°S, i.e. just north of Luderitz (new hypothesis based on parasite information). Evidence: Parasites (see Figure 10)
- C3: 3 stocks - a northern (Namibian) stock extending southwards to 27°S; a central (SA-Namibian) stock distributed between 25°S and 33°S, and a southern stock

extending southwards and eastwards from 31°S. The northern and central stocks overlap in the area 25-27°S, while the central and southern stocks overlap in the area 31-33°S (corresponds to initial hypothesis 1D). Evidence: GeoPOP as well as the Wilhelm conceptual model arising from evaluation of spatial patterns in Namibian survey data (see Figure 11)

### **December 2014 International Stock Assessment Review Workshop:**

Links between this ECOFISH workshop and the dedicated joint assessment session planned for the December 2014 DAFF/NRF International Stock Assessment Review Workshop were described by Doug Butterworth (see supporting document MARAM/IWS/DEC14/Hake/P1). It was agreed by the workshop that the international panel should be approached for guidance to facilitate prioritisation of further research (in terms of order of attention) of:

- Approaches to modelling movement
- Approaches to modelling selectivity
- Incorporation of cannibalism and interspecific predation

Data/documentation required for that workshop (to be submitted to Doug Butterworth for circulation by Wednesday 26 November 2014):

- Hake catch and abundance estimates from SA and Namibia
- Report from November 2014 ECOFISH workshop (this report)
- Genetics results (Matthee and Henriques)
- Revised hake stock structure hypotheses (Figure 2 of this report)
- Waples' information doc (Appendix 2 of this report)
- SAM SCAA comparison document (Kathena *et al.*, in prep)
- Available data from Namibia and the most recent assessment (Kirchner *et al.*, 2012)
- Possible movement models (Rebecca Rademeyer)
- Hake cannibalism document (Andrea Ross-Gillespie)
- Background document on survey/vessel intercalibration using GeoPOP (Thygesen *et al.*, in prep)

Preliminary IWS schedule of ECOFISH sessions:

- The workshop dates are set for 1 – 5 December 2014 (09h00 – 17h30)
- Preliminarily 8 sessions are planned for ECOFISH (hake), 4 sessions for sardines and 4 sessions for penguins
- Introductory material on hake will be presented for initial discussion during the first 2 sessions on day 1 (1 December). This would include the updated genetics results, the hypotheses developed during this workshop and the information requested by Robin Waples.

- Discussions of this material will continue on day 2 with a view towards finalising the details of the various stock structure hypotheses. The subsequent schedule will be planned during these discussions, and will primarily involve developing the detailed specifications for assessments corresponding to the different stock structure hypotheses.

**ECOFISH-related meetings required in 2015:**

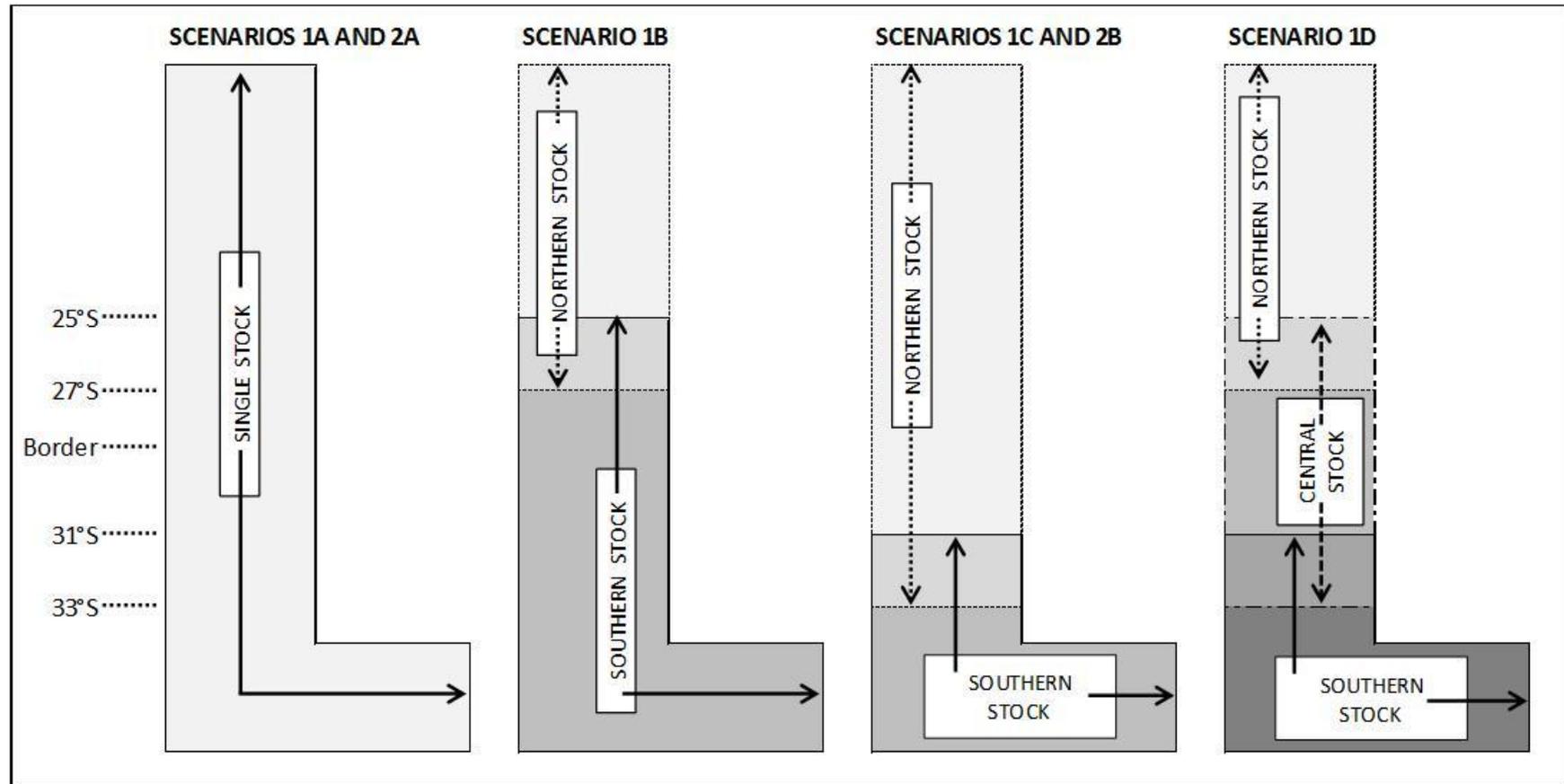
- BCC DWG meeting (June/July 2015)
- Ageing Workshop (March 2015- Namibia (hake), April 2015- Angola (Sardinella and Horse mackerel)
- BCC ASF 2015 - Deon Durholtz will initiate a schedule via email to facilitate setting the date
- SAM/ R training workshop (finalise details in December 2014)

