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1) Background

Working group papers WG-EMM-2022/15 and WG-FSA-2022/02 were presented at last year's EMM and FSA meetings. The papers gave detailed information regarding the discovery of a nest area for notothenioid icefish (*Neopagetopsis ionah*, Nybelin 1947) of an unprecedented extent that had been observed in the southern Weddell Sea (Purser et al. 2022) during RV *Polarstern* expedition PS124 from February to March 2021 (Hellmer and Holtappels 2021).

The EMM Working Group recommended that the recently discovered *N. ionah* nesting ground should be protected in a timely manner (WG-EMM-2022 Report, para 3.28 and 3.29), and noted that protection in the immediate term could be provided either by expanding CM 22-06 on VMEs to include fish nest areas, or through the creation of a separate conservation measure dedicated to the protection of essential fish habitats. Additionally, the EMM Working Group invited interested participants to continue the discussion on the protection of important areas such as this *N. ionah* nesting ground in the e-group "Vulnerable Marine Ecosystems Review". In the CCAMLR VME e-group, initial suggestions were provided concerning the definition of a "fish nest area" and the design of the protection zone for such an area.

The FSA Working Group agreed that the presence of an extensive icefish nesting ground was indicative of a VME and requested the Scientific Committee to consider a modification of CM 22-06 as a mechanism to protect these nest areas when discovered (WG-FSA-2022 Report, para 6.26).

Based on the discussions and recommendation of WG-EMM and WG-FSA, two background documents papers were submitted to SC-CAMLR-41:

(a) SC-CAMLR-41/BG/05 presented again detailed information regarding the discovery of a fish nesting ground of *Neopagetopsis ionah* in the southern Weddell Sea of unprecedented extent (SC-CAMLR-41 Report, para 5.40).

(b) SC-CAMLR-41/BG/39 Rev. 1 proposed modifications in CM 22-06 for including fish nest areas following the advice of WG-EMM-2022 and WG-FSA-2022. In addition, an Annex 22-06/B for the *N. ionah* nest area in the Weddell Sea was included for consideration by the Scientific Committee (SC-CAMLR-41 Report, para 5.41).

The Scientific Committee welcomed the documents and agreed on the importance of protecting nest areas like the one encountered in the Weddell Sea (SC-CAMLR-41 Report, para 5.42). The Scientific Committee recommended the revision of CM 22-06 and identified four specific changes (see SC-CAMLR-41 Report, para 5.44). In addition, the Scientific Committee recommended that the fish nest area of *N. ionah* in the Weddell Sea be included in the CCAMLR VME registry with the coordinates given in SC-CAMLR-41/BG/39 Rev. 1 (SC-CAMLR-41 Report, para 5.45).

2) Discussions and recommendations of CCAMLR-41

The Commission noted (1) the recommendation of the Scientific Committee to use a modification of CM 22-06 as a mechanism to protect "fish nest areas" (CCAMLR-41 Report, para 4.88), and (2) that no consensus could be reached on amending CM 22-06 (CCAMLR-41 Report, para 4.89). Some Members considered that these recommendations could be better addressed through a self-standing CM.

The Commission considered the proposal from the EU and its Member States of a new CM 32-XX to protect fish nest areas in the Convention Area that would give effect to the recommendations of the Scientific Committee on this matter (CCAMLR-41 Report, para 9.14). Some Members stated that they could not support the current proposal, noting that further work was needed in the Scientific Committee, such as to:

(a) define the term "fish nest area",

(b) identify relevant indicators, and

(c) refine the review process for opening and closing fish nest areas to bottom fishing activities.

3) A proposal for further action

As no consensus could be reached on the proposal for a measure to protect fish nest areas in the Southern Ocean, we would like to make suggestions here on the open issues raised at the 41st meeting of the Commission.

(a) Definition of the term "fish nest" and indicators thereof

A **nest** is a clutch of eggs situated within a visible structure made of gravel and/or sediment or within secondary structures such as the interior of large sponges. A nest may (but need not) be attended by one or more fish. We suggest using the clutch of eggs as the indicator.

The definition of a nest proposed here is based on Purser et al. (2022) and the CCAMLR VME e-group proposal (post from 20 Oct 2022).

