SPFA
SCOTTISH PELAGIC FISHERMEN'S ASSOCIATION

Fisheries Sampling and Data Collection

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FISHING INTO THE FUTURE

CHARTING A COURSE TO SUSTAINABLE UK FISHERIES

The Scottish Government
Riaghaltas na h-Alba

Scientist for the Scottish Pelagic Fishermen's Association

Scottish pelagic fishermen, respected providers of scientifically credible data that's used to assess fish stocks, monitor changes in the pelagic ecosystem, and support management decisions.

1. Establish pelagic fishing vessels as research platforms, mapping changes in the abundance and distribution of pelagic fish in the areas they operate.
2. Work with fish factories to promote the collection of scientific biological data on pelagic fish
3. Actively contribute to European and international developments of the science agenda influencing approaches to management of pelagic stocks.
4. Strengthen and promote collaborative science partnerships involving industry, government and academia.
5. Build awareness and understanding of the science concepts and issues relevant to pelagic industry, through engaging and informative media.
6. Uphold scientific standards and maintain scientific reputation at all times

Equip and train in relevant technologies and methods to achieve 1.

Overview of this session

What information is needed and why

How it's collected - understanding different approaches to data collection and the methods used

How it's used

How can industry contribute?

What information is needed and why?

Key information needs and its use

How many fish in the sea? → Setting fishing quotas and conservation measures.

How many get caught? → Estimating how many fish of each age group are in the sea and whether fishing pressure is sustainable.

The 'biology'- age, length and weight composition of the **population** and **catch**.

Where boats fish and how much (effort, catch per unit effort). → Translating goals for maintaining stocks in to the amount of fishing effort required for good average long-term catches. Indicators of the fishery performance and stock availability. Partitioning impacts by fleets.

Where fish are, where they go and why? → Fish migration and distribution patterns used in defining stocks, estimating abundance, fishing opportunities and spatial management measures.

How changes in the environment affect fish. → How changes in availability and productivity affect sustainable harvest rates and fishing opportunities.

Where does the information come from and how is it collected?

Data sources and the methods used to collect it

Sources of data

Fisheries Dependent

*– meaning information **about catches and fishing activity** collected from the industry during the course of their normal operations.*

Conducted as a requirement under statutory sampling programmes such as the EU Data Collection Framework (DFC) or for specific research programmes.

Includes catch and effort data plus biological data from landings.

Fisheries Independent

*– meaning **information about the fish population and environment** collected during scientific surveys, using sampling designs that provide the best estimate of stock density.*

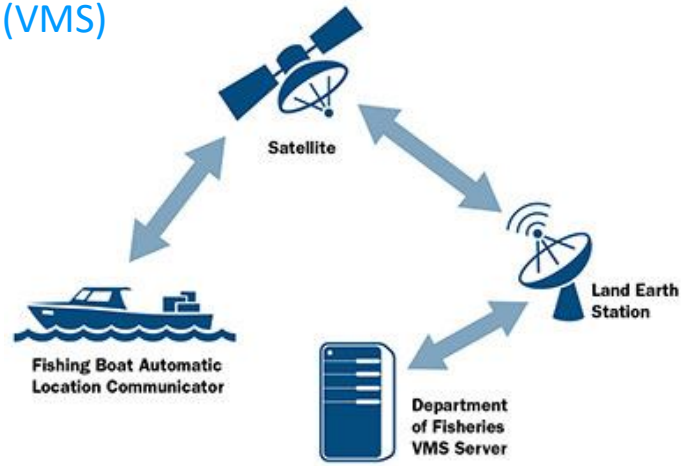
Conducted as a statutory requirement (DCF) or to address specific research questions.

Includes survey catch and effort data plus a variety of biological, oceanographic and environmental data.