**Information for Robin Waples**

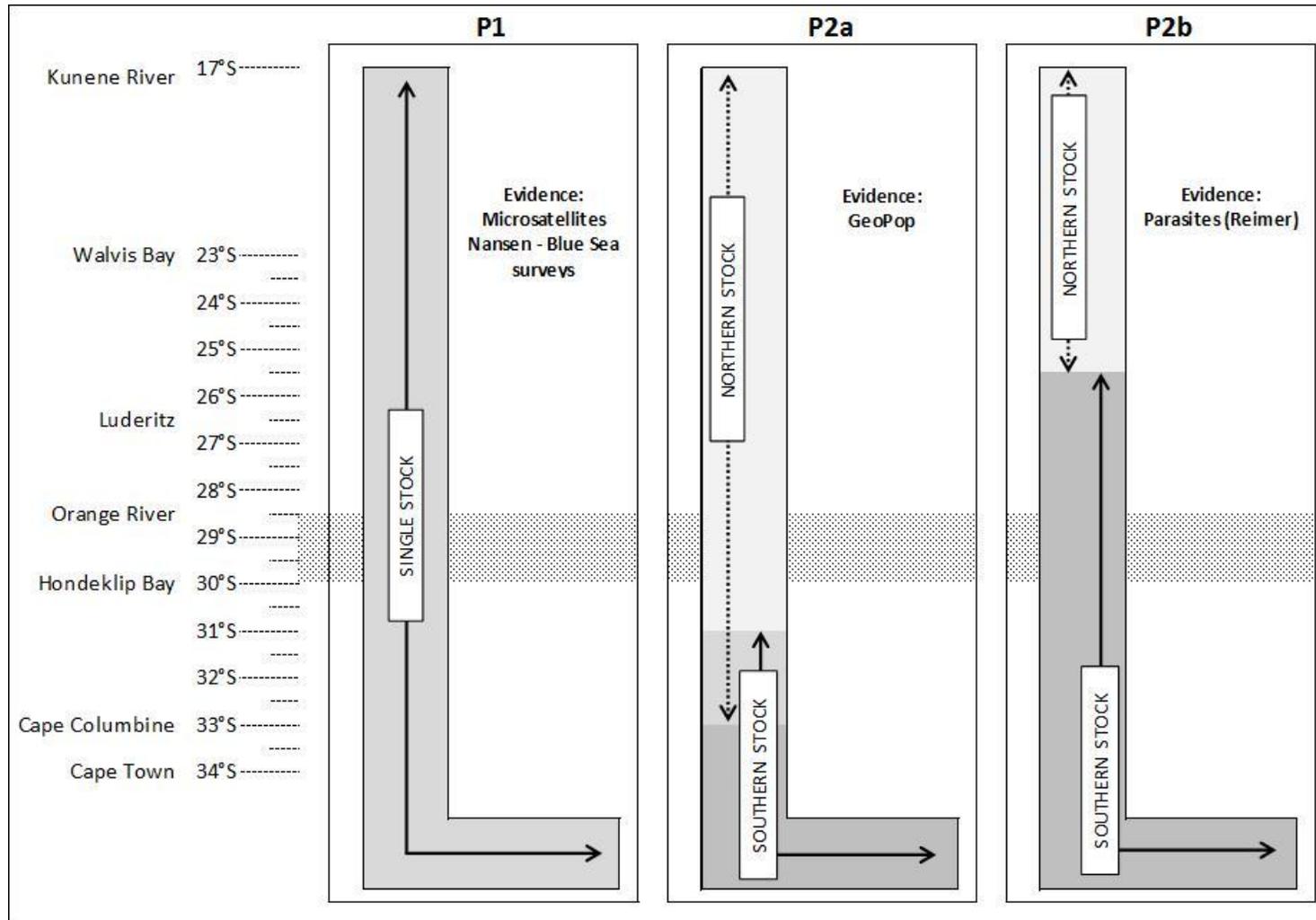
Robin Waples, an international expert on fisheries genetics and an invited panellist at the December IWS workshop, requested a brief summary of available information on hake biology:

- age structure
- age at maturity
- age specific survival and fecundity
- generation length
- time and location of spawning
- larval biology and length of larval life
- what is known about dispersal, and whether it is a function of age or sex
- recruitment variability in space and time

