Linking inconsistencies in trophic level of marine fauna to fisheries discard consumption

OCEAN SCIENCES MEETING 2022

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Ifremer

Fishing activity, fisheries discards and discard bans

Fisheries discards = animals caught, but returned to the sea, **dead** or alive

Global discard rates ~ 7-10 million tons / year
~ 10% of global catches
(Kelleher, 2005; Zeller et al., 2018)

But **important variation according to geographic zone / fishing activity**

North-East Atlantic ocean has been identified as a '**discard hotspot**'
(Guillen et al., 2018)

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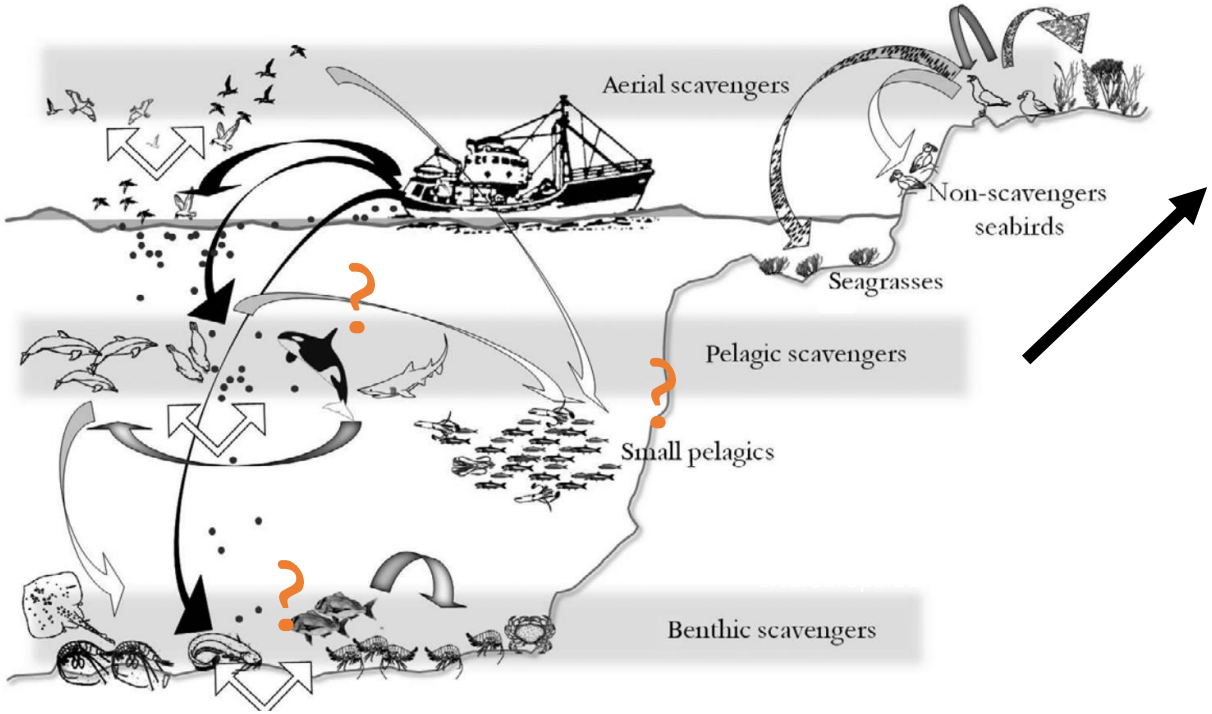
The **EU** adopted a **discard ban** in the form of a **Landing Obligation (LO)** under the reform of its Common Fisheries Policy (Gradual implementation over 2015-2019)

➔ Essentially aims to stop discarding of species under 'total allowable catches' / quota

➔ However, fishing has impacted marine ecosystems since ancient times…
➔ **Food web consequences of reducing fishing discards ?**

What is the fate of discards in marine ecosystems ?



Oro et al., 2013

Consumption by seabirds

= relatively well studied

➔ Significant part of the diet

➔ Important impact on population dynamics of some species (e.g.: Sherley et al, 2019)

But most discards sink… (e.g.: Depestele et al, 2016)

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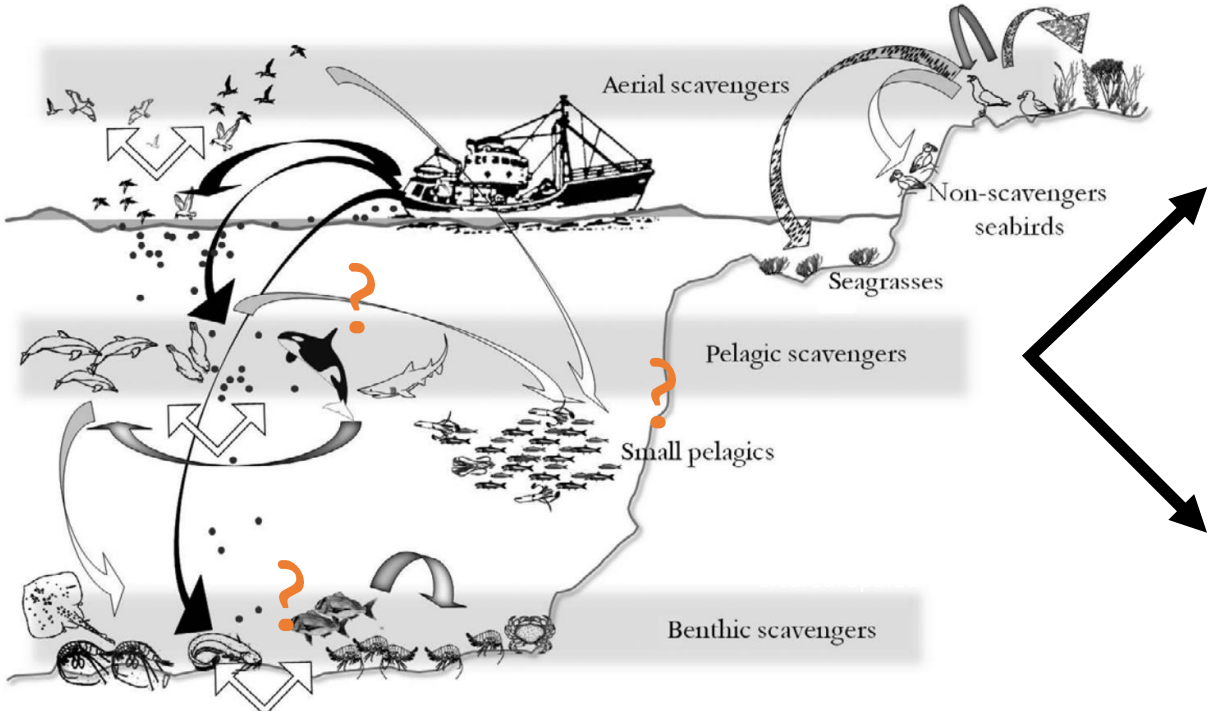

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Consumption by aquatic species?

➔ Food subsidy potentially supporting non typical scavengers

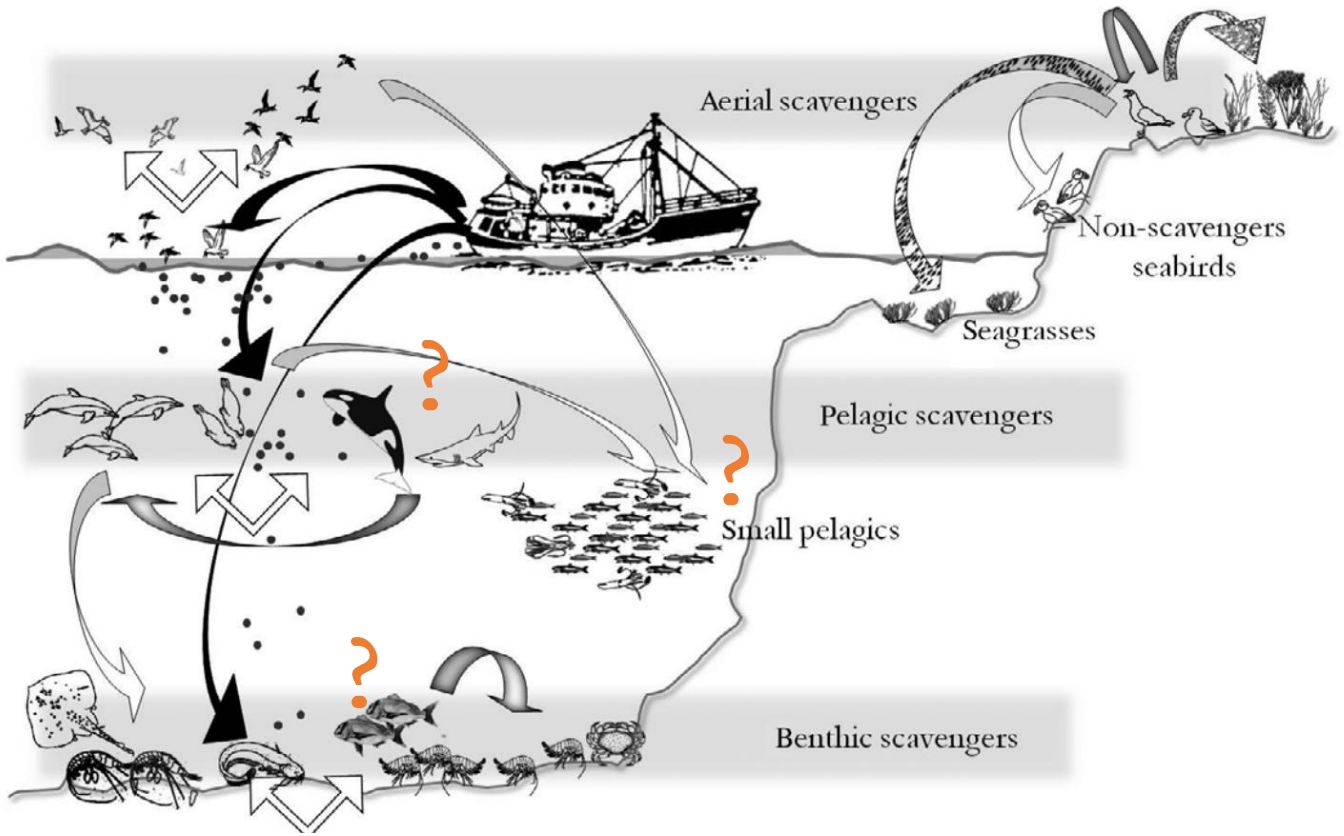
➔ Contrasted predictions from ecosystem models…

(e.g.: Catchpole and Frid, 2006 vs. Depestele et al, 2019)

Uncertainties:

- **Consumption of discards:** understudied and certainly underestimated (Guillen et al, 2018)
- **Quantification of discards:** ↑ monitoring needed

What are the challenges of studying discard consumption by marine fauna ?



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<u>Multiple challenges</u> linked to:

1. Diet assessment techniques

Traditional gut contents ➔ Usually low resolution of diet items identification.

Baited underwater video systems

➔ Does not allow to ponder the importance of discards consumption relative to other items in the diet.

