Extensions of Ecofish stock structure hypotheses for *Merluccius paradoxus,* and a comment on the relative plausibility for P1, P2a and P2b

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Extensions: A recent workshop (12 and 13 November 2014) developed stock structure hypotheses for the Ecofish scientific project, for ***Merluccius paradoxus*** and ***Merluccius capensis***. For ***Merluccius paradoxus***, the following hypotheses were developed:

- P1: A single stock under panmixia.
- P2a: Two stocks with a broad region of overlap along the South African coastline.
- P2b: Two stocks with a sharp boundary close to Luderitz along the Namibian coastline.

Stock was loosely defined but was assumed to comprise a reproductive unit, and by "location of stock" was taken to mean where the catch for said reproductive unit is made. There was a general understanding that varying degrees of interchange may occur between these stocks, and that the interchange required to obscure the genetic signal that two stocks are reproductively isolated is small from a fisheries management perspective.

The scope of "stock hypothesis" from the 12 13 November 2014 meeting did not include:

- The size and sex selectivity for hakes in the different regions of hake fishing,
- The associated migratory processes which may be contributing to fisheries specific availability issues,
- Precisely where spawning might be taking place for single or multiple stocks,
- Possible species linked spatial dynamic processes over the history of the hake fishery which might be relevant to an interpretation of the evidence for stock structure, or to the detail of stock structure hypotheses.

These factors did however surface from time to time and played some role in the support that competing hypotheses received. In particular, the fact that no evidence was tabled documenting spawning by ***Merluccius paradoxus*** in Namibian waters, coupled with microsatellite work suggesting that there is a genetically homogenous stock of ***Merluccius paradoxus*** in the entire Benguela region, provided support for the single stock hypothesis for ***Merluccius paradoxus***.

It was suggested at the workshop of 12 and 13 November that the scope of the concept "a stock structure hypothesis" will ultimately have to be broadened to include these other more detailed aspects (as above) in order to be able to quantitatively assess their management significance. The following qualifications are proposed as input into this process - these are by no means exhaustive:

Q1: Remnant stock hypothesis: If the ***Merluccius paradoxus*** caught in Namibian waters are non-reproducing non-returning migrants from a reproductively active South African stock then Namibian management action has no implications for the sustainability of the South African stock, whereas the reverse is not true. A modification of this is that the remnant stock has some diminished reproductive output. This is a modification to **P1.**

Q2: Selectivity effects: Exactly which age classes of ***Merluccius paradoxus*** are exploited in Namibia compared to South Africa has a bearing on the relative impact of each of these fisheries on the sustainability of a possible single shared stocks, as well as for a two stock situation in which there is some overlap. **Relevant to P1, P2a and P2b.**

Q3: Recent colonizer theory: ***Merluccius paradoxus*** may be a relatively recent (last 30 years) colonizer of the Namibian habitat, either as a separate Namibian stock (e.g. relevant to **P2a and P2b**) or as an overflow of a single stock expanding from South Africa (**relevant then to P1**).

Q4: Phase of vulnerability: If there are fish that are exploited in Namibian waters that are the reproductive products of spawners from a single stock whose progeny are predominantly exploited in South African waters, then it is relevant whether their migration to Namibian water preceded their commercial recruitment or not – in the latter case potential migrants to Namibia may have to pass a phase of vulnerability to the South African hake fishery before reaching Namibian fishing waters. For Q4 we assume there is a phase of vulnerability. **A modification / clarification of P1.**

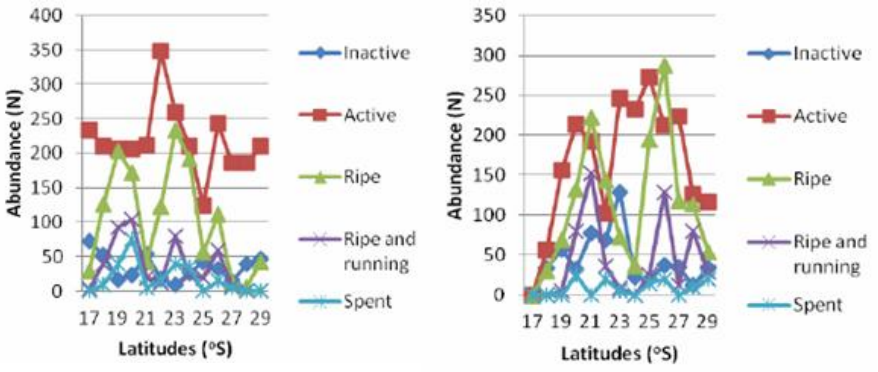
Q5: Absence of a phase of vulnerability: If there is a shared stock, but no, or limited, South Africa – Namibia mixing of fish once recruited to the commercial stock, then the Namibian and South African components of the stock are reliant on a shared reproductive output. For this option there is no phase of vulnerability to the South African fishery prior to commercial recruitment of migrants into Namibian waters. However, the extent to which this sharing is quantitatively meaningful for management is undecided for now. We suggest to quantify this by assuming a randomly varying proportion of a joint (South Africa + Namibia) juvenile recruitment level recruiting to Namibian waters. A modification of **P1.**

Q6: A two stock modification of Q4: In this scenario there are two stocks but some mixed spawning occurs, sufficient to erase the genetic signal about the separation of the two stocks. There is also a phase of vulnerability of Namibian caught ***M. paradoxus*** in South Africa, consistent with spawning of both stocks occurring in South African waters, and gradual migration into Namibia. Relevant to **P2a and P2b.**

Q7: A two stock modification of Q5: In this scenario there are two stocks but some mixed spawning occurs, sufficient to erase the genetic signal about the separation of the two stocks. There is no phase of vulnerability, even though spawning of both stocks may occur in South African waters. That is, migration into Namibian waters takes place before commercial recruitment. **Relevant to P2a and P2b.**

Evidence for spawning by *Merluccius paradoxus* in Namibian waters: Following the 12 13 November Ecofish workshop, a publication has come to light which appears to provide evidence for

spawning by ***Merluccius paradoxus*** in Namibian waters. The following diagram from Nashima et al (2013) is self-explanatory:



Abundance of *M. capensis* (left) and *M. paradoxus* (right) within the various maturity stages along the latitudinal gradients (°S). Taken from Nashima *et al* (2013)

This information changes the relative plausibility of P1, P2a and P2b for ***Merluccius paradoxus*** in favour of P2a and P2b.

References

DAFF, 2014. Report of the Benguela Current Commission – ECOFISH WP1-WP2 Hake Biology Workshop, DAFF Fisheries Research Seminar Room, 12 – 13 November 2014. 14 pages.

Nashima, F.P., Julies, E. and A. Samakupa. 2013. Distribution patterns of spawning stock of hake maturity stages in the Benguela ecosystem of Namibia. Journal of Research in Ecology. 2013: 2(2) 100 – 107.