Based on current knowledge, we would refrain from considering empty nests (without eggs) as a relevant indicator as well, even though habitat engineering carried out by the nesting fish during nest formation has an impact on local biogeochemical cycles years after nest abandonment (Purser et al. 2022). To date, there is no indication whether nests are used repeatedly in subsequent years. In the future, if certain areas are found to be used preferentially as nest areas due to environmental conditions (e.g., bottom temperature, bathymetric and topographic features, and/or sediment characteristics), and/or abandoned nests are revisited, empty nests and/or environmental proxies could be used as additional relevant indicators of a "fish nest area".

(b) Definition of the term "fish nest area"

To develop a proposal for defining the term "fish nest area," we analysed still images from the OFOBS deployment (Station 21-7) that initially discovered the fish nest area of *Neopagetopsis ionah* in the southern Weddell Sea during RV *Polarstern* expedition PS124 (Hellmer and Holtappels 2021). All seabed images taken at Station PS124_21-7 are available via the data repository PANGAEA (https://doi.pangaea.de/10.1594/PANGAEA.932826). We selected the OFOBS dive at Station 21-7 for analysis because a traditional sampling strategy was used that will likely be used in future seabed surveys. The OFOBS was towed behind a research vessel at an altitude of 1.5 m above the seafloor and with a tow speed of 0.5 kts (Purser et al. 2022). Still images were taken approx. every 20 seconds.

The entire OFOBS deployment (Station 21-7) lasted just over three hours, and the total area covered by still images (596 images in total) was approx. 1.6 km². To minimise the time required for image analysis and reflect variation in the number of fish nests with less sampling effort, we randomly extracted five data subsets from the Station 21-7 data set, each containing 15 minutes of consecutive dive time.

The seafloor area covered by each image was determined from the 50 cm spaced laser points visible in all images. All active nests observed in each image (i.e., nest with eggs only or with one or more fish in addition) were counted. Nests with less than half of the nest perimeter in the imaged area were assigned a value of 0.5. The densities of nests were then computed for each subset.

The mean transect length for the five subsets was approx. 200 m and the mean number of still images 50 (Tab. 1A). On average, the images per subset covered a seafloor area of approx. 130 m^2. The subsets contained a total of 251 still images, which upon analysis revealed 265 nests across approx. 651 m² of sampled area (Table 1A). The number of nests/m² varied between 0.16 and 0.76 across subsets. In almost 40% of all cases, 1 to 1.5 active fish nests are captured with a single image (Table 1B). Purser et al. (2022) determined the number of nests/m² to be between 0.166 to 0.331 across other OFOBs dives (Stations 63-1, 67-1, 101-1) in the same *N. ionah* nest area. Although Purser et al. (2022) evaluated a 10-fold higher number of still images (total: 2,608) than we did - explaining the smaller variation in the number of nests/m² compared to our analysis - both evaluations show a minimum value of approx. 0.16 nest/m².

Table 1A: Analyses of five data subsets extracted from the Station 21-7 data set collected during PS124 within the *Neopagetopsis ionah* nest area. Number of nests and the approx. area sampled are given, in addition to the number of still images analysed for each subset. Seabed images taken at Station 21-7 are available at: https://doi.pangaea.de/10.1594/PANGAEA.932826 (Purser et al. 2021).

Subset	length of transect (m)	n images	area sampled (m²)	n nests	n nest/m2
Subset1	141	60	158	87	0.55
Subset2	195	53	140	28	0.21
Subset3	228	38	100	75.5	0.76
Subset4	217	52	134	54.5	0.41
Subset5	193	48	123	20	0.16
Total	974	251	651	265	0.41
Mean	195	50	130	53	0.41
SD	34	8	21	29	0.25

Table 1B: Analysis of the five data subsets extracted from Station 21-7 data set collected during PS124 in the *Neopagetopsis ionah* nest area. Number of still images per data subsets for each category "n nests".

N nests in a single image	0	0.5	1/1.5	2/2.5	3/3.5	4
Subset1	7	6	25	18	3	1
Subset2	23	6	23	0	0	0
Subset3	1	0	13	12	8	2
Subset4	16	4	19	18	3	1
Subset5	26	6	14	1	0	0
Total	73	22	94	49	14	4
%	29	9	37	19	5	2

Accordingly, we propose the following definition of the term "fish nest area":

An area is classified as a **fish nest area** if the nest density per square metre is at least 0.16.