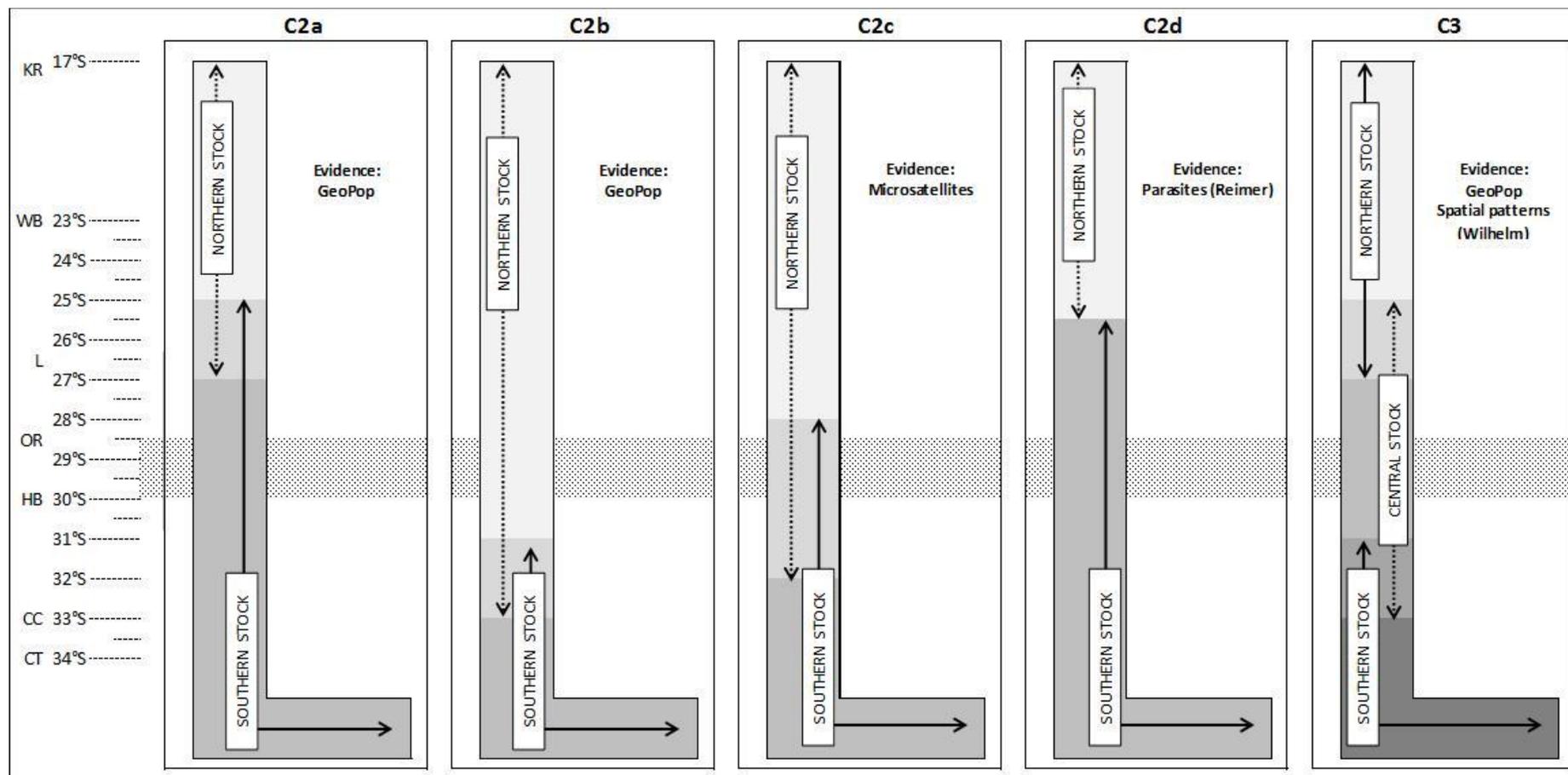
It was agreed that Doug Butterworth, Rebecca Rademeyer, Larvika Singh and Deon Durholtz would collate the available information into an IWS document.



**Figure 1:** Schematic illustration of the preliminary hake stock structure hypotheses developed during the March 2014 ECOFISH hake biology workshop. *Merluccius capensis*: 1A – 1D. *M. paradoxus*: 2A and 2B.



**Figure 2:** Schematic illustration of the revised *M. paradoxus* stock structure hypotheses arising from the November 2014 ECOFISH workshop. The border between Namibia and South Africa is indicated with the horizontal shaded area (note that the border extends south-west from the coast at the Orange River mouth).



**Figure 3:** Schematic illustration of the revised *M. capensis* stock structure hypotheses arising from the November 2014 ECOFISH workshop. The border between Namibia and South Africa is indicated with the horizontal shaded area (note that the border extends south-west from the coast at the Orange River mouth).

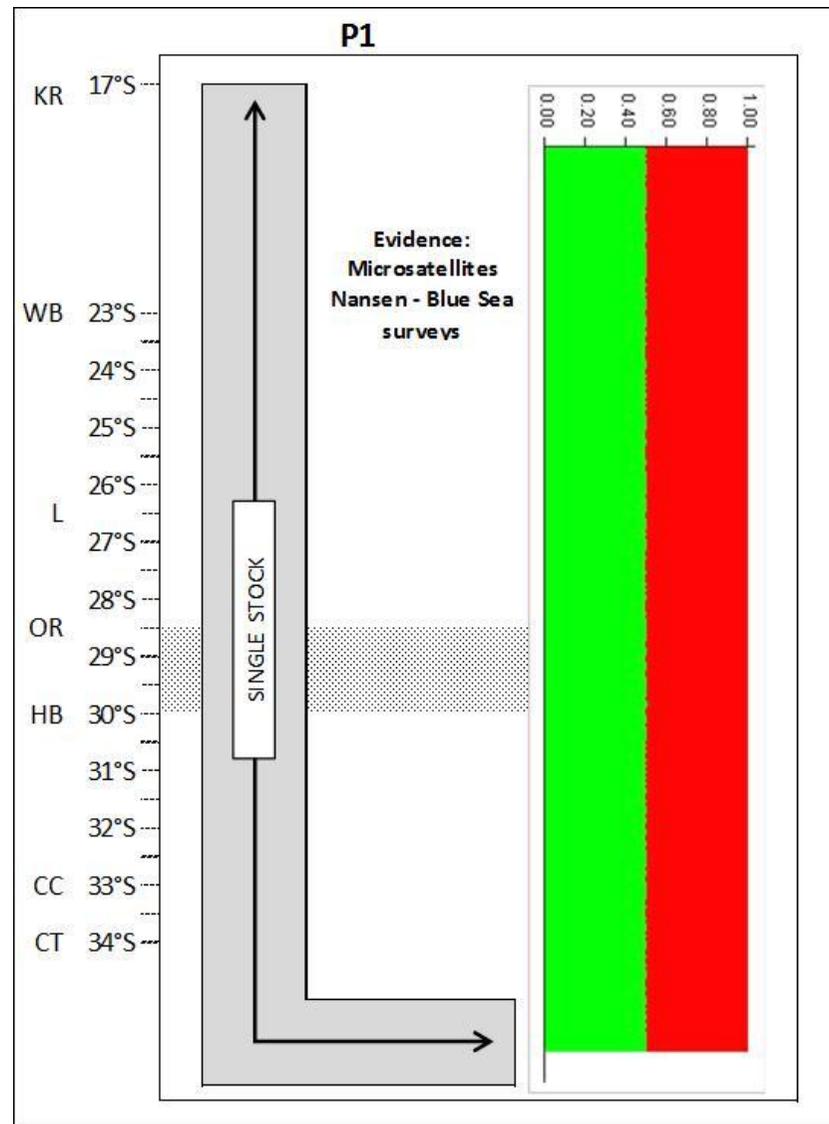


Figure 4: Hypothesis P1 – *M. paradoxus* 1 stock.

