Estimating seafloor pressure from trawls and dredges based on gear design and dimensions

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Establishing demersal gear traits

1. Obtain vessel and gear data from industry survey
2. Define functional groups from gear and target species knowledge
3. Estimate vessel size ~ gear width relationships by groups/metiers
4. Break down total swept area into partial contributions from primary gear components
5. Assign physical impact level of individual components based on review of the scientific literature
6. Establish integrated seafloor footprints by group/metier

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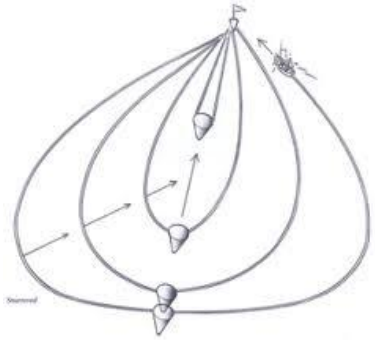
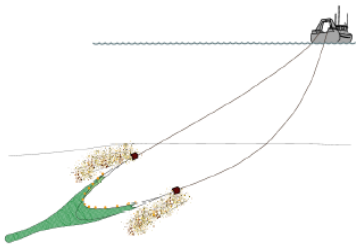
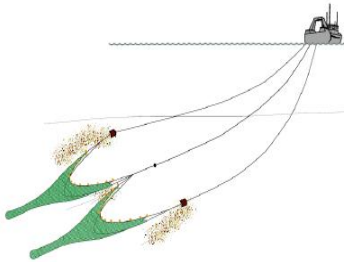
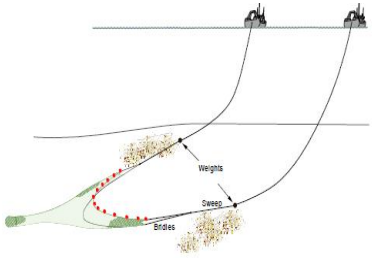
Common active demersal gears

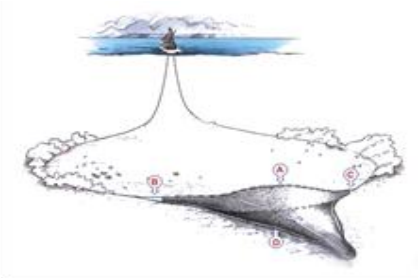




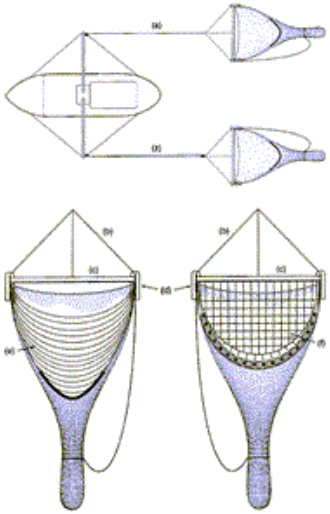




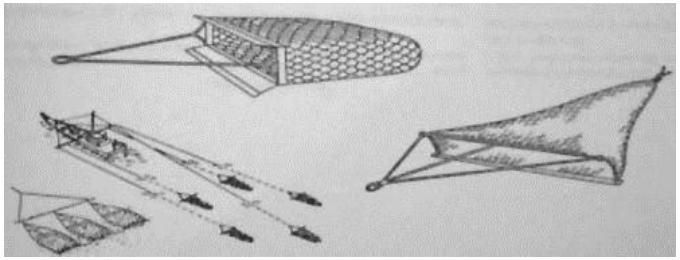
Otter trawls



Demersal seines



Beam trawls



Dredges

(Illustrations from FAO)

OT_Questionnaire

Country:			
Fishing area:			**Bottom trawls**
Date:			*BENTHIS-2013*
vessel:			(partner)
Trawl	type and name		
Trawling mode*	one or two vessels (single or pair trawling)		
Rigging	number of trawls per vessel		
Net maker	company name		
Codend	stretched mesh size (mm)		
Target species	single species fishery: cod, plaice, Nephrops, etc. or mixed fishery: "cod, haddock and saithe", "nephrops and monkfish", etc. (common name(s) + FAO-code)		
Bottom type	bedrock, hard bottom, sand, hard clay, mud		
Vessel	engine power in kW		
	tonnage in GRT		
	Loa: overall length in metres		
Trawl circumference	number of meshes		
	stretched mesh size (mm)		
Trawl	Trawl height (metres)		
	Wing spread (metres)		
Doors	pelagic or bottom		
	number		
	producer and model		
	length (m)		
	height (m)		
	weight (kg)		
Door spread	door spread (metres)		
Sweeps	sweep length (metres)		
Bridles	number and length (metres)		
Tickler chains/lines	number		
	total weight of each chain or line (kg)		
Groundgear	length of groundgear (metres)		
	type, e.g. rockhopper, bobbins, discs, etc.		
	diameter of ground-gear (mm)		
	total weight of ground gear (kg)		
Clump	type (e.g. chain or roller)		
	weight of clump (kg)		
Other chains in gear	number and location in gear		
	total weight of each (kg)		

* In cases of pair trawling, it is sufficient with vessel information (kW, Lenght and GRT) from the vessel/skipper intervie

Trawling speed (knots):			
Steaming speed (knots):			
Fuel consumption trawling (litres/hour):			
Fuel consumption steaming (litres/hour):			
Consumption other activities (litres/hour and activity):			

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Survey coverage

	Institutes	OT	TBB	DS	DRB
Western Baltic / North Sea	DTU Aqua	72	2	65	
	SLU	98			
North Sea	IMR	6		17	
	IMARES	5	16		
	ILVO	8	29		
	Marine Lab	115			
Western waters	MI	60			33
	IFREMER	9			
Mediterranean	CNR (Mygears-Med)	508	9		
	HCMR	37			
Black Sea	CFRI	21	22		
	Total	939	78	82	33

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BENTHIS-metier definitions and gear data analyses

- Based on DCF- metier principles, target species biology and related catch principles (e.g. herding, non-herding) the joint partner data set of vessels and gears was divided into 14 different BENTHIS metiers corresponding approx. to DCF-metiers level 5½.