Taking into account logistical constraints, such as dive and ship-time availabilities in the Southern Ocean, while trying to ensure a representative density estimate over an area (rather than a point observation), we propose that the determination of nest density be based on at least 50 images taken along a transect of at least 200 m (giving a sampling area of about 130 m²). The spatial extent of a fish nest area is defined by the latitude and longitude of the first and last image along the transect that contains at least 0.5 fish nests.

If a transect is longer than 200 m and the nest density/m² over the entire sampling area is less than 0.16 m², the nest density/m² should also be determined for at least five data subsets (if the transect length allows, otherwise correspondingly less) randomly extracted from the entire (transect) data set, each containing 15 minutes of consecutive dive time. Each subset with a nest density of at least 0.16 m² is considered part of the fish nest area. The overall spatial extent of the fish nest area is then defined by the latitude and longitude of the first and last subset (using the first and last image containing at least 0.5 fish nests) that exhibit a nest density of at least 0.16 m², regardless of whether there are one or more subsets in between that have a nest density of less than 0.16 m².

It is important to note that the proposed definition of a fish nest area is based exclusively on the nest area of *N. ionah* in the southern Weddell Sea. In this area, which has a homogeneous environmental envelope in terms of bottom temperature, depth, and topographic features (Purser et al. 2022), this taxon seems to be relatively evenly distributed (no clustering) (see Fig. 1). However, under different environmental conditions, *N. ionah* could show a different spatial distribution pattern. Furthermore, there is currently no knowledge on whether other nest guarding fish taxa show similar spatial distribution patterns. Nevertheless, this is the best scientific basis currently available to establish a definition of the term fish nest area. Of course, this definition should be adapted, if necessary, as more information on fish nest areas becomes available.