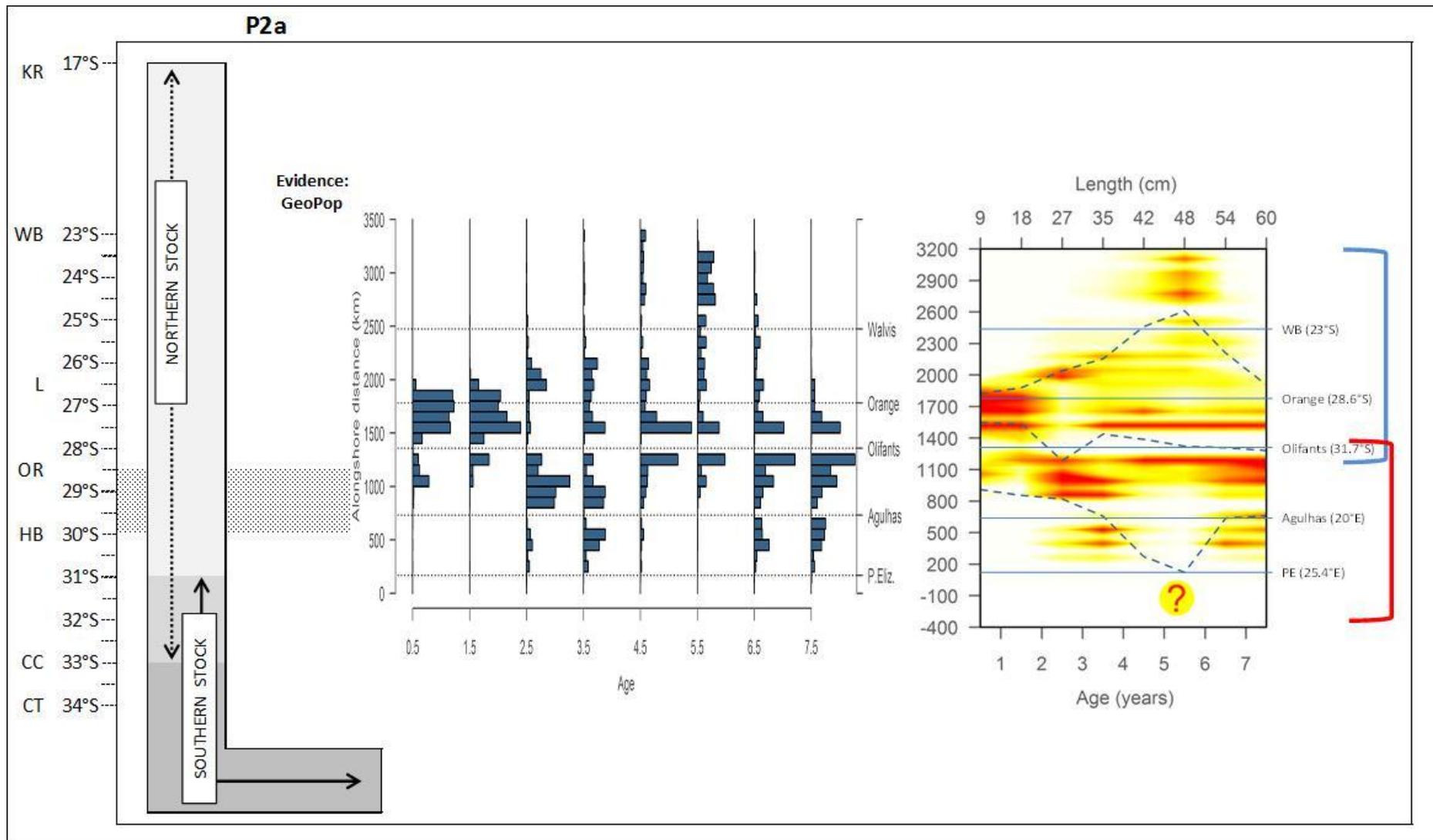


Figure 5: Hypothesis P2a – *M. paradoxus* 2 stocks.