2. Variation in discard rates and ID

- geographic location
- fishery
- season
- …

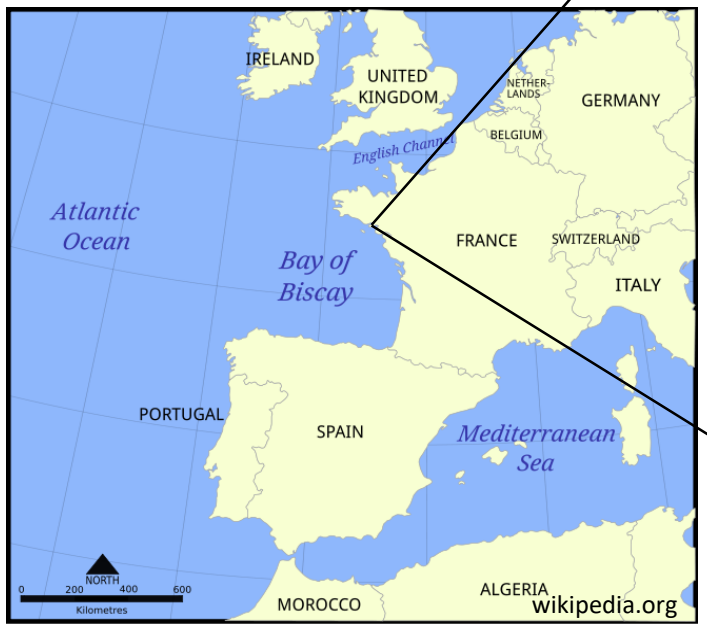
3. Impossibility to decipher between diet items ingested as discards (i.e. scavenging) vs. ingested as living prey (i.e. natural predation)

Aims of this research

Aims: (1) Quantify discards consumption by marine fauna in a coastal area subject to important discarding activity
(2) Identify potential pathways through which the LO may propagate changes through the trophic network in such environments.

Complementary approaches: - Stable isotope analysis: Time and space integrative trophic tracers
- Gut content DNA metabarcoding: High resolution diet information

'Baie de Bourgneuf'
Bay of Biscay, France
(North-East Atlantic)



- Shallow bay (0 to 34m depth)
- Diverse in substrate types and species

Sampling: 10.95 m long commercial trawler single bottom trawl used to target multispecies fish assemblages (20 m headline and 70 mm diamond mesh codend).

Captured individuals were directly frozen to be further dissected in the lab.

Stable isotope analysis: 27 consumer taxa (**184 individuals**)
Metabarcoding: 22 consumer taxa (**369 individuals**).
Record discard frequency by taxa during the study period.

Stable isotope analysis: looking for inconsistencies in Trophic Levels (TL) (Lejeune et al. in review)

Hypothesis: If discarding is important and stable over time, discard consumers may depict higher than expected TL

			Global averaged TL		Modelled TL	
Class	Taxon	n	Mean	SE	Median	CI
Actinopterygii	*Callionymus lyra*	7	3.3	0.4	2.8	2.6-3.1
Actinopterygii	*Chelidonichthys lucerna*	7	4	0.1	3.6	3.4-3.8
Actinopterygii	*Conger conger*	6	4.3	0.4	3.6	3.3-4.0
Actinopterygii	*Engraulis encrasicolus*	7	3.1	0.4	3.1	2.8-3.4
Actinopterygii	*Sardina pilchardus*	6	3.1	0.1	3.0	2.7-3.4
Actinopterygii	*Sprattus sprattus*	7	3	0.1	2.9	2.7-3.1
Actinopterygii	*Scomber scombrus*	7	3.6	0.2	2.8	2.5-3.2
Actinopterygii	*Osmerus eperlanus*	7	3.5	0.4	3.8	3.6-4.1
Actinopterygii	*Belone belone*	4	4.2	0.4	3.2	2.5-4.2
Actinopterygii	*Trachurus trachurus*	7	3.7	0.0	3.8	3.5-4.0
Actinopterygii	*Pollachius pollachius*	7	4.3	0.3	3.7	3.4-4.0
Actinopterygii	*Trisopterus luscus*	7	3.7	0.1	3.8	3.4-4.2
Actinopterygii	*Merlangius merlangus*	6	4.4	0.2	4.2	3.9-4.5
Actinopterygii	*Merluccius merluccius*	7	4.4	0.0	3.6	3.3-3.9
Actinopterygii	*Pagrus pagrus*	7	3.9	0.2	3.8	3.5-4.0
Actinopterygii	*Spondyliosoma cantharus*	7	3.3	0.2	3.7	3.4-4.0
Actinopterygii	*Labrus bergylta*	4	3.2	0.0	3.3	2.8-3.8
Actinopterygii	*Solea solea*	7	3.2	0.2	3.3	3.1-3.6
Chondrichthyes	*Raja undulata*	7	3.5	0.4	4.1	3.8-4.5
Chondrichthyes	*Scyliorhinus canicula*	7	3.8	0.3	4.3	3.9-4.7
Cephalopoda	*Alloteuthis* sp.	7	3.5	0.4	4.4	3.7-5.2
Cephalopoda	*Sepia officinalis*	7	4.3	0.7	4.2	3.7-4.8
Decapoda	*Atelecyclus undecimdentatus*	9	> 2.8	NA	3.2	2.9-3.6
Decapoda	*Cancer pagurus*	7	3.1	NA	3.8	3.4-4.4
Decapoda	*Necora puber*	7	2.6	NA	3.5	3.1-4.0
Decapoda	*Maja brachydactyla*	7	3.2	0.2	3.6	3.2-4.2
Decapoda	*Pagurus* sp.	7	3.6	0.2	3.4	3.1-3.9
Decapoda	*Crangon* sp.	7	3.2	0.5	3.8	3.5-4.4
Gasteropoda	*Buccinum undatum*	7	3.4	0.4	3.7	3.3-4.4
Polychaeta	*Aphrodita aculeata*	6	3.2	0.4	3.8	3.3-4.5

1. TL modelling using bayesian mixing models ‘tRophicPosition’ (Quezada Romegialli et al 2018)
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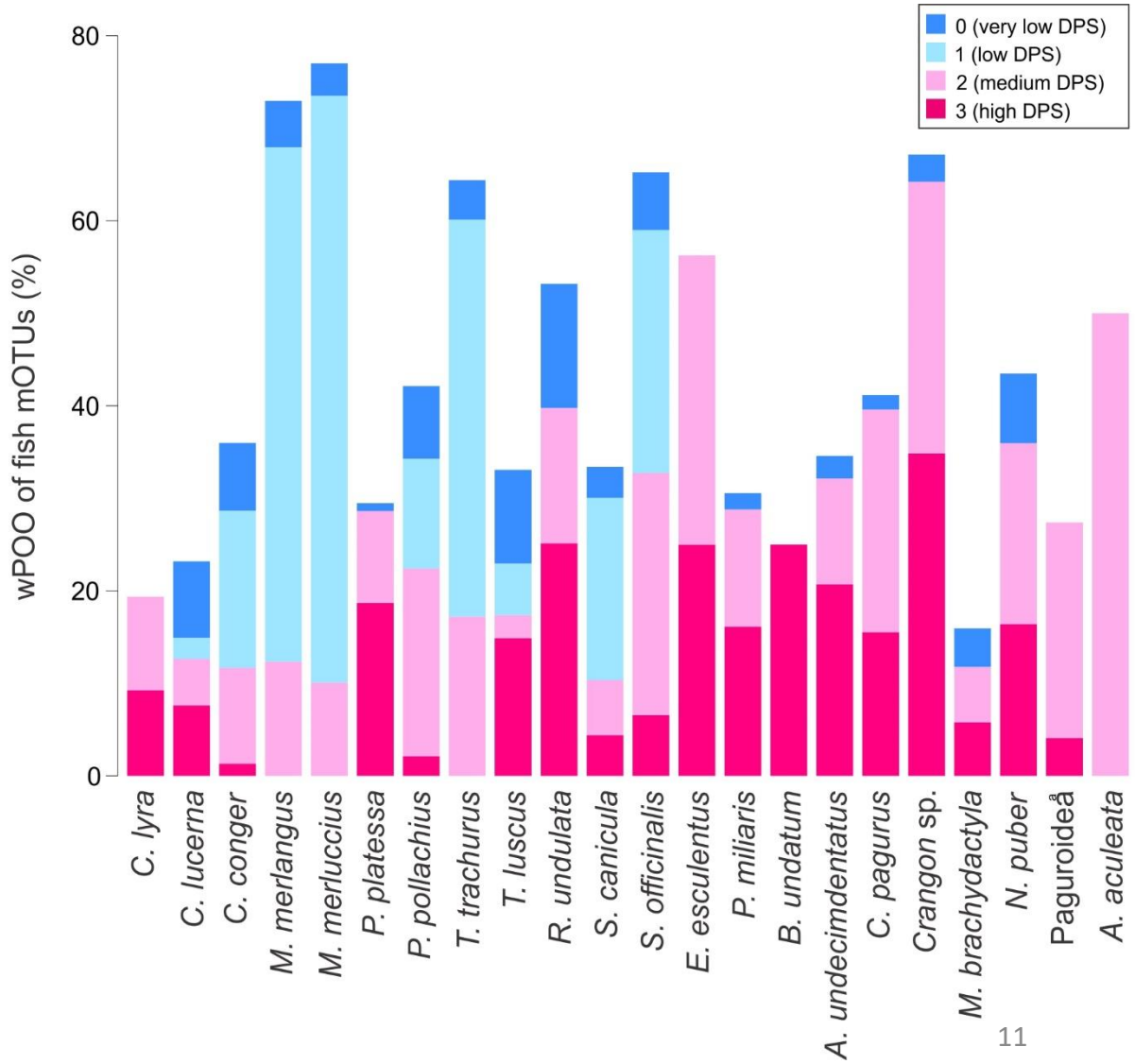
Diet contributions of potential discards (cumulated means) using mixsiar mixing models (Stock et al 2018):

- **Ray: 26%** (pelagic + high TL fish)
- **Squid: 19%** (high TL fish)
- **Crabs: 7-30%** (pelagic + high TL fish)
- **Buccinum and Aphrodita: 35-40%** (fish and crustaceans)

Metabarcoding – Prey classification according to their probability of being ingested as discards, a novel approach (Lejeune et al. in press: https://doi.org/10.1139/cjfas-2021-0267)

« Discard Probability Score » (DPS):
Prey = discard: 0 (very low probability) → 3 (high probability)