- The relationship between vessel size (Loa or kW) and gear size (gear width) was estimated for each BENTHIS-metier.

- Least squares means methodology was used for choosing between Loa and kW and between a power function link and a linear link in the gear size vessel size estimation procedure.

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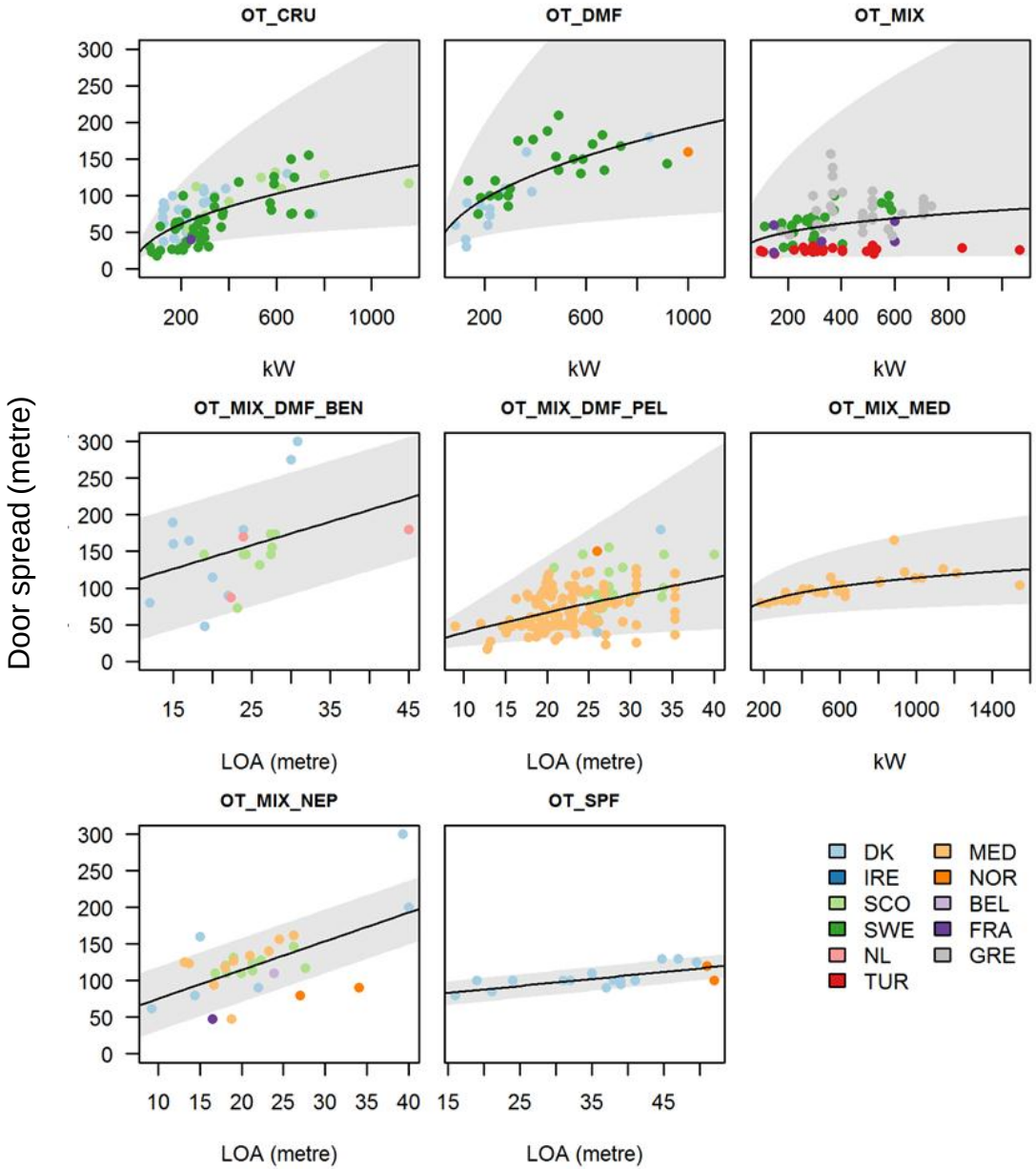
OT vessel size ~ Door spread relationships



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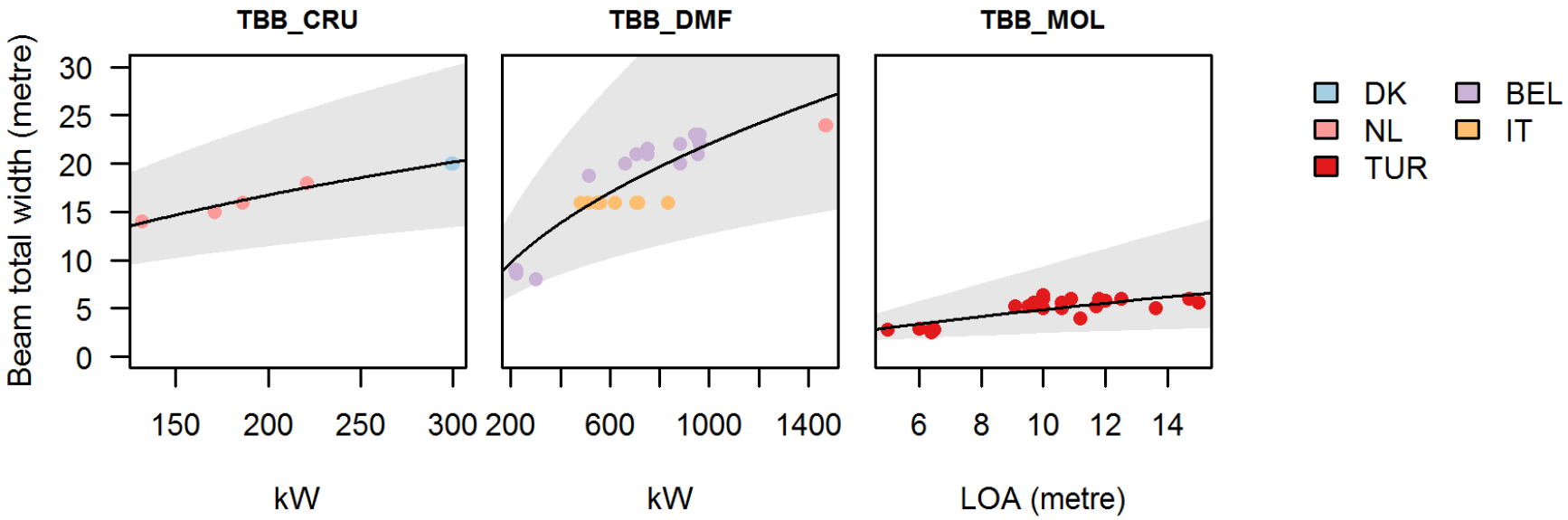
Outliers – e.g. Danish multi-rig for Nephrops (12 trawls)