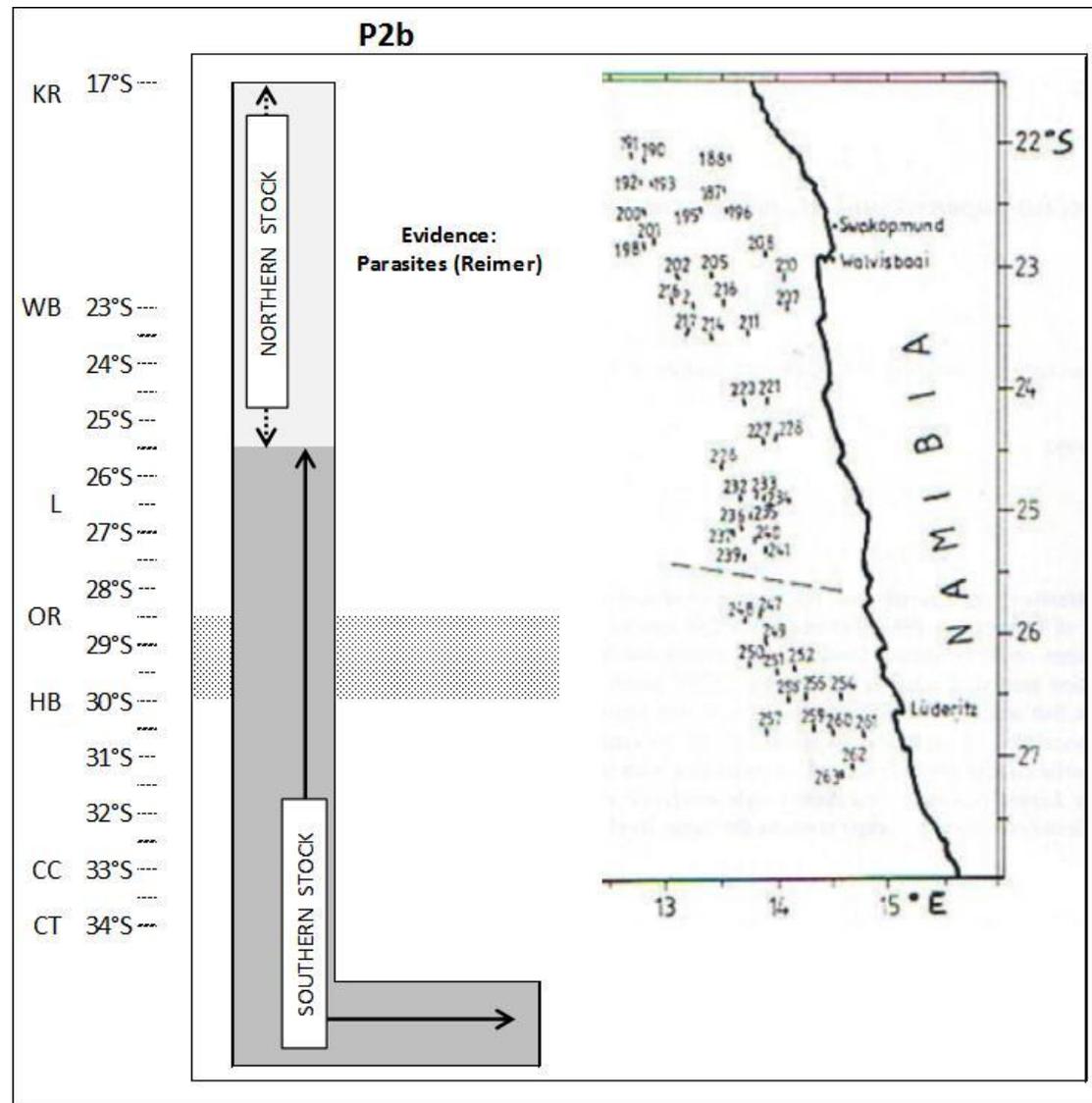


Figure 6: Hypothesis P2b – *M. paradoxus* 2 stocks.