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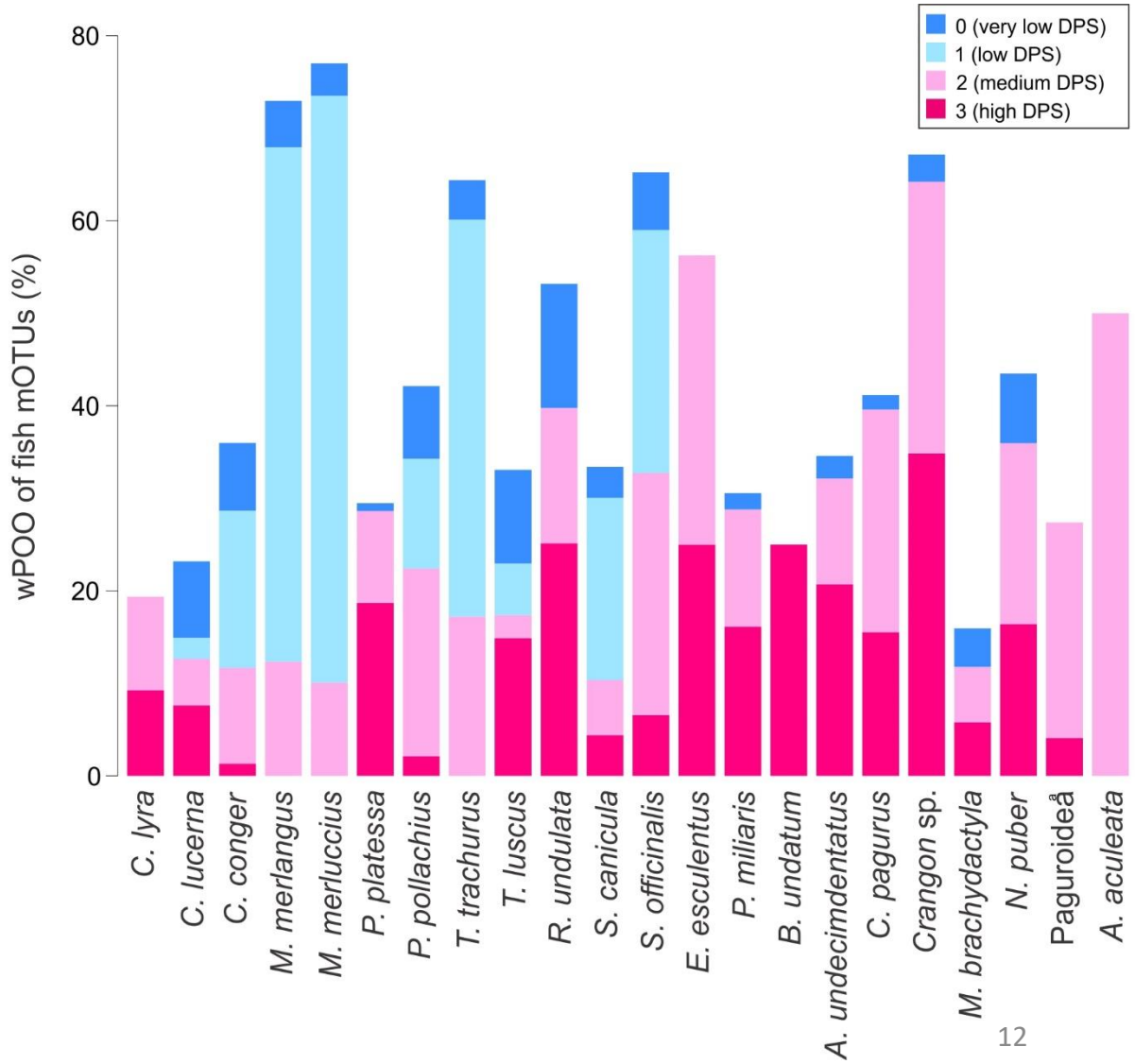
***in situ* discard frequency:**
Score: 0 → 2

- *in situ* observations
- OBSMER database



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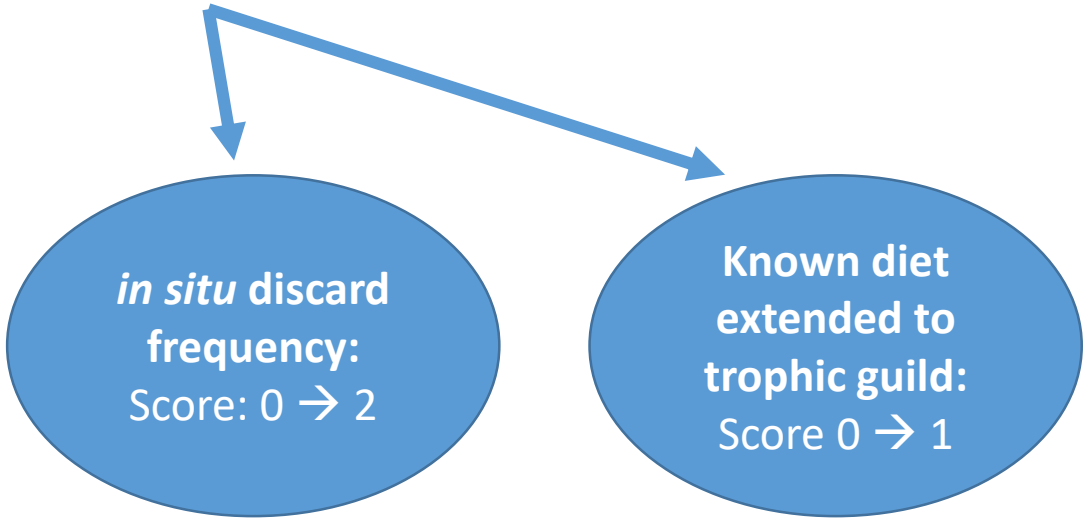
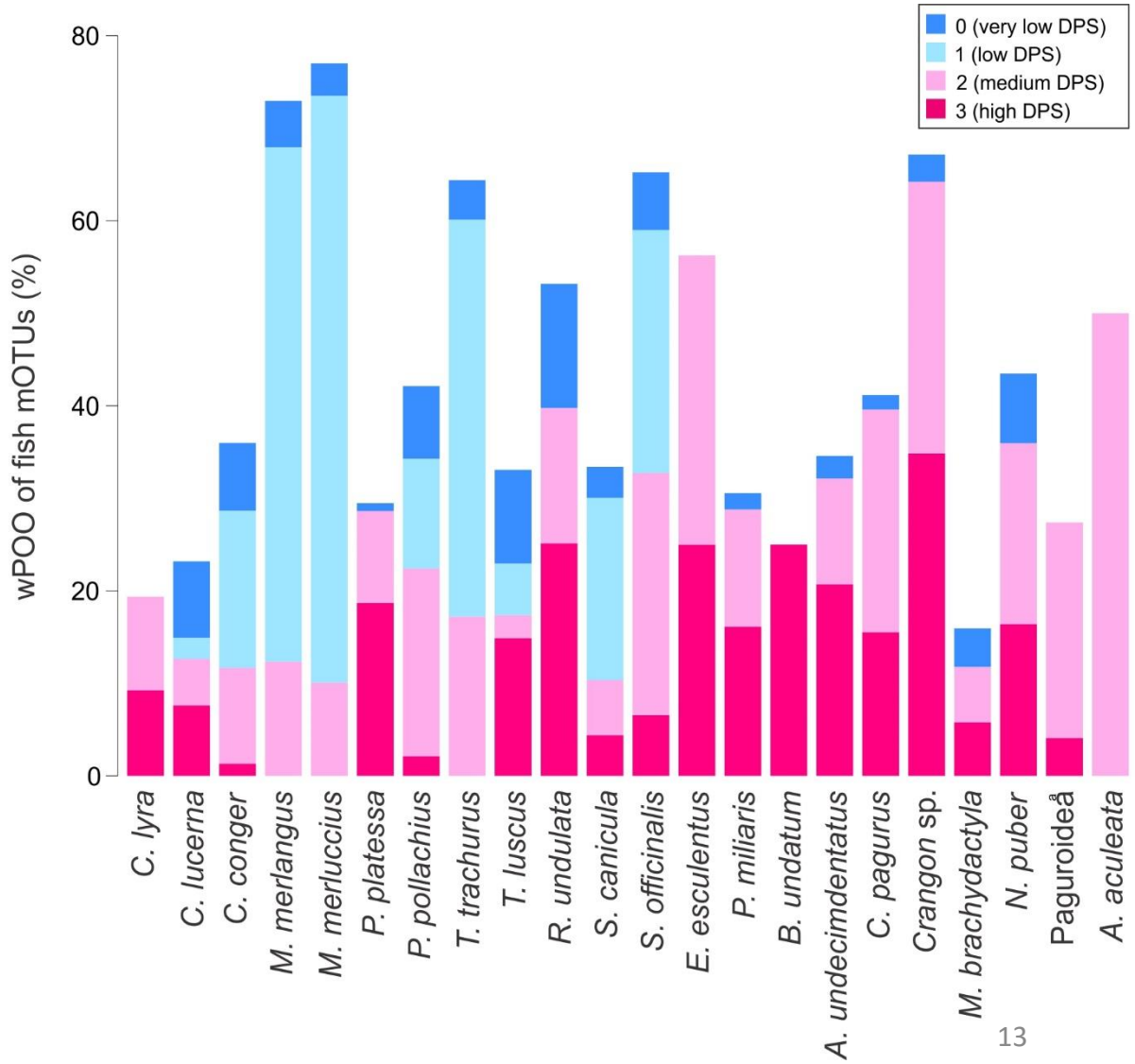


- *in situ* observations
- OBSMER database

- Fishbase, Sealifebase, DAPSTOM, ICES 'year of the stomach' + complementary literature