TBB vessel size ~ total beam width



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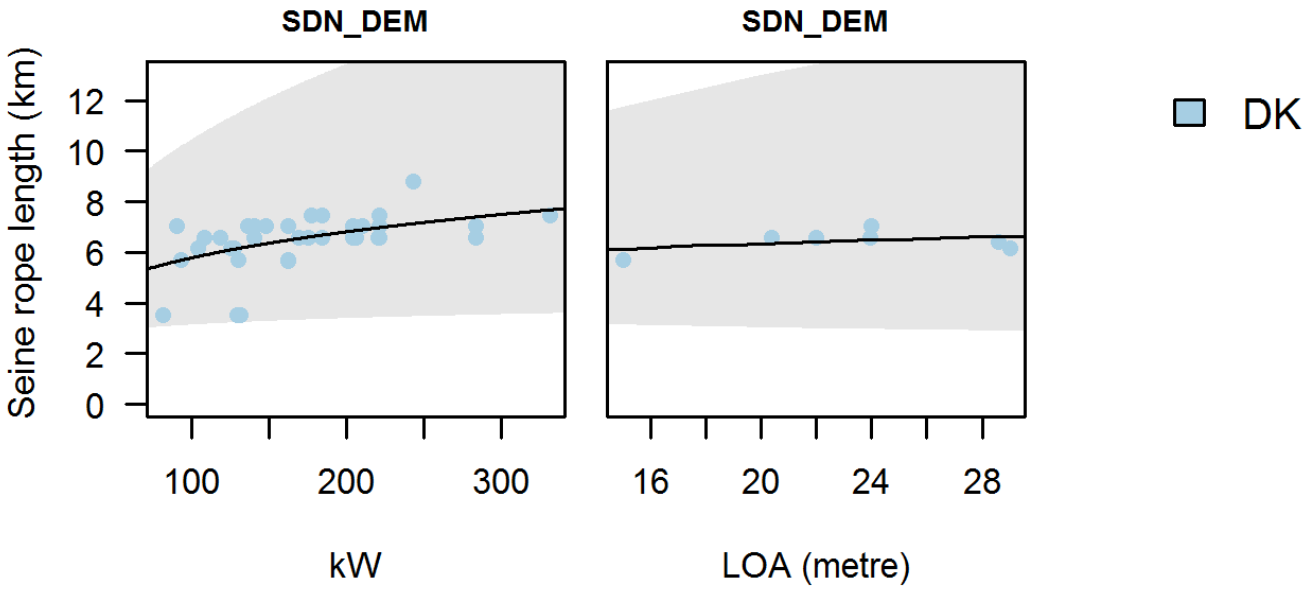
SDN and SSC vessel size ~ seine rope length relationships



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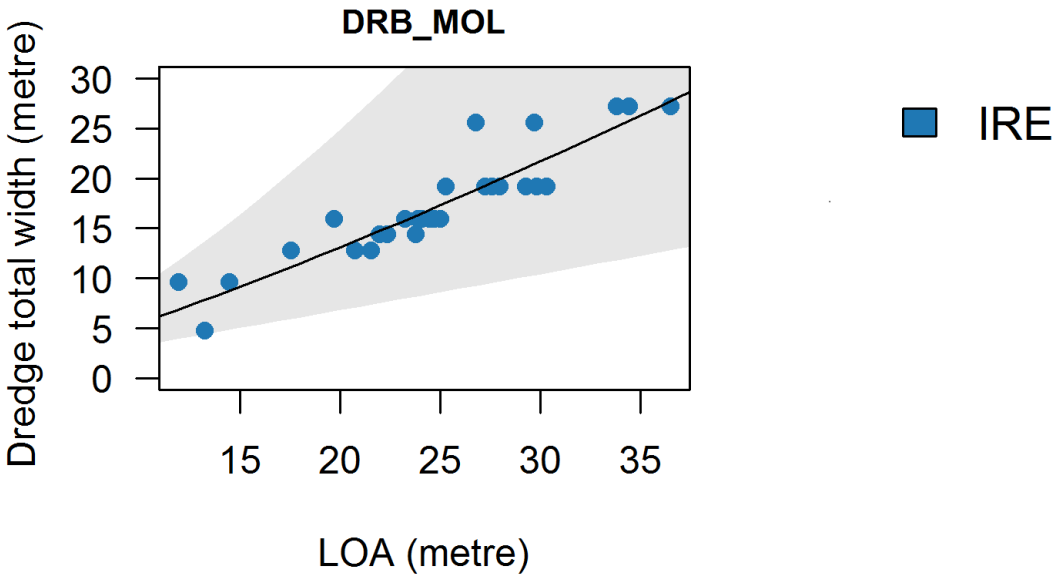
DRB vessel size ~ gear size relationships