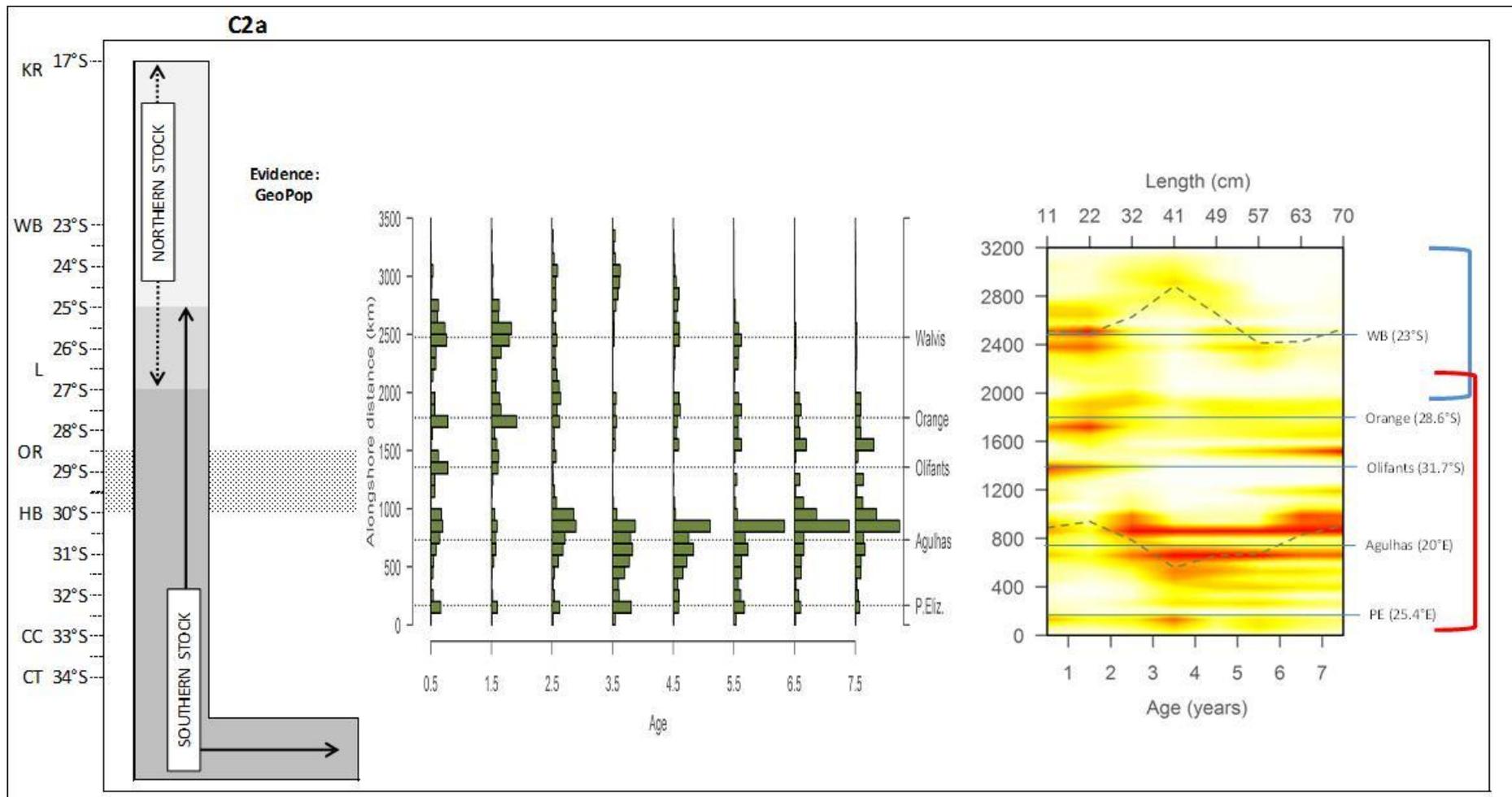


Figure 7: Hypothesis C2a – *M. capensis* 2 stocks

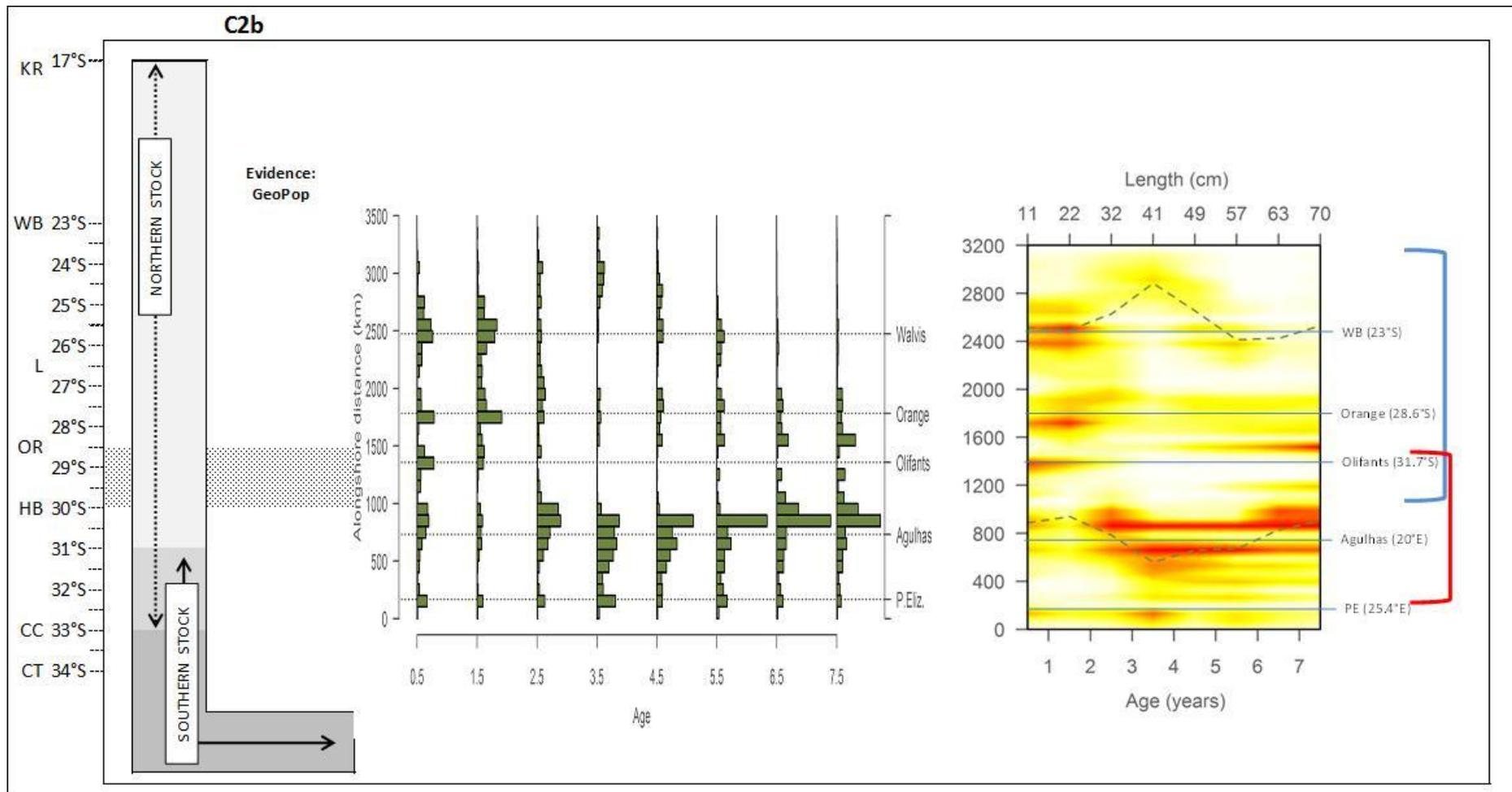


Figure 8: Hypothesis C2b – *M. capensis* 2 stocks

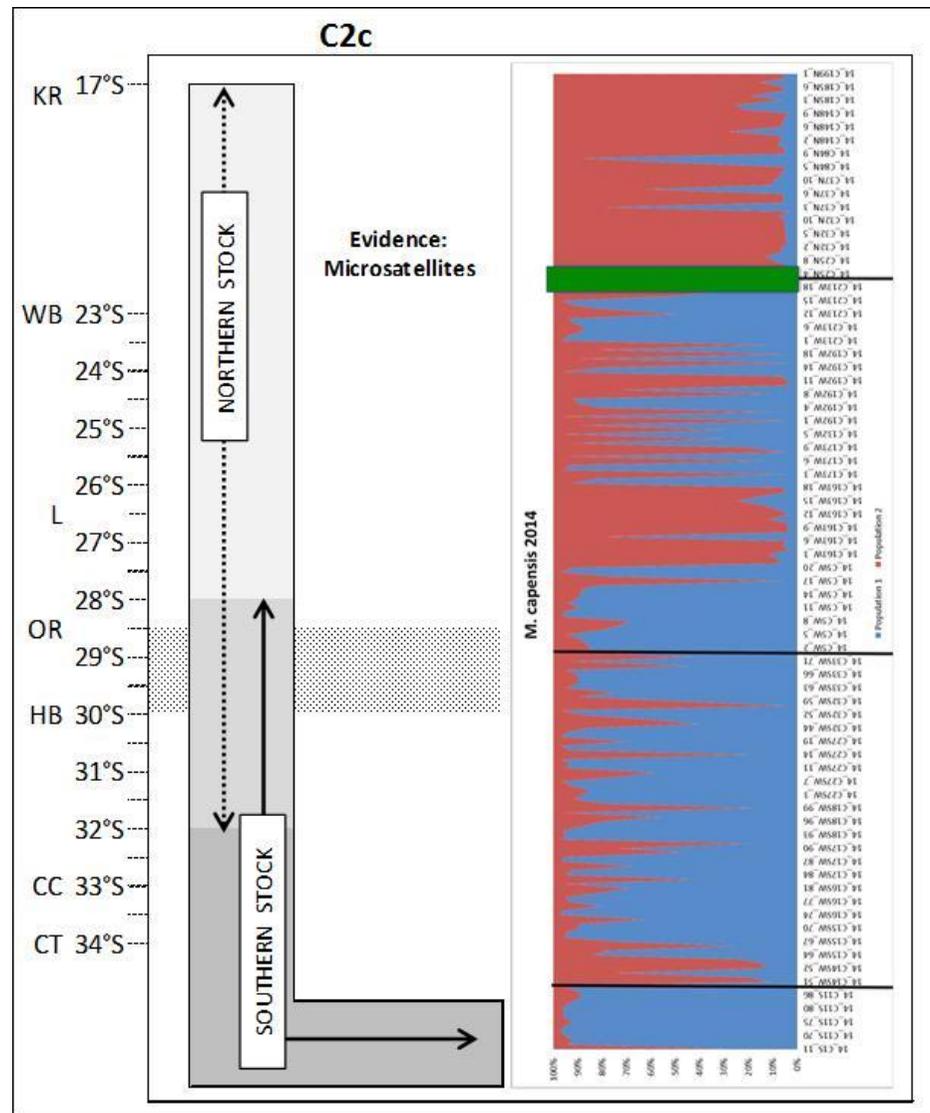


Figure 9: Hypothesis C2c – *M. capensis* 2 stocks

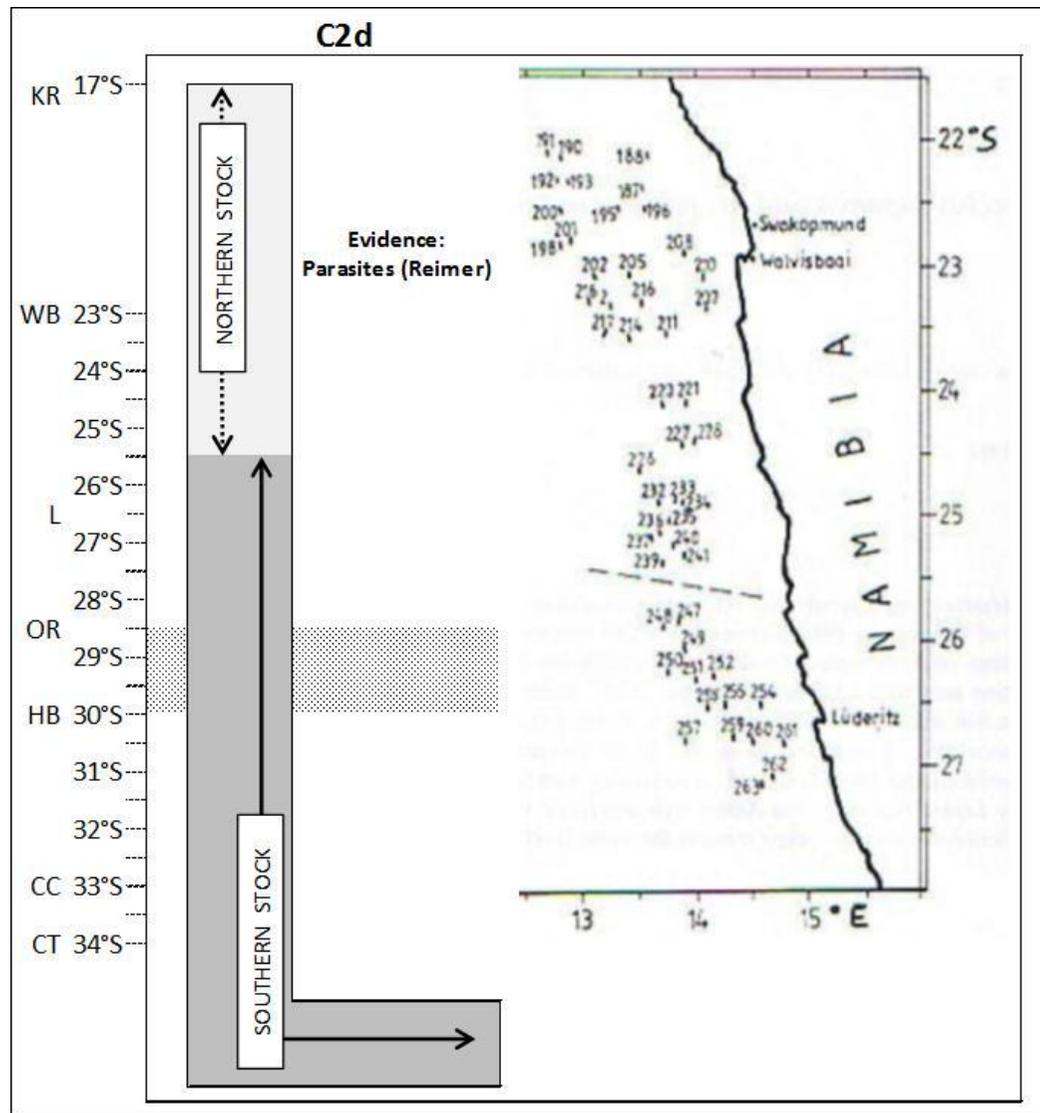


Figure 10: Hypothesis C2d – *M. capensis* 2 stocks

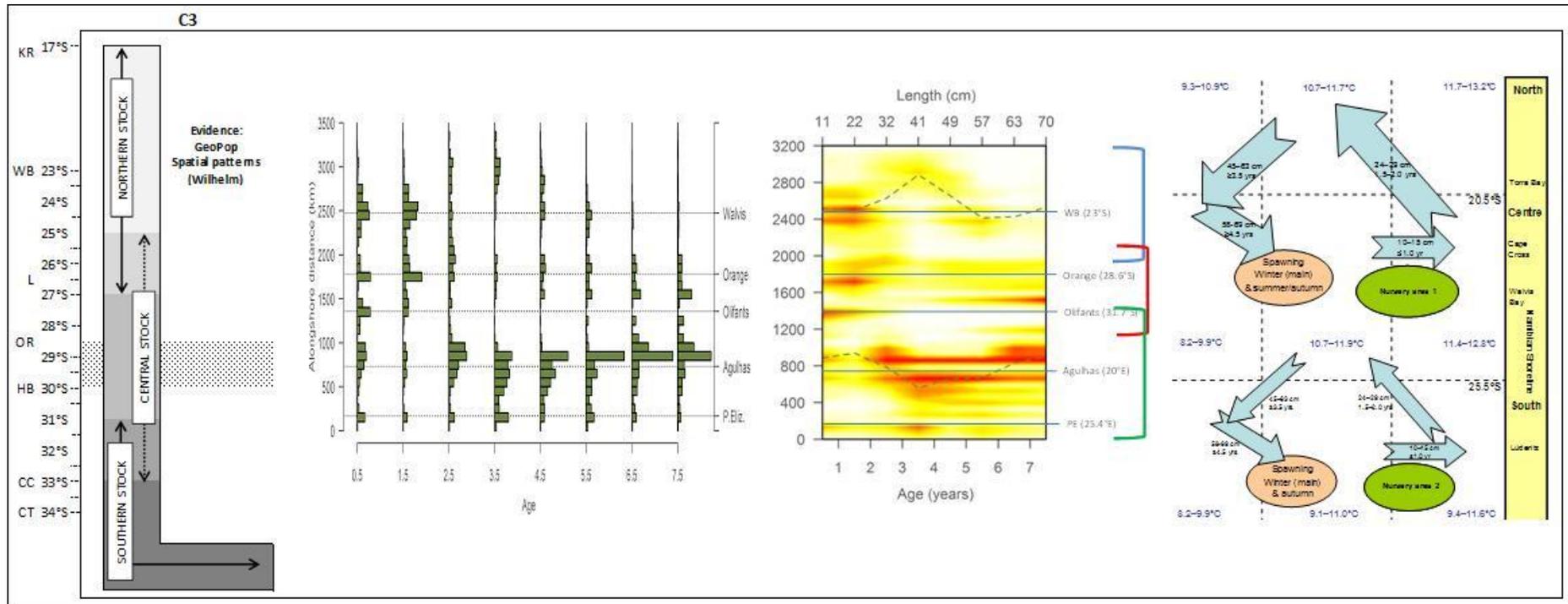


Figure 11: Hypothesis C3 – *M. capensis* 3 stocks

## APPENDIX 1

### WORKSHOP PROGRAMME

#### ***Day 1 Session 1 (Wednesday 12 November 09h30 – 10h45):***

- a) Opening (Hashali Hamukuaya)
- b) Introduction (Chair)
  - Background
  - Objectives
  - Workshop programme
- c) Description of the ICES assessment and decision making process (Jan Beyer)
- d) Review of March 2014 Workshop outcomes (Doug Butterworth) and adoption of report of that workshop
- e) Review of May 2014 Copenhagen WP1 Workshop outcomes, with emphasis on the movement model outputs (Jan Beyer/Doug Butterworth).
- f) Illustration of the joint assessment process to follow, and how input from this workshop can inform that (Doug Butterworth)

#### ***Day 1 Sessions 2 and 3 (Wednesday 12 November 11h00 – 13h00 and 14h00 – 15h45):***

Presentations/descriptions of further available data/analyses to inform construction of plausible stock structure hypotheses:

- a) Genetics (Conrad Matthee / Romina Henriques)
- b) GeoPop analyses (Jan Beyer)
- c) Age and growth (Sarah Paulus / Paul Kainge)
