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**AGE FREQUENCY AND RECRUITMENT – AN INSIGHT INTO ORANGE ROUGHY RECRUITMENT SUCCESS IN THE SOUTHERN INDIAN OCEAN**

*Relates to agenda item:5.1* Working paper ☐ Info paper x☒

There is little evidence that recruitment in the population of orange roughy aged for this study is episodic; rather the data appears 'normal' for exploited marine fish populations.

After adjusting age class numbers for natural mortality an estimate of the fishing mortality for a range of age classes where there appears to be full recruitment to the fishery but still enough observations in the more recent, and thus more frequent age classes, gives an F = 0.011. This is < one quarter of a commonly used value for M of orange roughy of 0.045.

The estimated F of 0.011 indicates a low rate of exploitation, (F/(F+Z)) of 19.6%.

Delegation of SIODFA

SIODFA Technical Report
19/03

Southern Indian Ocean
Deepsea Fishers Association

**AGE FREQUENCY AND RECRUITMENT – AN INSIGHT INTO ORANGE ROUGHY RECRUITMENT SUCCESS IN THE SOUTHERN INDIAN OCEAN**

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## 1. INTRODUCTION

It is a common assertion that recruitment success of orange roughy stocks is spasmodic with good year class strength occurring only episodically. E.G., Cordue (2014) used an episodic model of recruitment success in an orange roughy stock assessment for a New Zealand stock. FAO (2002) referred to the episodic nature of orange roughy recruitment such that there could be long periods without recruitment. Koslow & Tuck (2011) examined the implications to long-term management strategy of highly episodic recruitment in long-lived fishes through studies of Pacific Ocean perch (*Sebastes alutus*) that lived 50-100 years and spanning occurred in bursts at around 10-20 year intervals. These authors noted that episodic recruitment is an extreme form of non-random variability, and fishes such as *Sebastes* spp. and orange roughy, which exhibit highly episodic recruitment, are among the most long-lived marine fishes. They noted that fishing substantially increases the risk of stock collapse of fishes subject to episodic recruitment, particularly under a constant quota management strategy, even if quotas are maintained well below MSY. The web site of the Australian Government, Department of the Environment and Energy notes that orange roughy recruitment appears to be highly episodic where recruitment to the adult population may be very low for extended periods of time (Bruce *et al*. 2002;

From this work for orange roughy form the Southern Indian Ocean it is concluded that the episodic-recruitment models (which had occasional large recruitments up to 20 times the average) would not provide satisfactory fits to the available data.

## 2. METHODS

Horn, Doonan & Ó Maolagáin (2019) undertook ageing of 400 orange roughy using otoliths obtained from a commercial vessel's catches in the Southern Indian Ocean. Orange roughy otoliths have been collected from this area since 2006, and in 2017 the Scientific Committee of the Southern Indian Ocean Fisheries Agreement (SIOFA) recommended an assessment of this stock be done because of the extensive data series (SIOFA 2017) that was available.

Otoliths were prepared using the NIWA method (Horn *et al*. 2016). One otolith from each of the pairs was individually embedded in resin and cured by heating in an oven. A thin section was cut along a line from the primordium through the most uniform posterior-dorsal axis using a sectioning saw with dual diamond-impregnated wafering blades separated by a 380 µm spacer. The section was mounted on a glass microscope slide under a glass cover slip.

Horne, Doonan & Ó Maolagáin (2019) provide a detailed description of the sampling method and origin of a sample of orange roughy whose otoliths are aged. The otoliths were chosen roughly randomly in proportion to the size of the orange roughy catch from each tow. The intention was to more intensively sample larger catches. This process was continued until there were 400 otoliths believed to be suitable for preparation. All usable otoliths from six of the seven largest tows were prepared. Details of the stations and otoliths used in the analysis are given by Horn *et al.* (2019).

For each tow, an age frequency was formed. The combined age frequency was the weighted mean age frequency over the tow age frequencies, where the weight was the square-root of the tow's catch.