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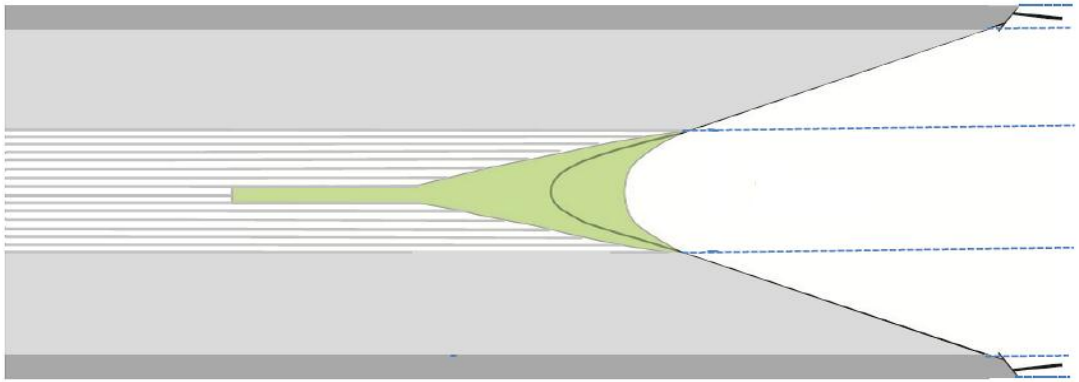
OT (OTB+OTT+PTB) seafloor footprint



Doors /clump /weights

Sweeps and bridles

Groundgear

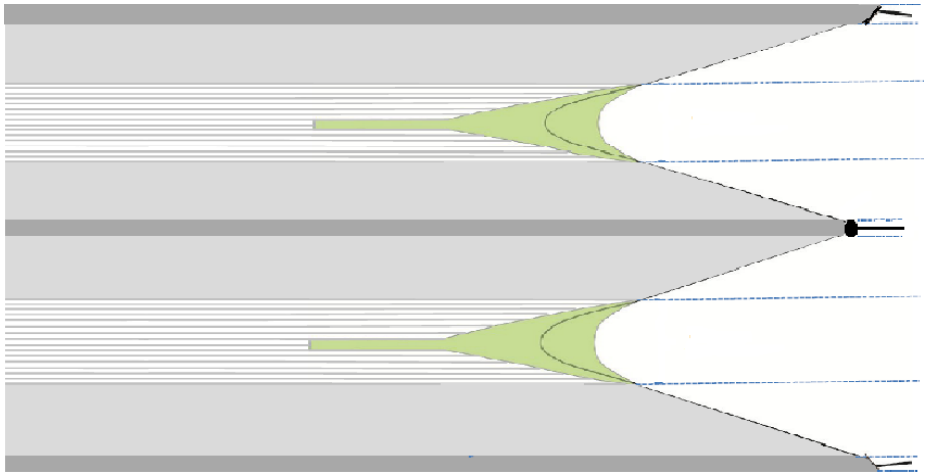


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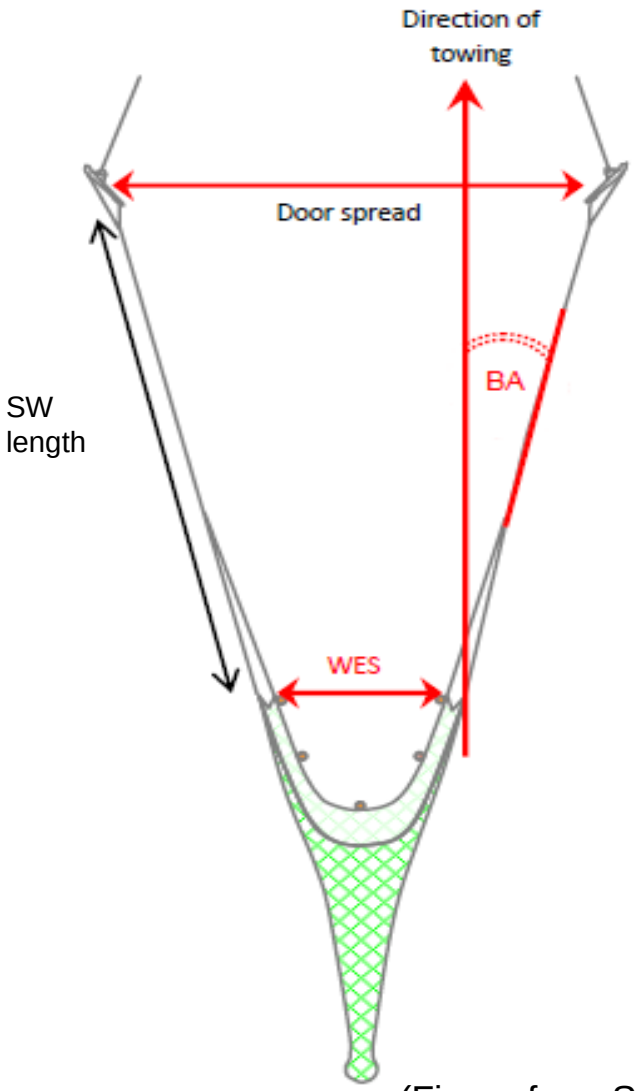
Illustration modified from figure in Buhl-Mortensen et al. 2013

Trawl geometry theory

Abbreviations
WES = wingend spread
BA = bridle/sweep angle
PW = path width
GG = groundgear
SW= sweeps+bridles
DO = doors

Assumptions:
PW_GG = 0.4 * GG_Length
PW_ SW = sinus (10º) * SW_length
PW_DO = 0.4 * DO_length

(assumptions based on Valdemarsen et al., 2007 and SEAFISH, 2010)



(Figure from SEAFISH, 2010)

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Relative path widths of OT gear components

		Average path width (% of total gear width)		
	Observations	Doors and clump(s)	Sweeps and bridles	Groundgear
OT_SPF	4	3,3 (±0,1)	57,3 (±1.5)	39,3 (±0.2)
OT_CRU	30	2,5 (±0.9)	61,0 (±17.8)	36,4 (±17.4)
OT_MIX_NEP	14	1,9 (±1.0)	66,3 (±15.0)	31,8 (±10.5)
OT_MIX_DMF	109	2,0 (±0.5)	69,1 (±17.4)	28,9 (±13.2)
OT_MIX_MED	43	1,3 (±0.2)	71,0 (±7.6)	27,6 (±8.0)
OT_DMF	7	1,6 (±0.3)	76,7 (±16.7)	21,7 (±8.4)
OT_MIX	24	1,9 (±0.5)	84,1 (±16.7)	14.0 (±14.7)