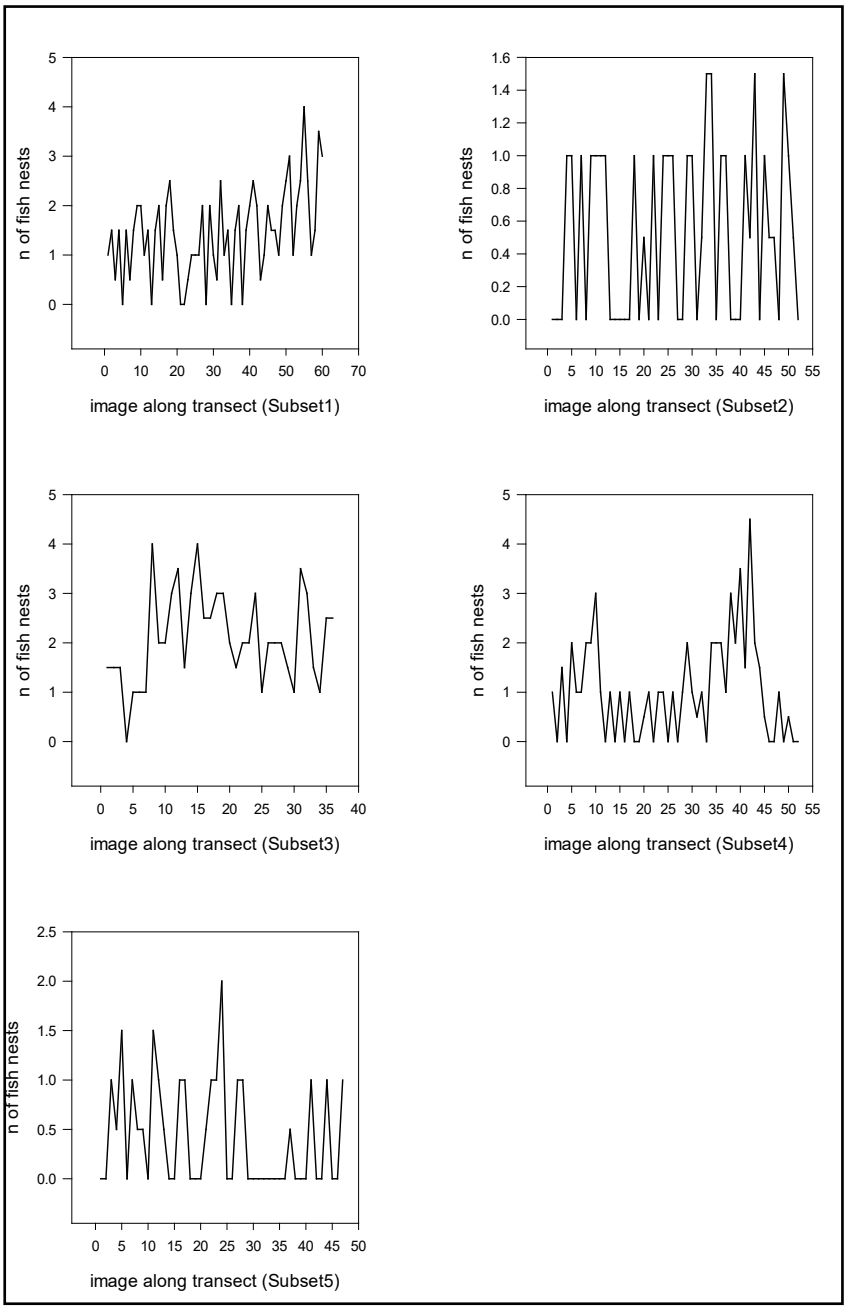

Figure 1: Number of fish nests/image along transects (Subsets 1 to 5).

(c) Definition of a "fish nest protective zone"

A confirmed fish nest area shall be protected through a fish nest protective zone delimited by a protective buffer of 10 nautical miles (nm). In the case of a confirmed fish nest area along a transect, a protective buffer of 10 nm shall be established around the fish nest area (with the start and end point of fish nest area defined under 3b). If a fish nest area is identified along two or more transects within 10 nm of each other, the fish nest protective zone shall be designed by a 10 nm buffer around the outermost start and end points of the combined fish nest areas.

The definition of a fish nest protective zone is based on the proposal of the CCAMLR VME e-group (post from 20 Oct 2022) and includes the following considerations for setting the protective buffer at 10 nautical miles:

- In general, the (mostly accidental) discovery of a fish nest area is not followed by a large-scale survey to further determine the extent of the fish nest area due to logistical reasons, such as dive and ship-time availabilities (Purser et al. 2019). This is also evident with respect to seafloor surveys in the Weddell Sea over the past decade (e.g., Knust and Schröder 2014; Schröder 2016). With the exception of the study by Purser et al. (2022), incidental observations of fish nests were not followed up by a more comprehensive survey. This means that there is usually a high degree of uncertainty about the overall extent of the detected fish nest area.

- Bottom fishing has the potential to impact fish nest areas, which could adversely affect both the population of the nest guarding fish taxon and the ecosystem. Fishing gears that are dragged along the seafloor (e.g., trawls, dredges) are known to adversely impact benthic communities and habitats, including fish nest areas (see e.g., reviews from Dayton et al. 1995; Grabowski et al. 2014). In the high seas areas of the CCAMLR Convention Area the use of bottom trawling gear is restricted to areas for which the Commission has conservation measures in force for bottom trawling gear (see CM 22-05).

- The 10 nm protective buffer is time-limited and will be reduced to a 1 nm protective buffer around the fish nest area unless it is demonstrated again that the fish nest area still exists in this zone (see details under d).

(d) Review process for opening/closing of fish nest areas

Regarding the review process for opening and closing of fish nest protective zones for bottom fishing activities, we proposed the following:

The fish nest protective zone is closed to bottom fishing activities for five years from the time a fish nest area was confirmed. If the confirmed fish nest area is detected again and/or a new fish nest area is discovered in the 10 nm nest protective zone within the five years, the fish nest protective zone shall be renewed for another five years (from the date of confirmation of the latest fish nest area). If a new fish nest area is confirmed inside the 10 nm nest protective zone and it is not clear whether the first confirmed fish nest area still exists, the nest protective zone shall be redesigned according to the design for two or more transects (see 3c) and it will be active for five years from the date of confirmation of the latest fish

nest area. If it is clear that the first confirmed fish nest area no longer exists, the original protective zone ceases to exist and a new 10 nm nest protective zone is designed around the new fish nest area.