These frequencies should decline in relation to the natural mortality. Thus a second plot was done of the relative frequencies where they were adjusted according to:

$$\textit{Relative frequency} = f_a\, e^{0.045(A-20)}$$

**Where:**

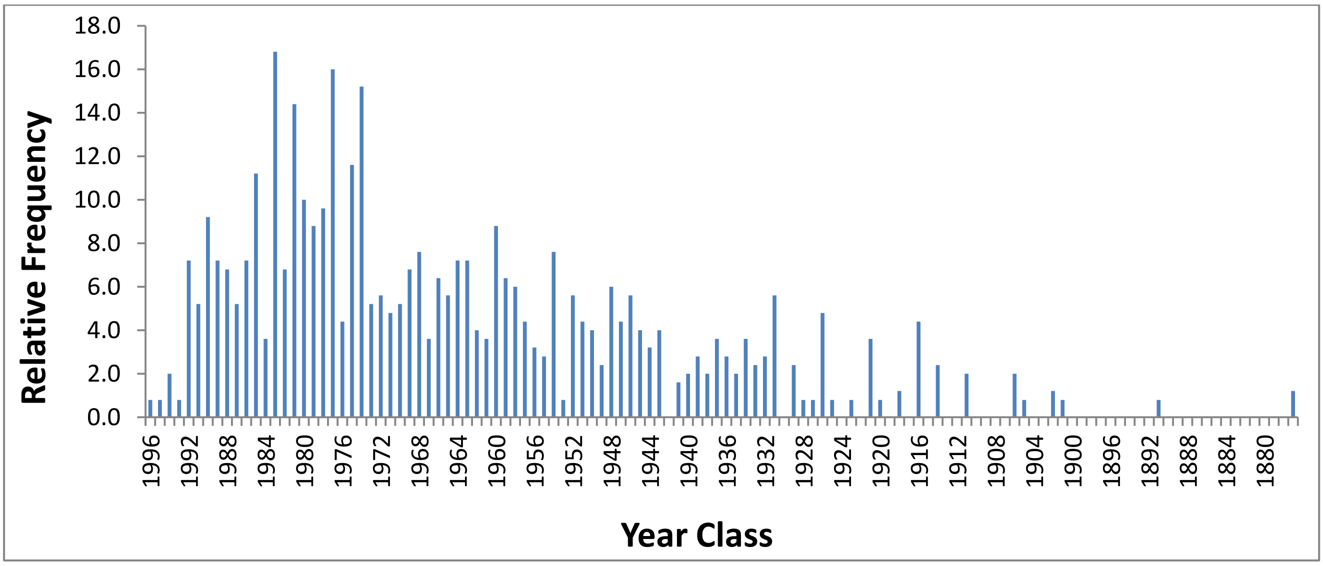
A = fish age
20 = age at first recruitment to the fishery.

The frequency distribution resulting from this adjustment is shown in Figure 2.

## 3. RESULTS

The relative frequency of otoliths in the sample of 400 in terms of year class strength is given in Figure 1. The most recent year class evident in the fishery was for 1996; the oldest year class in the fishery was 1877.

**Figure 1**
**Relative frequency as a function of year class**




Outside of the period 1920 – 1986 there are so few observations that interpretation becomes problematic. Within this period 66 year period, there has only been eight - nine years in which there has been an apparent failure of recruitment – as indicated by the aging data – indicated by the red pointers in Figure 2. The trend line should provide an indication of the fishing mortality. There is a degree of subjectivity in the selection of years that have been identified as suffering a recruitment failure. Other readers may well make another selection that could be equally well entertained. The point evident here is that there is essentially no basis to assert that recruitment, in at least this orange roughy population, is episodic; in fact it appears is no different to that commonly evident in many other fish populations.

**Figure 2**
**Relative frequency of Age Class**

Red arrows indicate when there has been an evident fall in frequency from the preceding year. This may be interpreted as a relative recruitment failure. Entry into the fishery seems to increase up until age ≈ 35 years. Prior to age 25, recruitment appears to be only partial. Year class presence after ≈ age 90 is variable and so low as to exclude drawing confident conclusions.