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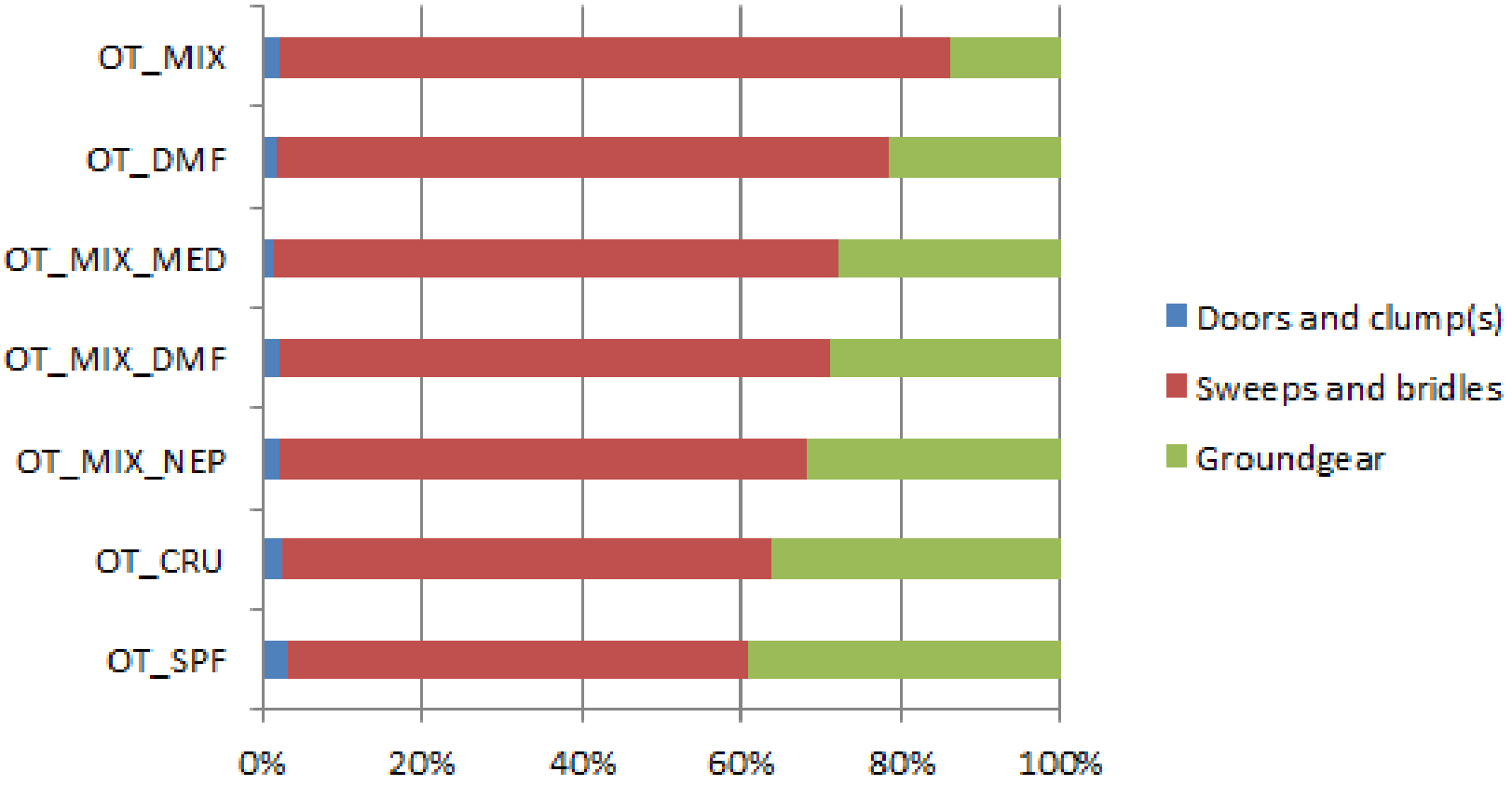
Relative gear width contributions of OT_components



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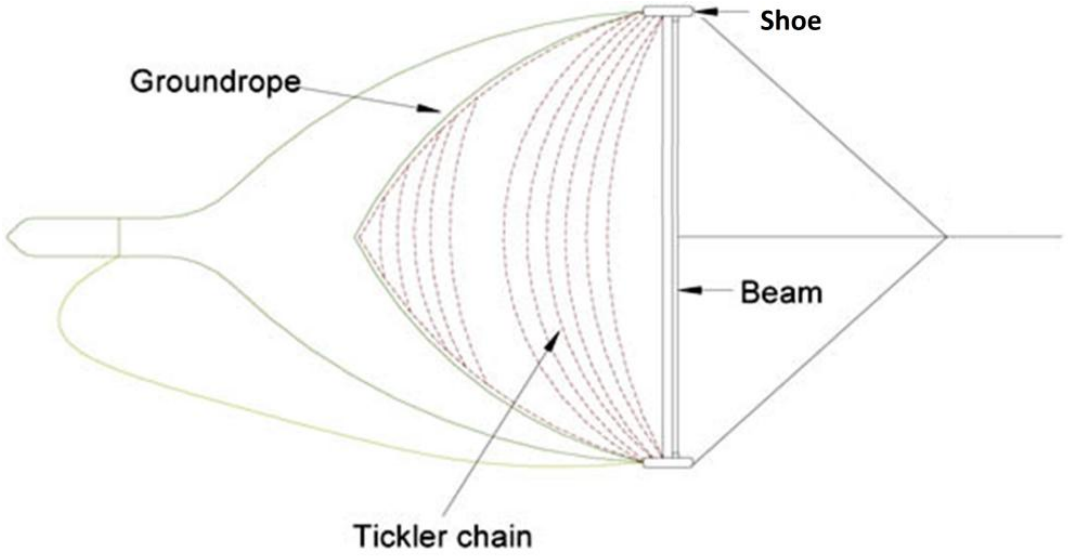
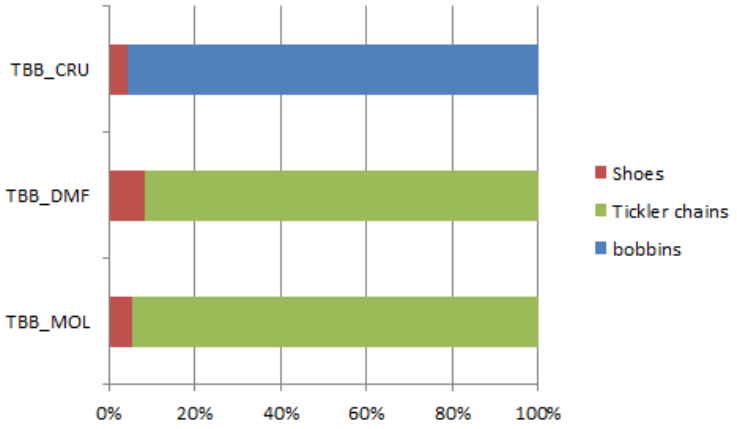
TBB seafloor footprint