- d) Stable isotope research (Johannes Iitembu / Paul Kainge)
- e) Hake parasite research (Larvika Singh)

#### ***Day 1 Session 4 (Wednesday 12 November 16h00 – 17h00):***

Open discussion:

- a) Genetics
- b) Parasites as biotags (Reimer 1993 paper)

#### ***Day 2 Sessions 1 - 4 (Thursday 13 November 09h00 – 17h00):***

Open discussion:

- a) Regional assessment-related research priorities for incorporation into the BCC application for a grant from the Norwegian Ministry of Foreign Affairs.
- b) ECOFISH sessions at the December 2014 International Stock Assessment Review Workshop
- c) ECOFISH-related meetings required in 2015
- d) Revision of the preliminary hake stock structure hypotheses
- e) Closing (Chair)

**Presentations:**

- Jan Beyer: Description of the ICES assessment and decision making process with personal observations on strengths and weaknesses
- Doug Butterworth: Points arising from the March 2014 ECOFISH hake biology workshop
- Jan Beyer: GeoPop application to NEA Mackerel survey data
- Jan Beyer: Work plan from May ECOFISH Stock Assessment meeting
- Romina Henriques: Genetic stock assessment of the hake species along the southern African coastline
- Paulus Kainge (on behalf of Johannes Iitembu): Some aspects of the trophic relationships of hake, horse mackerel and sardinella (ECOFISH WP2 Task 4 - Trophodynamics)
- Sara Paulus: Update of age and growth activities in ECOFISH (WP2 Task 3)
- Larvika Singh: Research on hake parasites as bio-tags – progress on *M. capensis*