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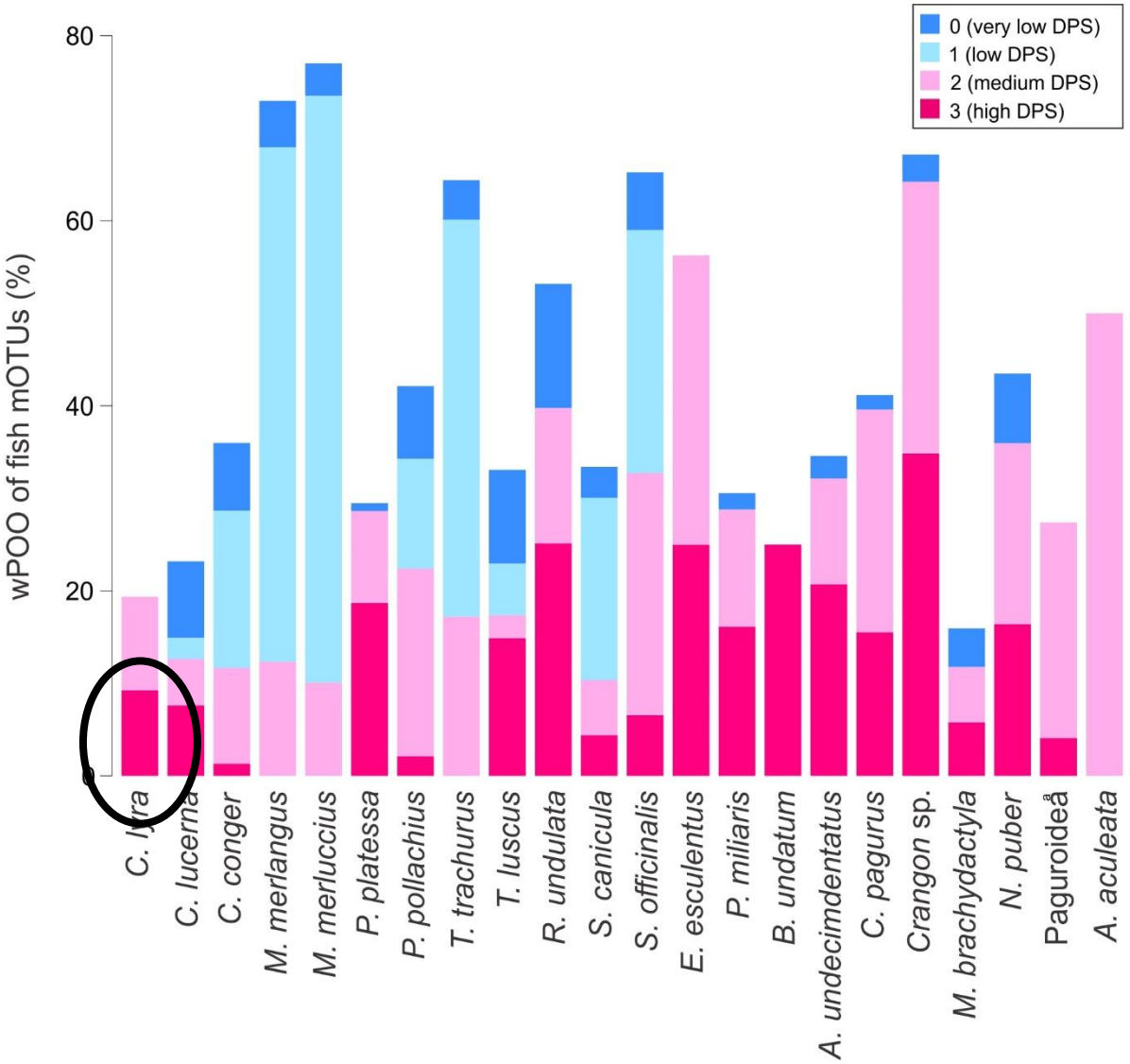

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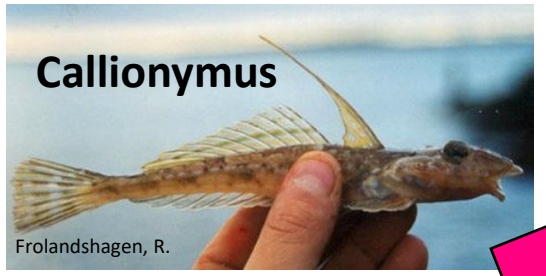

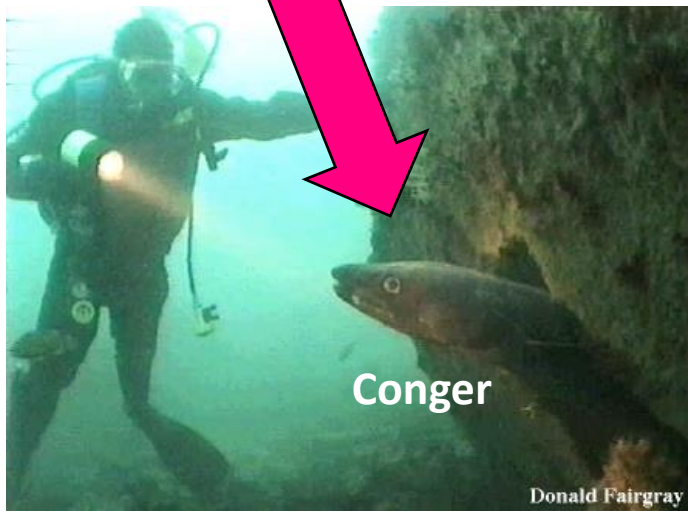

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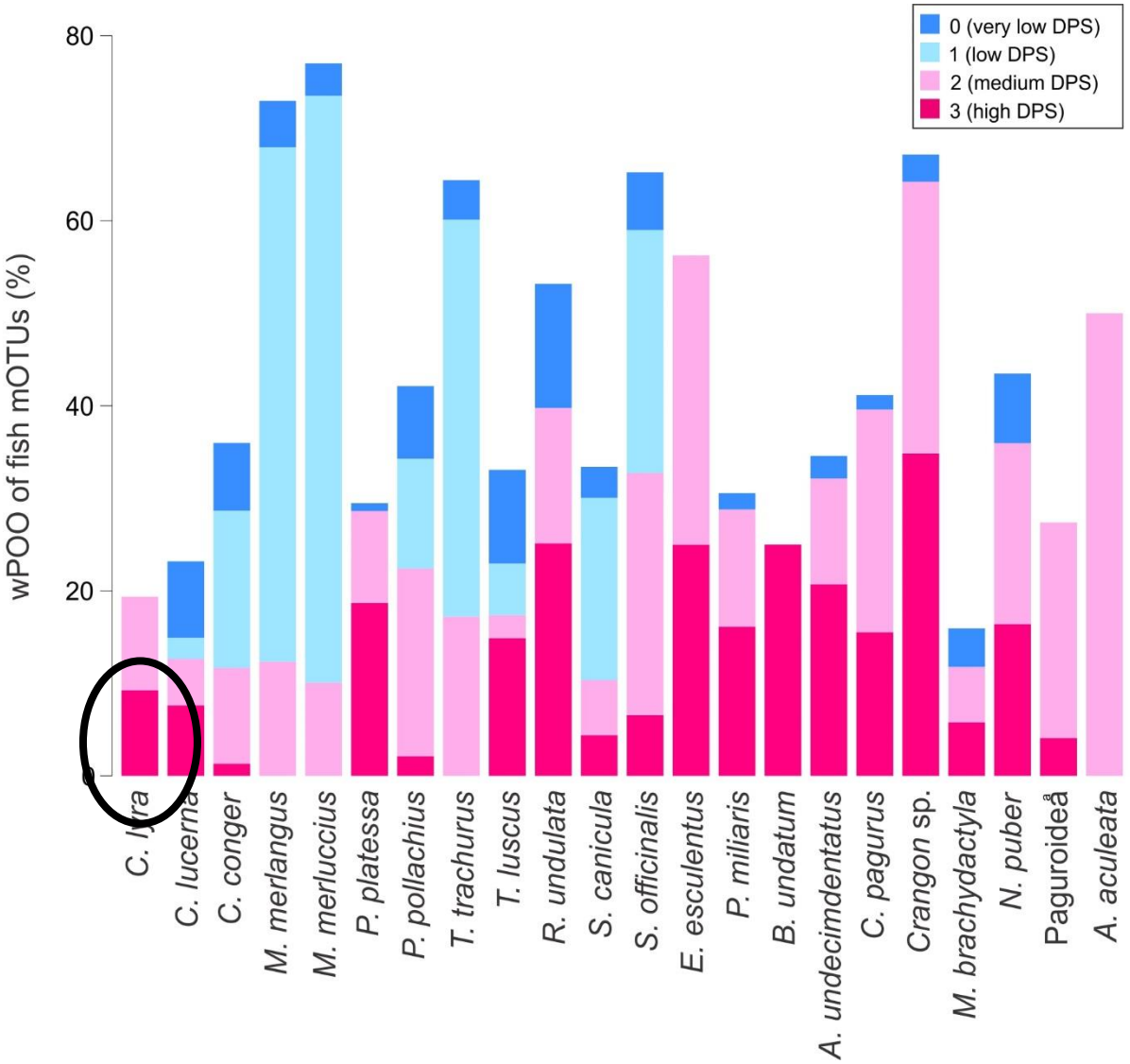

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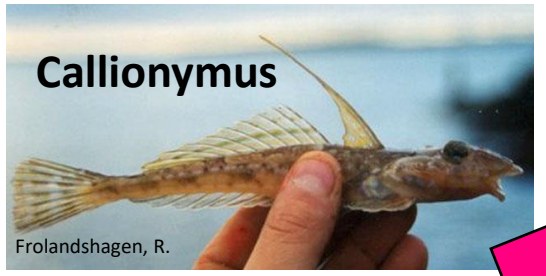
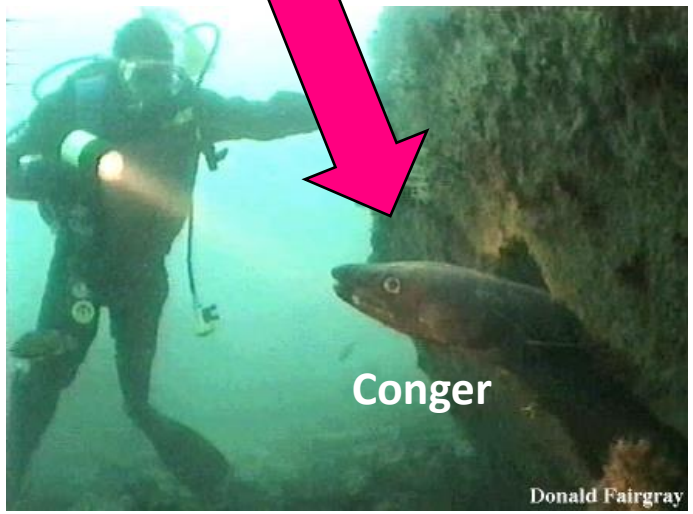
Conger
= highly frequently discarded → **+2**