		Average path width (% of total gear width)		
	Observations	Groundgear	Shoes	Tickler chains
TBB_CRU	7	95,6 (±2.1)	4,3 (±2.1)	No chains
TBB_DMF	34	91,7 (±3.4)	8,3 (±3.4)	91,7 (±3.4)
TBB_MOL	22	94,5 (±0.8)	5,5 (±0.8)	94,5 (±0.8)



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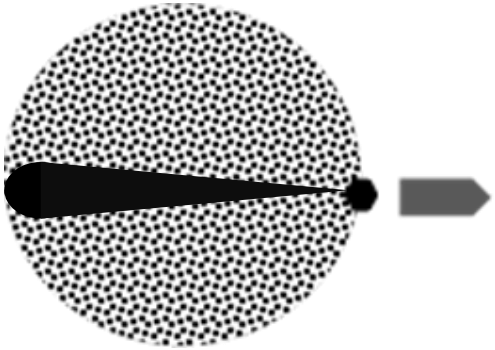
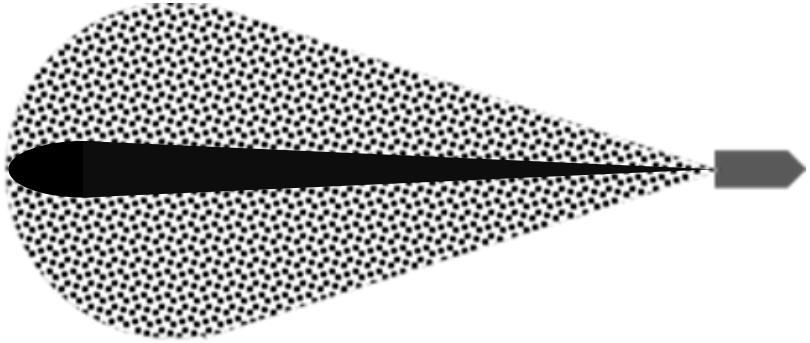
DS seafloor footprint assumptions

- SDN swept area = $\pi * r^2$, where r is total rope length/2π
- SSC swept area = 1½ * SDN swept area
- Seine rope impact area 90%
- Ground gear impact area = 10%





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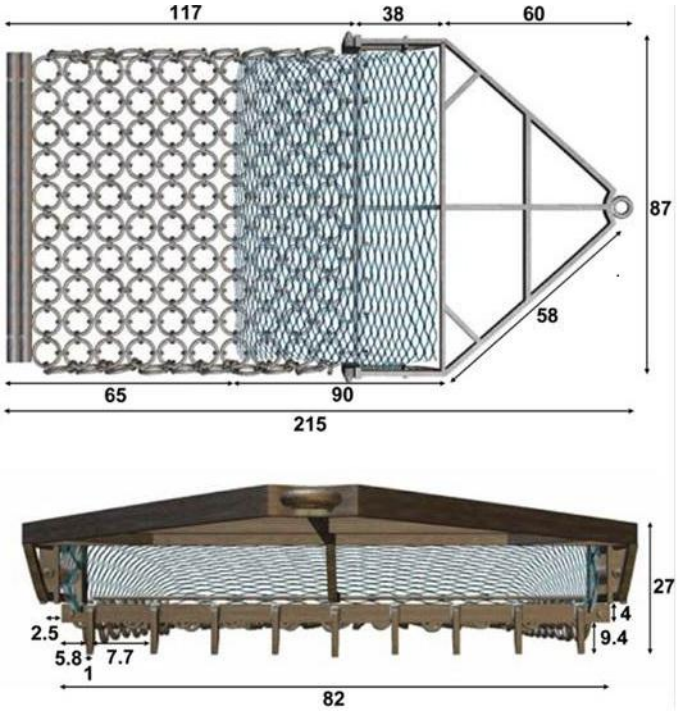
DRB seafloor footprint



Scallop dredge (from O'Neill et al., 2013)