**Primary documents:**

- **Benguela Current Commission** – Report of the March 2014 ECOFISH WP1-WP2 Hake Biology Workshop
- **Theygesen *et al.* (in prep)** Intercalibration of survey trawl gear using paired hauls
- **Butterworth and Rademeyer (2014)** An Outline of the Primary Objective for Hake Discussions during the 2014 International Stock Assessment Review Workshop *MARAM/IWS/DEC14/Hake/P1*
- **Reimer (1993)** Parasites of *Merluccius capensis* and *M. paradoxus* from the coast of Namibia. *Appl Parasitol.* **34(2)**:143-50.

**Supporting documents:**

- **Rademeyer and Butterworth (2014)** Specifications of the South African Hake 2014 Reference Case Assessment *MARAM/IWS/DEC14/Hake/P2*
- **Rademeyer (2014)** An initial attempt at a spatially structured stock assessment for the South African hake resource including explicit movement *MARAM/IWS/DEC14/Hake/P3*
- **Kirchner *et al.* (2012)** Evaluation of the Status of the Namibian Hake Resource (*Merluccius* spp.) Using Statistical Catch-at-Age Analysis. *Environment for Development Discussion Paper Efd DP 12-12*: 52 pp.

**Additional documentation circulated subsequent to the workshop:**

- **Sundby *et al.* (2001)** Interaction between Cape hake spawning and the circulation in the Northern Benguela upwelling ecosystem. *S. Afr. J. mar. Sci.* **23**: 317 – 336.
- **Kainge *et al.* (2007)** *Merluccius capensis* spawn in Namibian waters, but do *M. paradoxus*? *Afr. J. mar Sci.* **29(3)**: 379 – 392.