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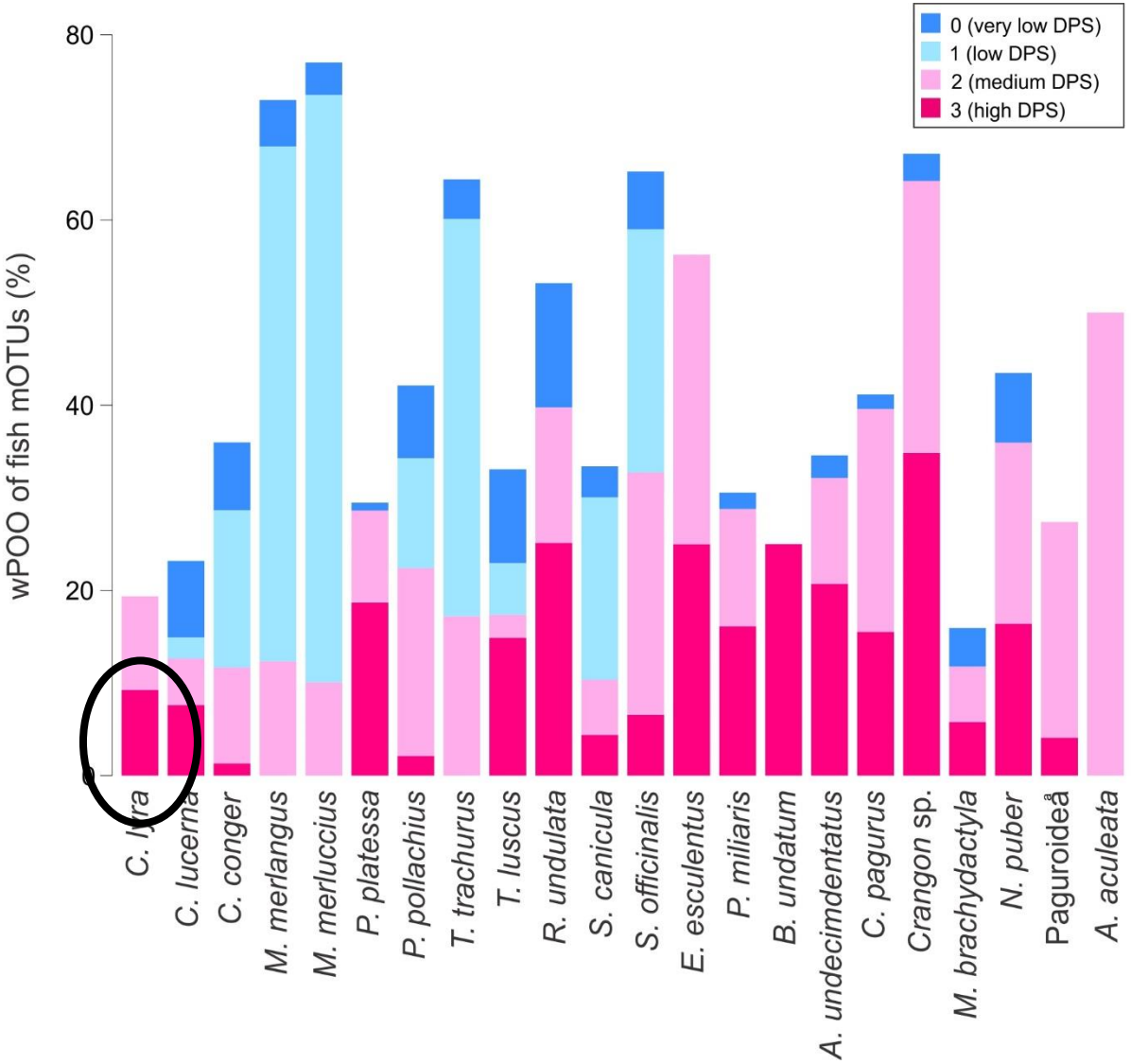

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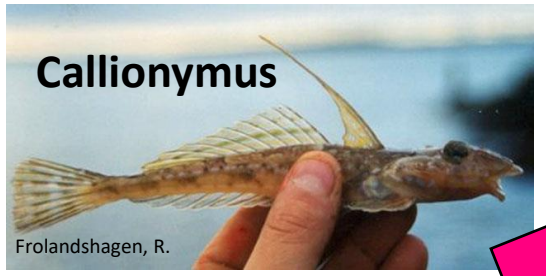
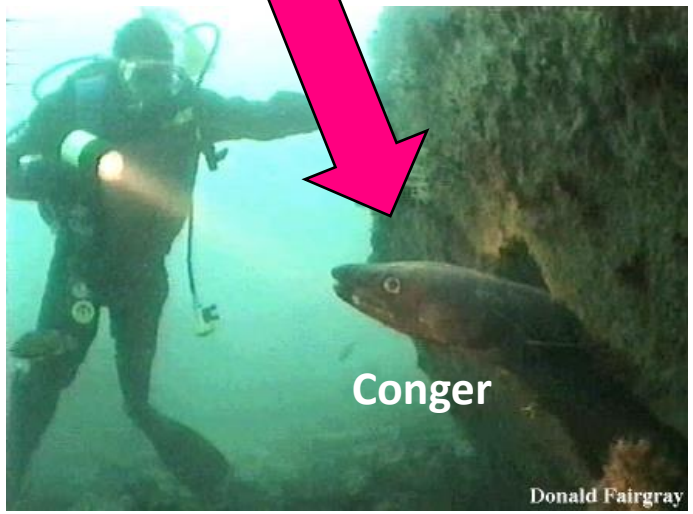
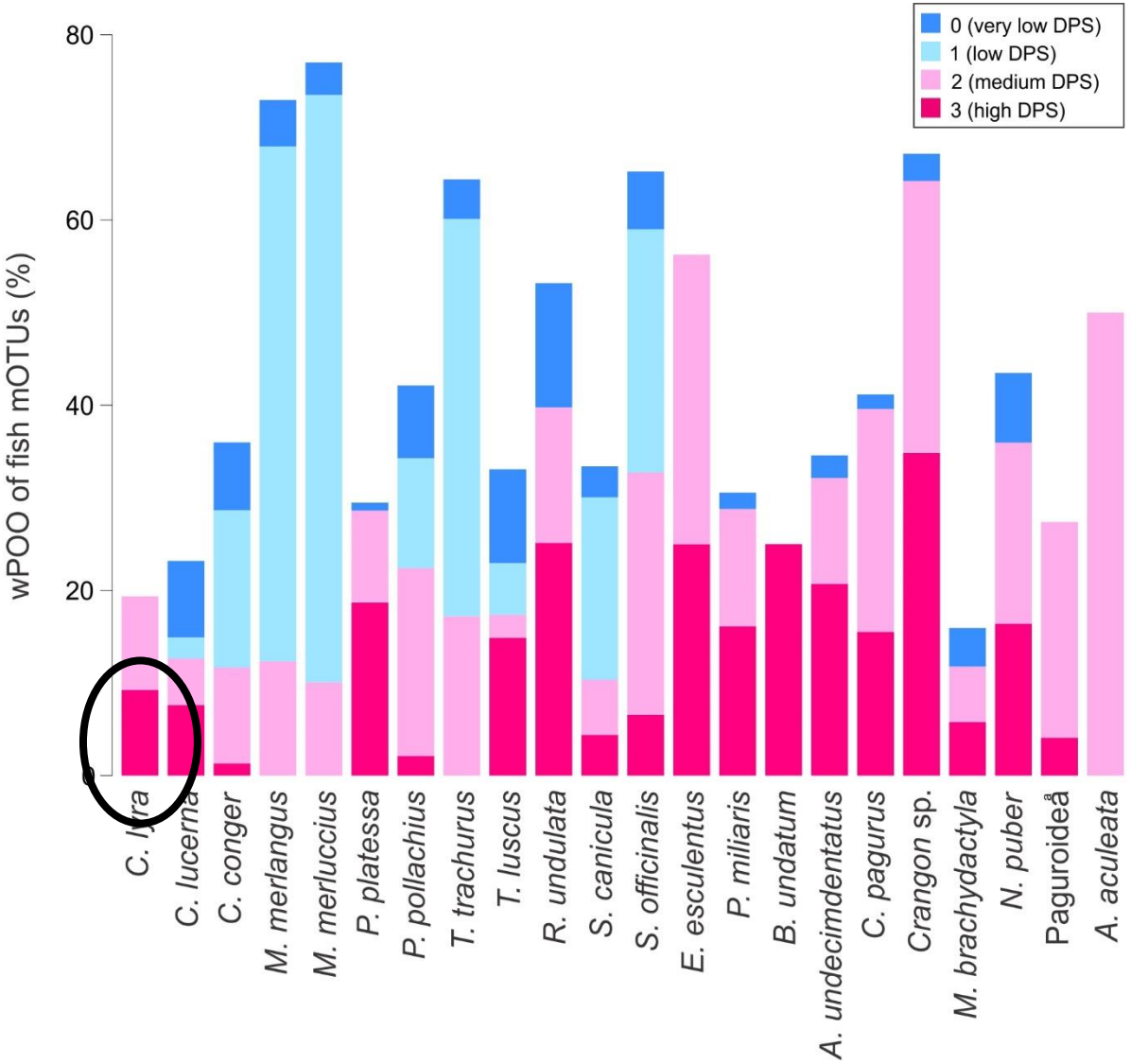


Conger
= highly frequently discarded → **+2**
= Unknown prey of Callionymus AND any other species belonging to the same trophic guild (Thompson *et al,* 2020)
→ **+1**

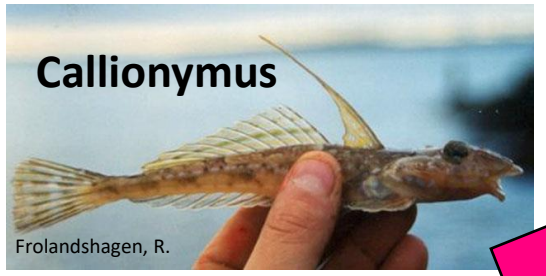


Metabarcoding – Prey classification according to their probability of being ingested as discards, a novel approach (Lejeune et al. in press: https://doi.org/10.1139/cjfas-2021-0267)



« Discard Probability Score » (DPS):

Prey = discard: 0 (very low probability) → 3 (high probability)



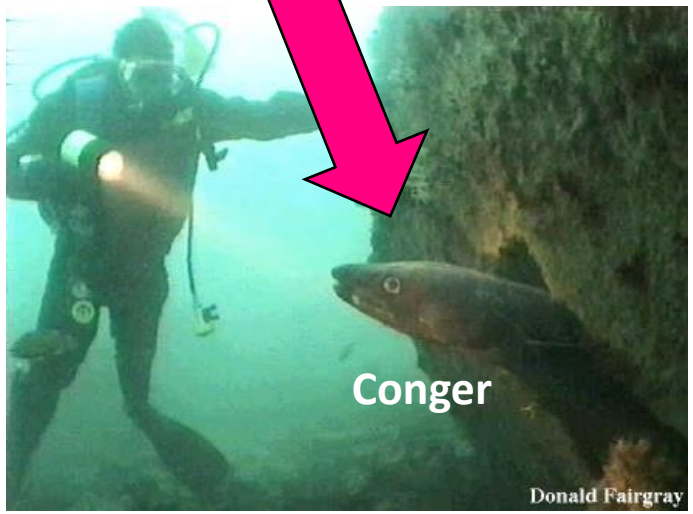
Conger

= highly frequently discarded → **+2**

= Unknown prey of Callionymus AND any other species belonging to the same trophic guild (Thompson *et al*, 2020)