Sheering edge width = 100%

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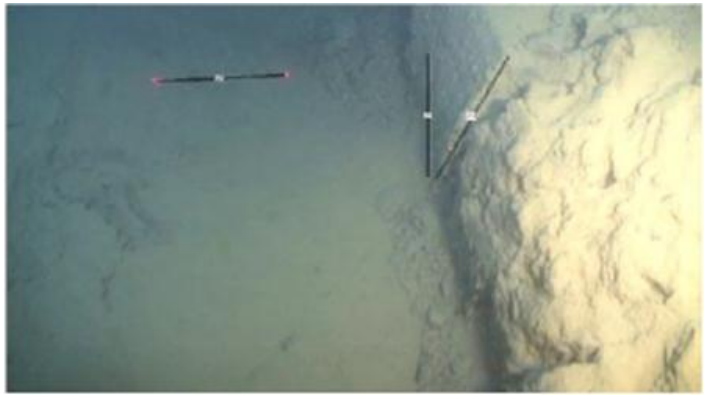
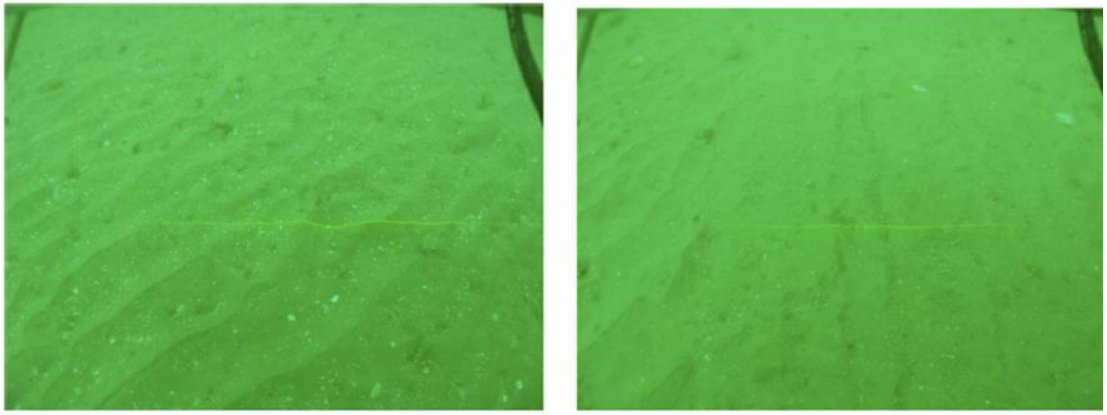
Review of physical impact investigations

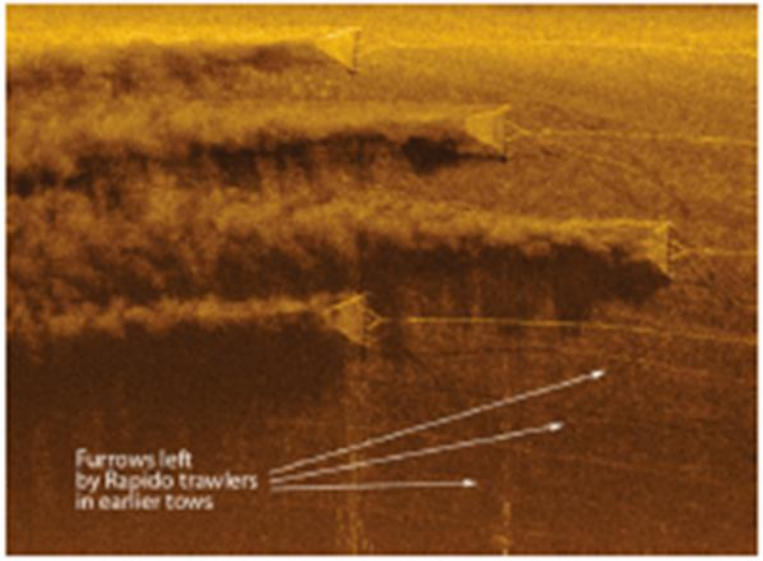
http://www.oceannetworks.ca



Trawl door path (DEGREE 2010)



Left: un-impacted seabed. Right: seabed after passage of scallop dredge (O'Neill et al 2013).



Furrows and resuspension of sediment from Mediterranean beamtrawls (Luchetti and Sala 2012))

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Literature based impact depths

Gear types	Gear components	Depth of gear impact
Demersal otter trawl	Sweeps and bridles	< 1cm
	Sweep chains	≤ 5 cm
	Trawl doors	≤ 35 cm
	Multirig clump	≤ 15 cm
	Ground gear	≤ 2 cm
Demersal seine	Seine ropes*	(< than trawl sweep impact)
	Ground gear*	(< trawl ground gear impact)
Beam trawl	Shoes	≤ 10 cm
	Tickler chains	≤ 10 cm
	Ground gear	< 1cm
Dredge	Ground gear	< 15cm

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Note !!! Maximum physical impact depths are informed across all sediment types described in literature

Index definition

- **Epifaunal:** impact area with penetration depth < 1 cm
- **Infaunal:** impact area with penetration depth >= 1 cm

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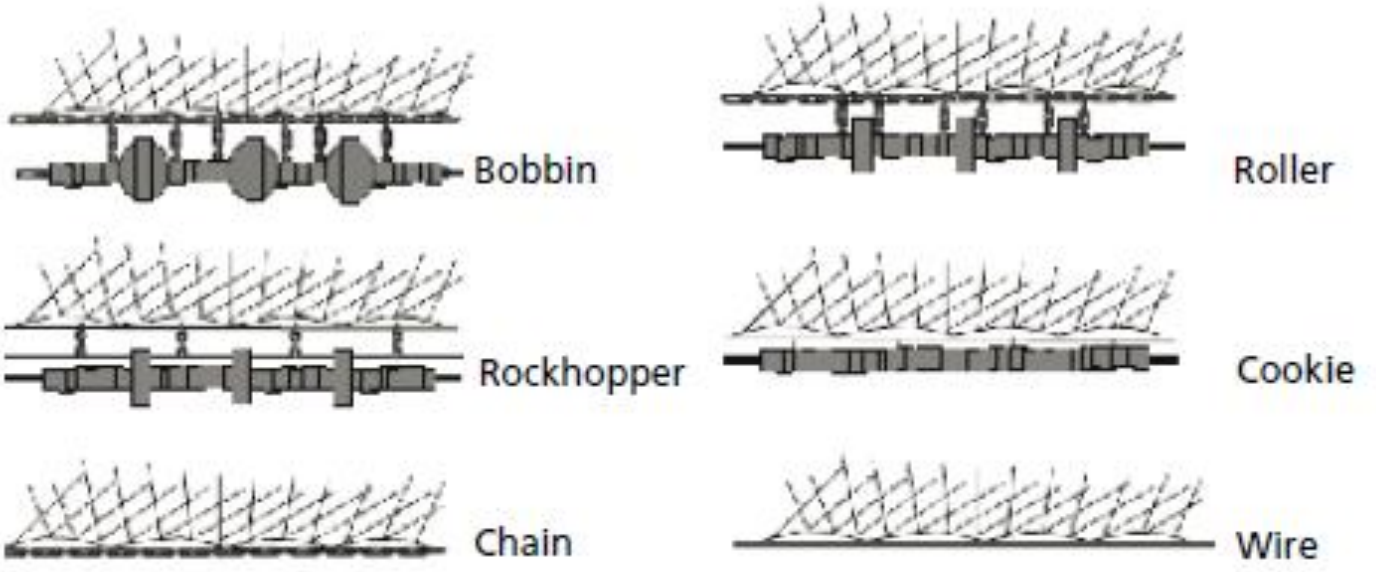
Groundgears come in different sizes and shapes