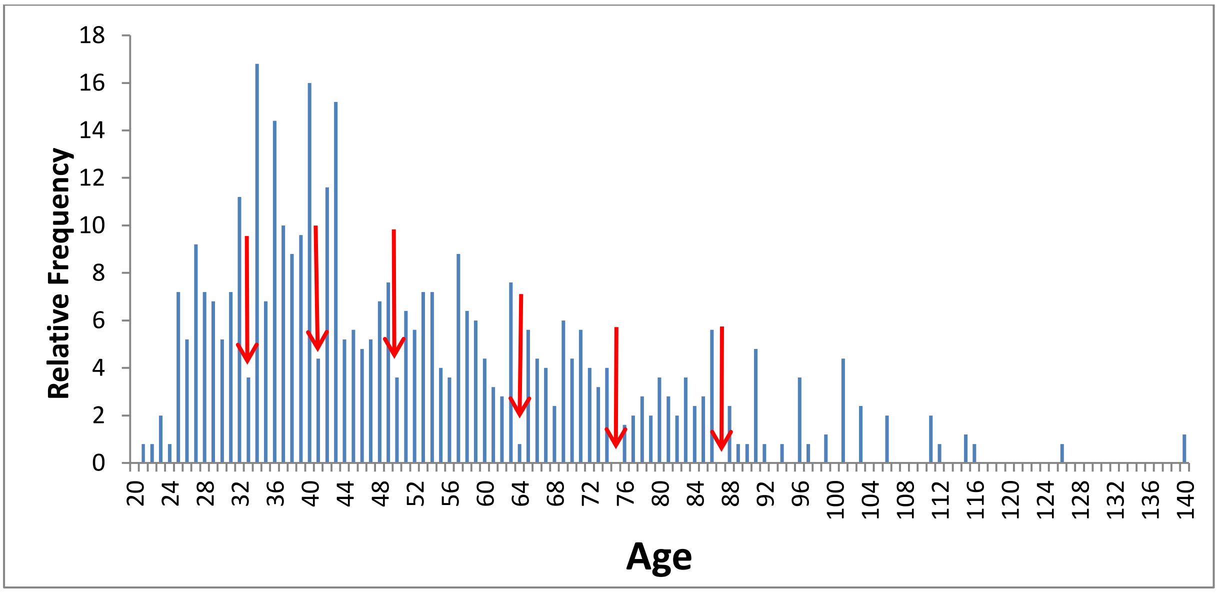



**Figure 3**
Relative frequency as a function of year class.

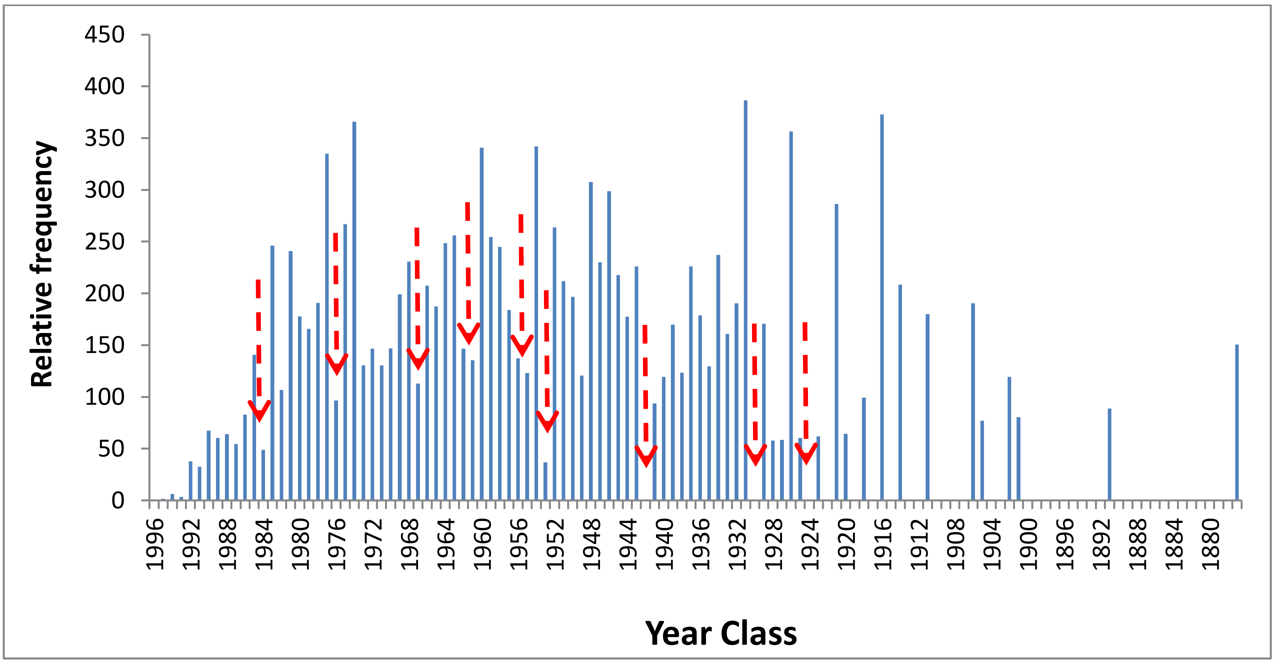
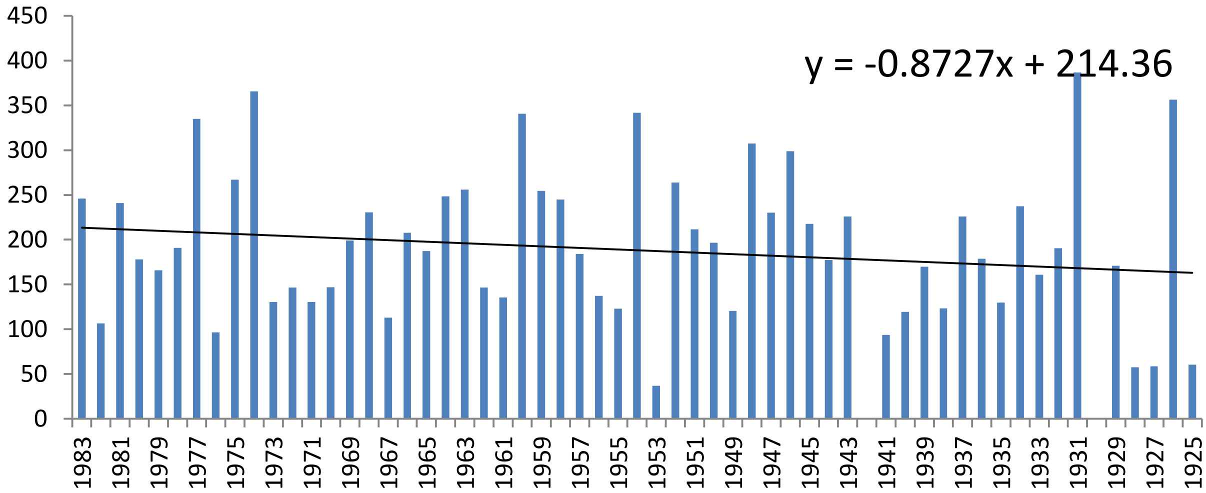



Figure 4 uses the data providing the results shown in Figure 3 but with the data outside this range removed from the plot. From this plot the fishing mortality can be determined as F = 0.011. This is slightly less than one quarter of the commonly used value of 0.045 (See e.g. Cordue 2014) for natural mortality of orange roughy and is a measure of $F_{MSY}$.

**Figure 4**
Relative frequency has been adjusted to account for natural mortality (M = 0.045) for the year classes 1925 – 1983. The slope of this line will vary according to the subjectively selected set of age classes used in fitting the data.




## 4. CONCLUSIONS

- There is little evidence to indicate that recruitment in the population of orange roughy aged for this study is episodic; indeed, the data indicate that recruitment could better described as 'normal' for exploited marine fish populations.
- After adjusting age class numbers for natural mortality an estimate of the fishing mortality for a range of age classes where there appears to be full recruitment to the fishery but still enough observations in the more recent, and thus more frequent age classes, gives an estimate of fishing mortality of F = 0.011. This is less than one quarter of a commonly used value for the natural mortality of orange roughy of 0.045. However, this value is sensitive to the range of age classes that are included in the analysis.
- The estimated F of 0.011 indicates a low rate of exploitation, (F/(F+Z)) of 19.6%.

## 5. LITERATURE CITED

Cordue, P.L. A 2014. Stock Assessment of Mid-East Coast Orange Roughy. New Zealand Fisheries Assessment Report 2014/32. 58pp.

FAO 2002. Report of the Second *Ad Hoc* Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean. Fremantle, Western Australia. 22 – 24 May 2002. *FAO Fish. Rep*. No. 677. Rome, FAO. 106 pp.

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Koslow, K. & G. Tuck 2011. The Boom and Bust of Deep-Sea Fisheries: Why Haven't We Done Better? Serial No. N4535 NAFO SCR Doc. 01/141. 10pp.