→ **+1**

→ **DPS = 3**



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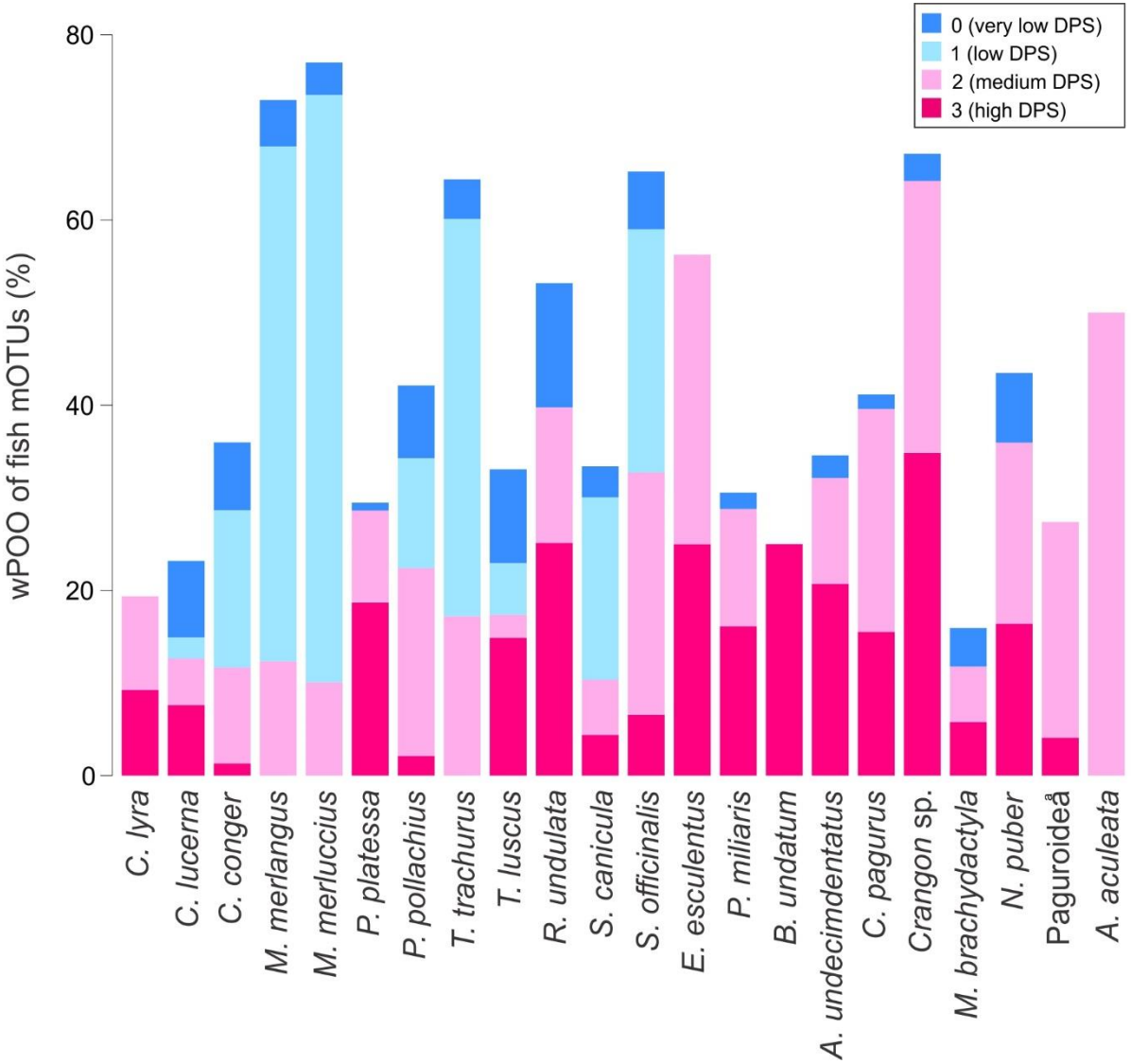

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→ 18/22 sp. ingested « highly probable » discards (DPS = 3)

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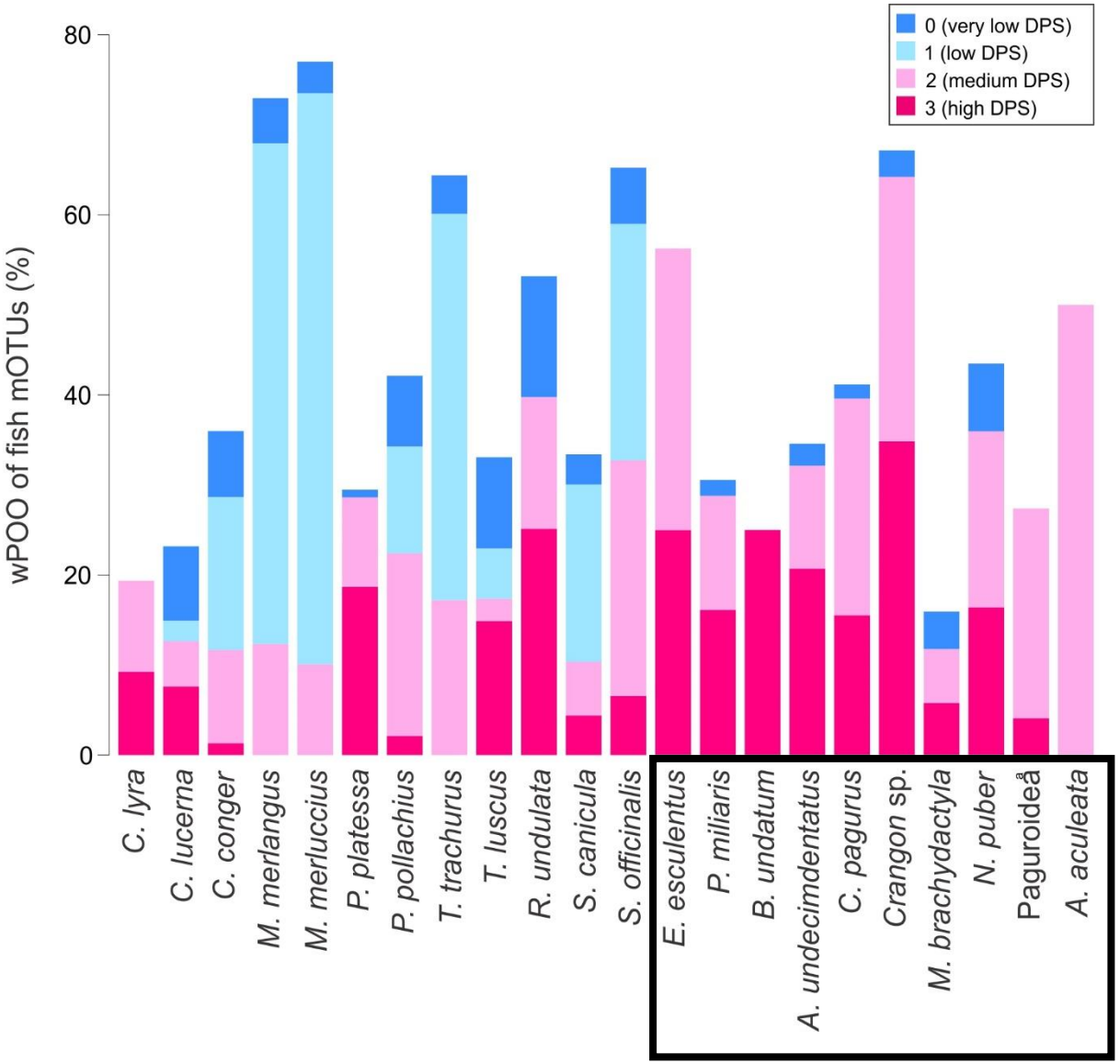

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→ Benthic invertebrates: potential discard consumption is important and main source of fish

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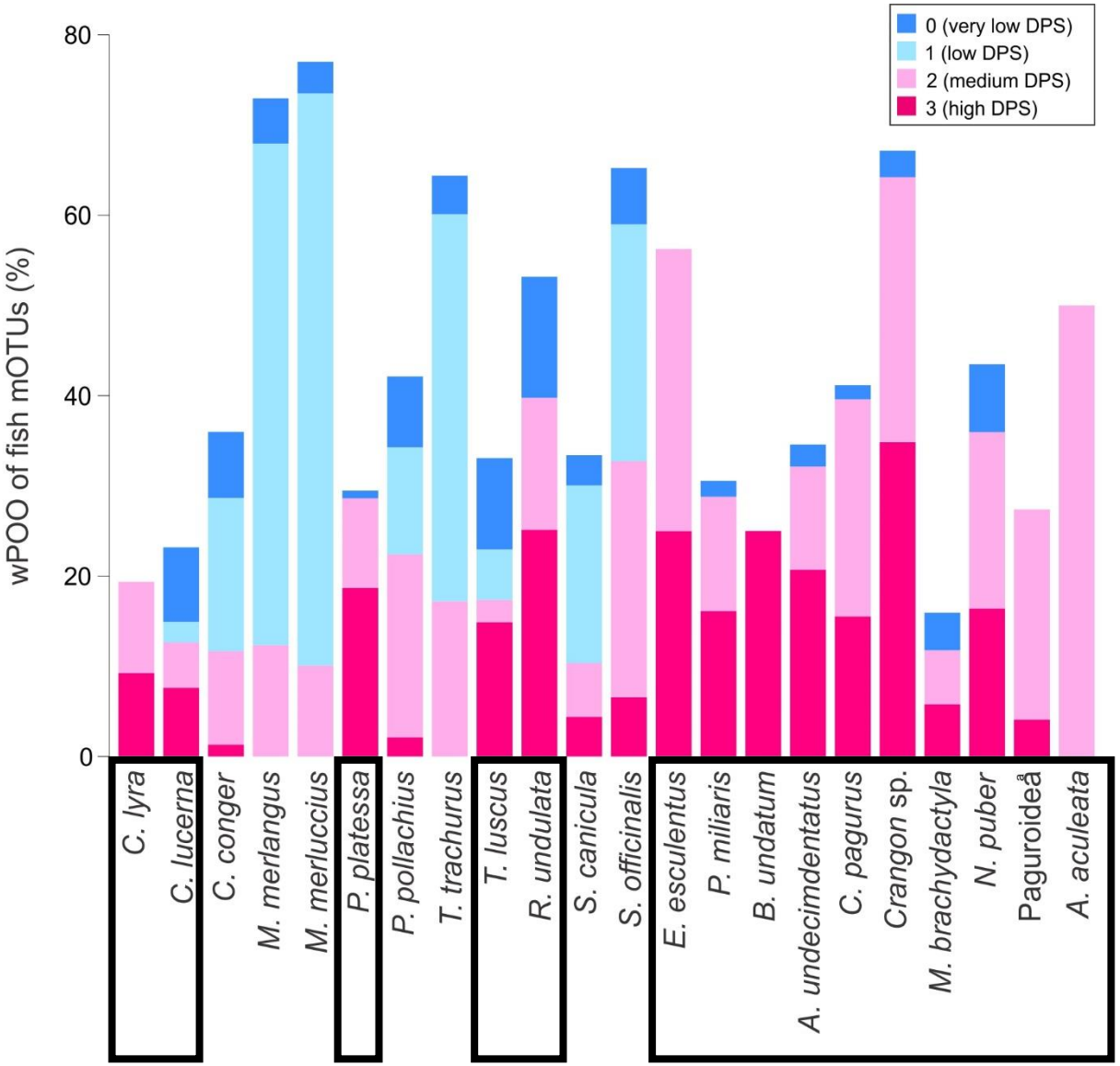