Ground gear categories



Source: He *et al.*, 2006

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Indexing ground gear impact

	Typical target species	Typical groundgear	Epifaunal impact (%)	Infaunal impact (%)
OT_SPF	Sprat or sandeel	Cookie	95	5
OT_CRU	Nephrops or shrimps	Cookie or discs	85	15
OT_MIX_NEP	Nephrops and mixed demersal	Bobbins, Discs, Rollers	75	25
OT_MIX_DMF	Mixed demersal fish species	Rockhopper, Bobbins	66	33
OT_MIX_MED	Mixed demersal fish species	Chain bightings	66	33
OT_DMF	Cod or plaice or Norway pout	Bobbins or cookie	75	25
OT_MIX	Individual species not informed	as other "Mix"	66	33
TBB_CRG	Crangon	Bobbins	75	25
TBB_DMF	Sole and plaice	Chains	0	100
TBB_MOL	Thomas' Rapa whelk	Chains	0	100
DRB_MOL	Scallops, mussels	Sheering edge	0	100
SDN_DEM	Plaice, cod	Cookie or discs	85	15
SSC_DEM	Cod, Haddock, flatfish	Chain bightings	66	33

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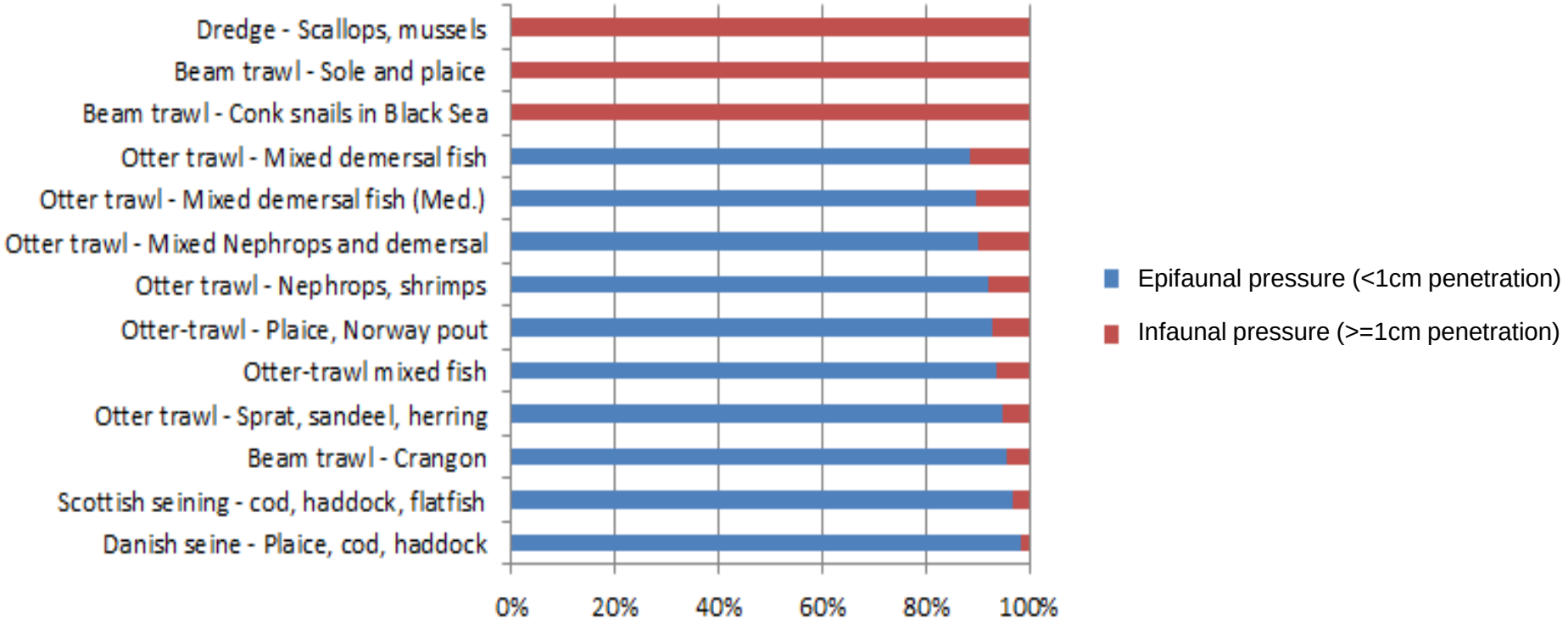
Summing components and ranking of towed gears



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Outcome of trait assignment

For any fishing operation / logbook observation holding:

- Vessel size
- Gear type
- Target species,

the established gear traits/seafloor footprints can be used to estimate total gear width (total impact area) as well as the proportion of epifaunal and infaunal impact

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Refinements

- Expand gear traits/footprints to integrate different sediment types
- Replace literature based estimations with physical model results (BENTHIS WP4)
- Expand gear traits with resuspension estimates from physical model results (BENTHIS WP4)
- Investigate regional approach to metier definitions
- Differentiate sweep angle assumption of fixed 10º - optimal angle is known to vary with target species

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