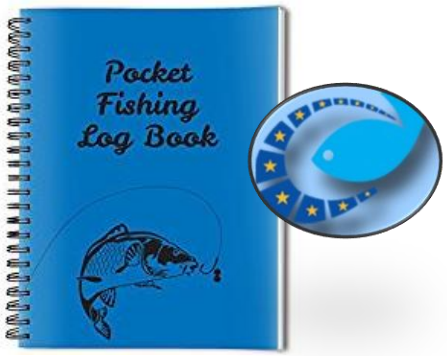
Fisheries dependent

Catch and fishing activity

Fishing position, time (VMS)

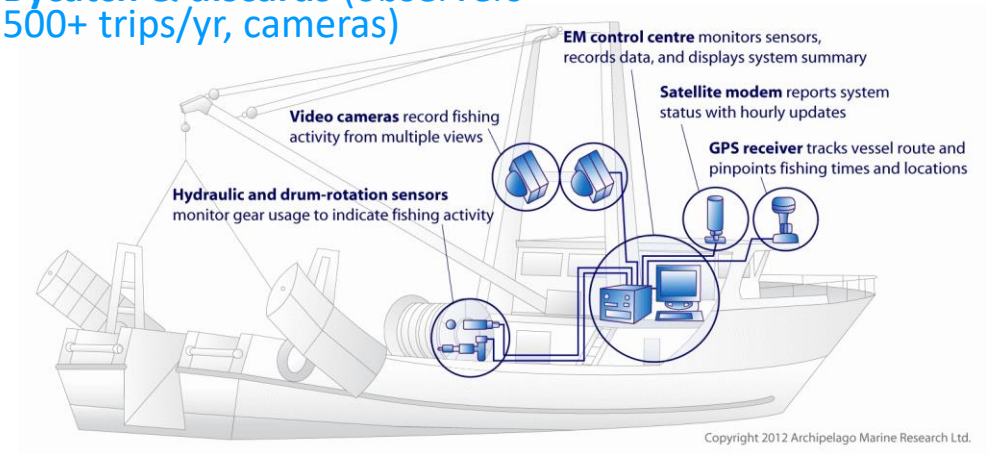


Catch records (logbook)



Vessels size/ power (registration)

Bycatch & discards (observers 500+ trips/yr, cameras)

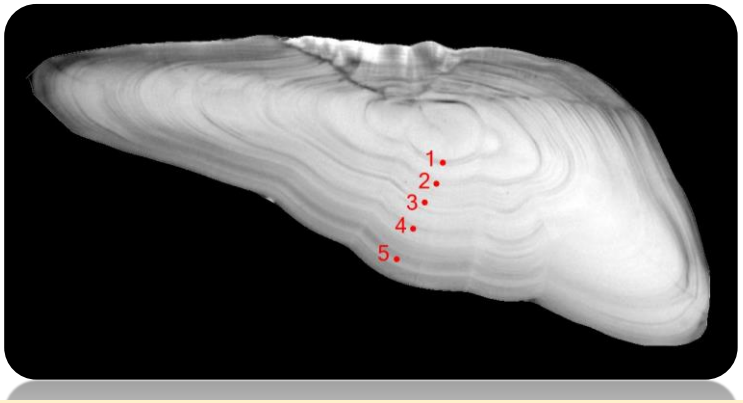


Fisheries dependent

Biological data on catch

Routine - Length, weight, sex ratio, maturity stage.

Then age determination from ear bones (otoliths).