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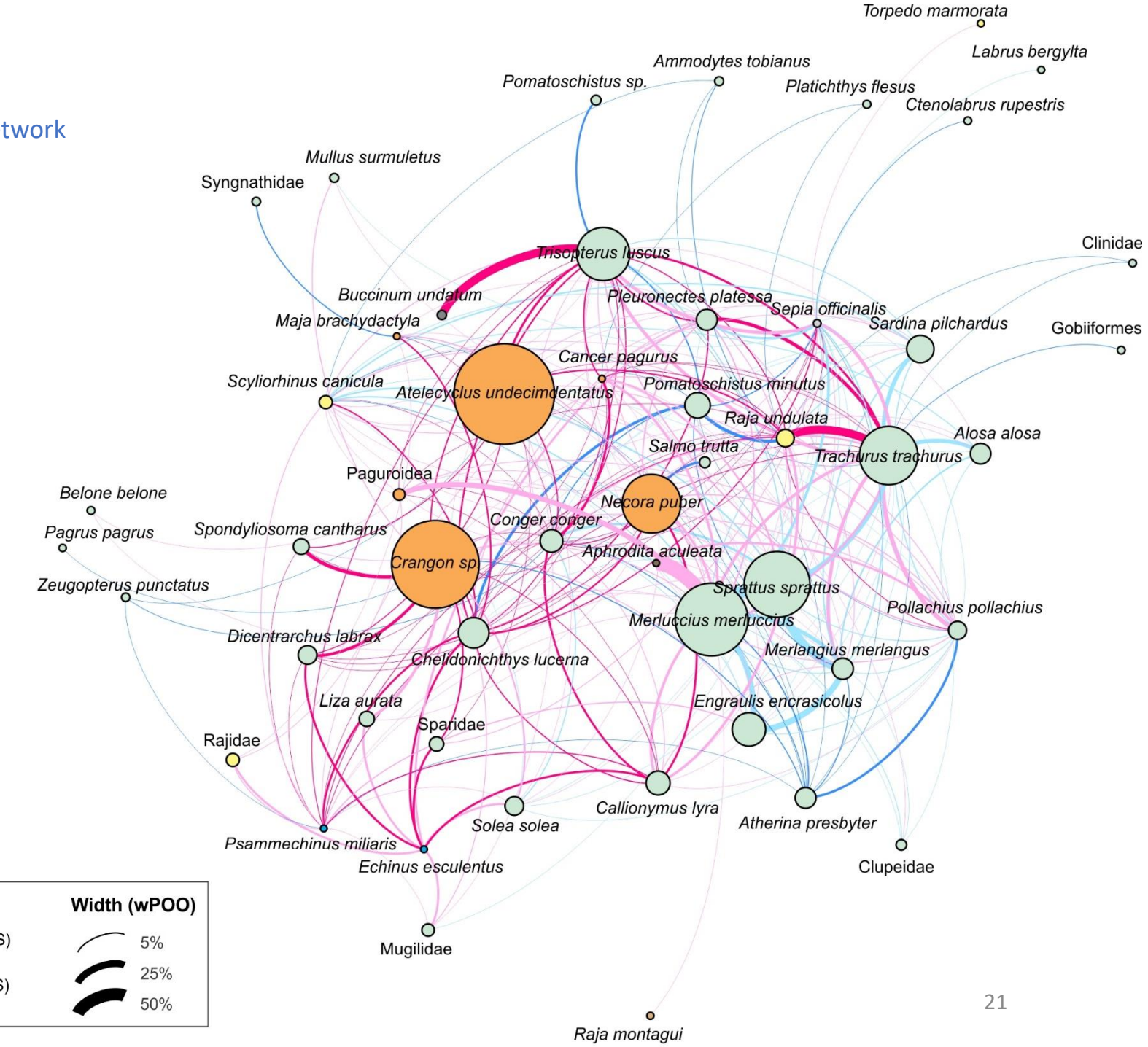
→ **Benthic invertebrates: potential discard consumption is important and main source of fish**

→ **Fish:** potential discard consumption is variable, but:

- Fish probably almost exclusively consumed as discards in **Callionymus** and **plaice**
- Discard consumption probably less important in higher trophic level fishes

Molecular ecological network Analysis

ForceAtlas2 algorithm to depict modular aspect of the network



Node

Taxonomic affiliation	Size (weighted in-degree)
Actinopterygii	0
Chondrichthyes	80
Cephalopoda	
Echinoidea	
Gastropoda	
Malacostraca	160
Polychaeta	

Trophic link

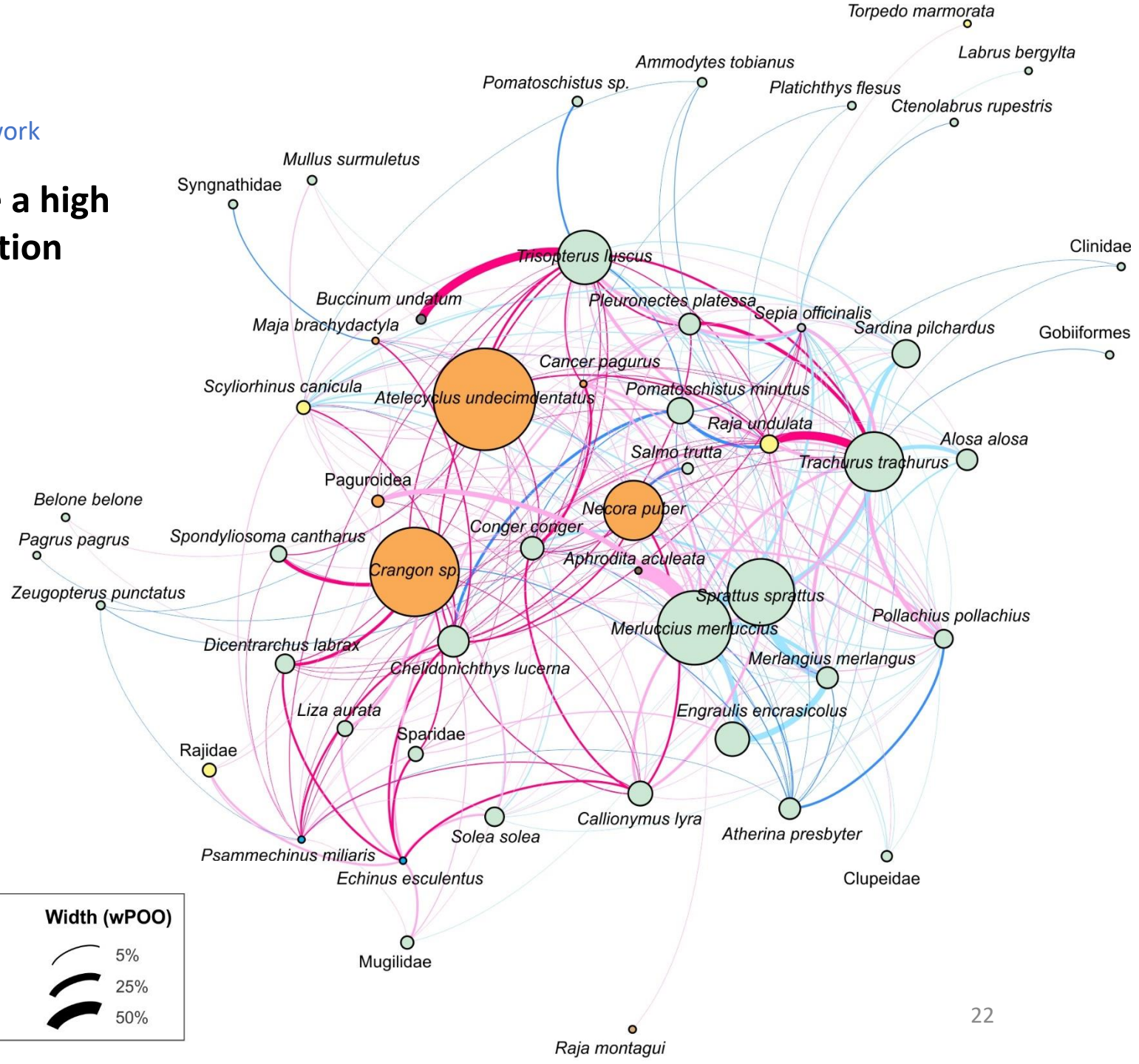
DPS	Width (wPOO)
0 (very low DPS)	5%
1 (low DPS)	25%
2 (medium DPS)	50%
3 (high DPS)	

Molecular ecological network Analysis

ForceAtlas2 algorithm to depict modular aspect of the network

Most interactions with « fish » prey have a high probability of involving discard consumption

➔ 66% DPS > 2, including **26% DPS = 3**



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Molecular ecological network Analysis

ForceAtlas2 algorithm to depict modular aspect of the network

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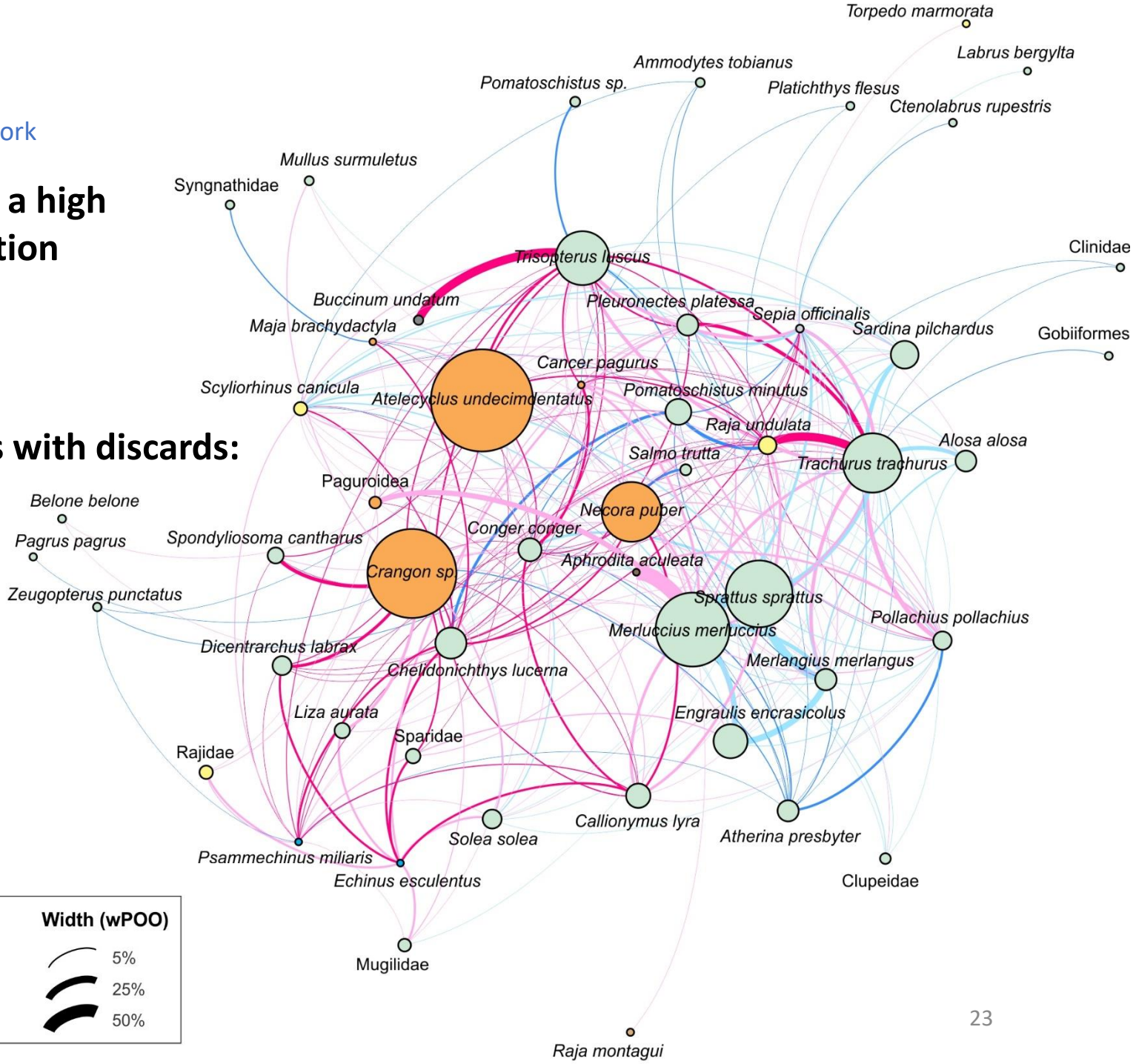
Functionally important species have links with discards:
(weighted in-degree + eigenvalue centrality)