If a follow-up survey is not possible within the five years after the initial discovery of the fish nest area, the fish nest protective zone shall be reduced to one nautical mile around the fish nest area. Within the 1 nm protective zone, bottom fishing remains prohibited until such a time when a camera transect (as previously proposed under 3b) can verify the fish nest area is absent. In that case, a reopening to fishing activities may occur as long as it does not contradict other CCAMLR CMs.

(e) The case of a potential fish nest area

If, during a transect survey, repeated observations of one or more fish are made at nests that do not contain a clutch of eggs, this may be an indication of an accumulation of fish ready to reproduce (shortly before spawning). In this case, we suggest the following, analogous to the above:

An area is classified as a **potential fish nest area** if the combined density per square metre of empty nests (without a clutch of eggs but with one or more fishes per nest) and full nests (if applicable, assuming the latter's density is below 0.16) is at least 0.16.

If a potential fish nest area is observed, this should be reported through the CCAMLR working groups and the Scientific Committee (see Fig. 2). This area could be classified as a "risk area" (or similar terminology) which requiring further research before a protective zone is established and the area is closed to bottom fishing activities.

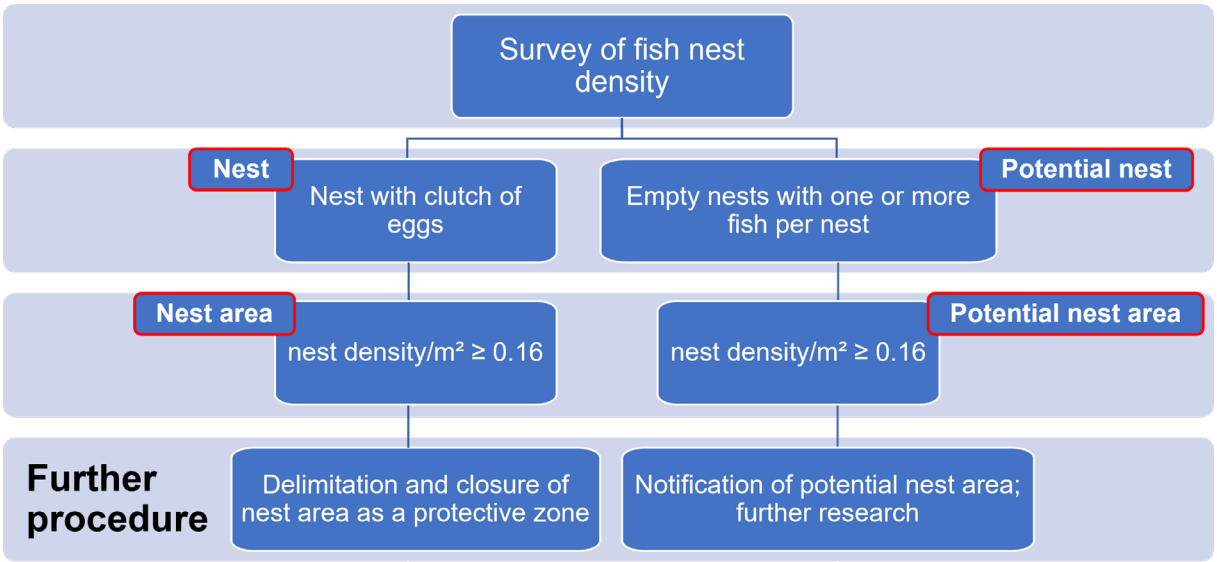

Figure 2: Summary of differences and similarities between a "real" and a "potential" fish nest and fish nest area and the respective further procedure.

4) Recommendation

We recommend that the open issues raised at the 41st Commission meeting, which were examined in more detail here for the first time, be worked on further, as necessary, in a sub-group on the margins of WG-EMM-2023.

The aim should be to submit this working group paper in revised form to WG-FSA-2023 and SC-CAMLR-42, as well as a revised CM 32-XX in accordance with the definitions developed to CCAMLR-42.

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