➔ Decapods (crabs, shrimps)
= important discard consumers

➔ Fish (Hake, Horse mackerel, Pout)
= frequently discarded species



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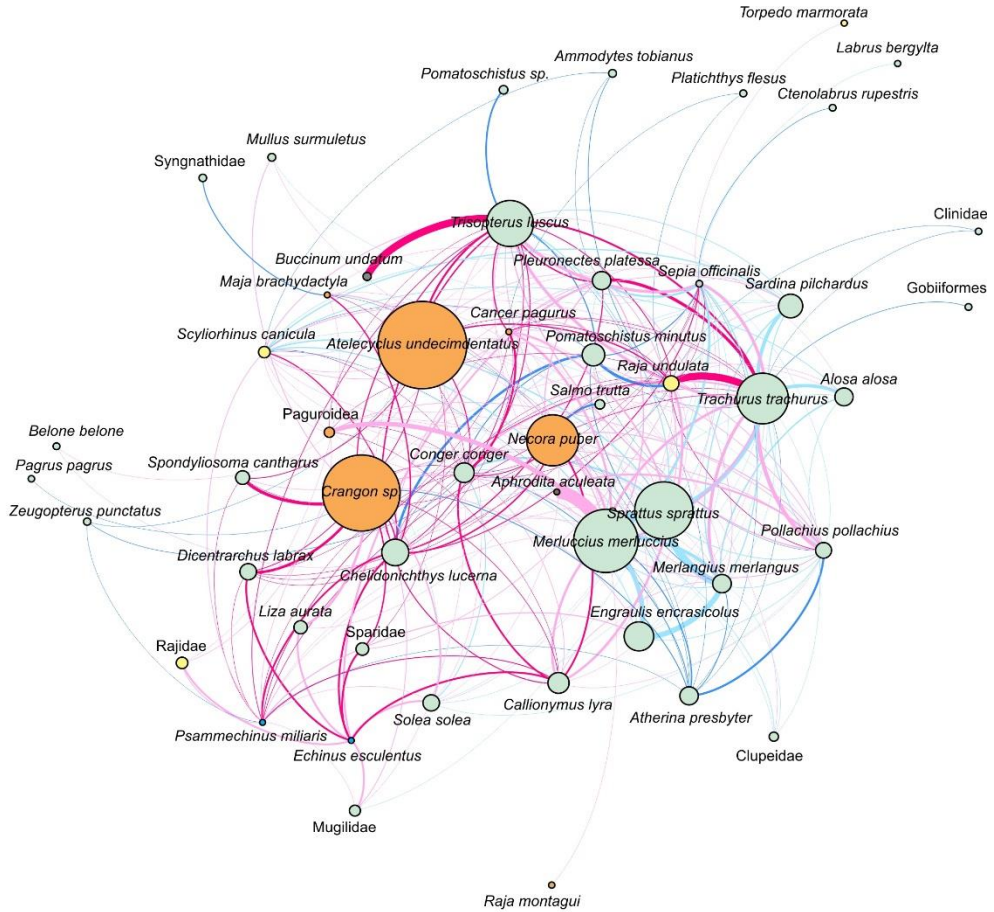
Discussion and perspectives

➔ **Analysis of TL** reveals that **benthic invertebrates, squids and rays depict potentially higher TL**, but stable isotopes alone provide low resolution in diet description



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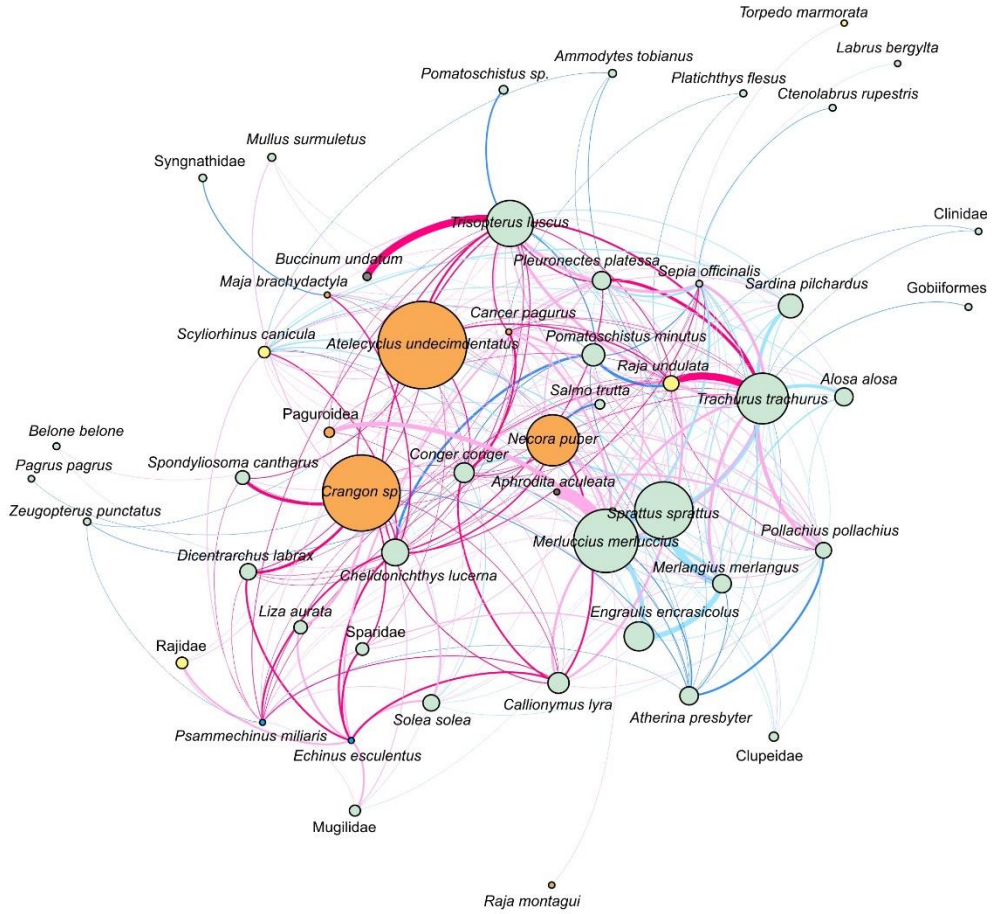
➔ Coupling **metabarcoding** with prey classification using discard probability score **could help advance research on discard consumption:**

- **Discard consumption** is **potentially important** and **generalized** across the studied bentho-demersal community
- **Discards may support functionally important species** (e.g. Decapods), suggesting the possibility of cascading effects in cases of discard reduction



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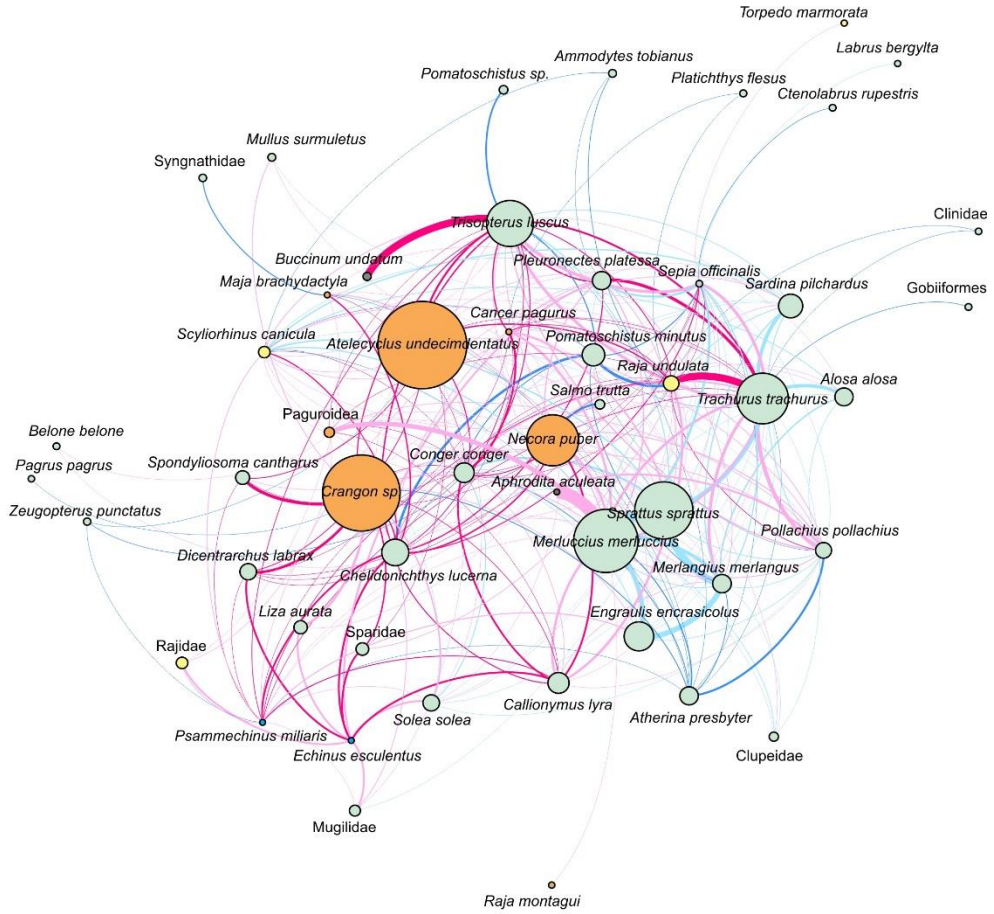

➔ Repeated measures and expansion to other areas are necessary to confrim and refine results ➔ **Goal = Improve ecosystem models where trophic links with discards could be currently underestimated**

➔ **Reducing bycatch and discards remain conservation priorities**, but it is **crucial to better understand discard reintegration in marine food webs** to anticipate consequences of discard reduction on the functioning of marine ecosystems subject to fishing

OCEAN SCIENCES MEETING 2022

Thank you !

Published work:

Lejeune Benjamin, Mouchet Maud Aline, Mehault Sonia, Kopp Dorothee **Gut content metabarcoding reveals potential importance of fisheries discards consumption in marine fauna**. *Canadian Journal of Fisheries and Aquatic Sciences* **IN PRESS**. https://doi.org/10.1139/cjfas-2021-0267

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