The End Game

How many fish of each age group were caught - for use in stock assessment

Numbers-at-age-matrix

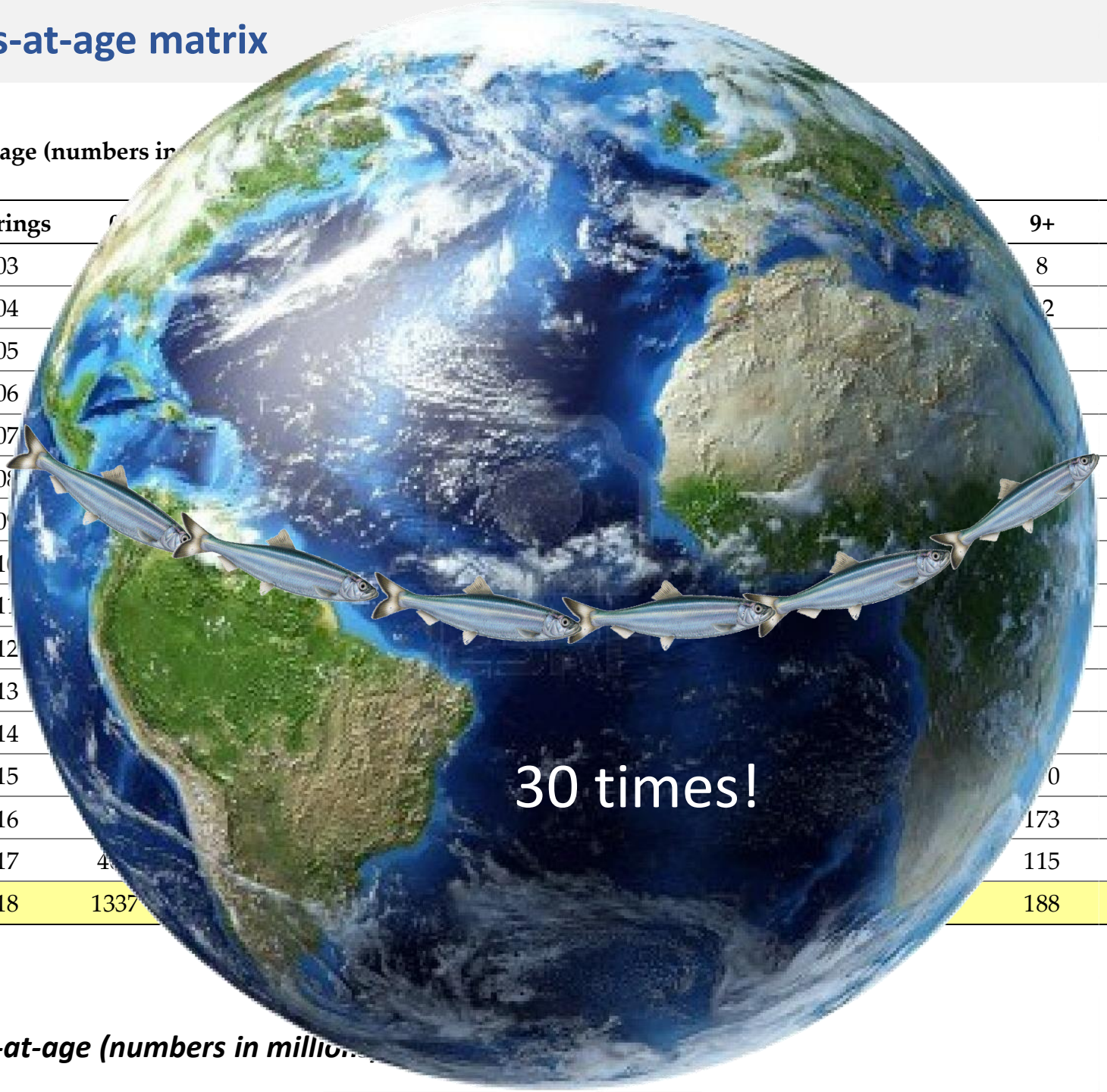
Catch numbers in millions (North Sea herring)

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794
2011	779	160	368	274	218	130	63	52	60	65	2168
2012	773	285	455	673	404	306	150	104	88	102	3341
2013	462	413	325	484	571	422	327	145	152	160	3461
2014	1389	371	383	386	617	488	285	192	92	123	4323
2015	538	395	552	248	283	461	432	271	168	170	3517
2016	1584	109	625	819	293	280	368	307	186	173	4745
2017	462	209	109	1080	838	223	146	176	107	115	3463
2018	1337	73	206	201	1179	849	224	145	144	188	4546

Numbers-at-age matrix

Catch at age (numbers in

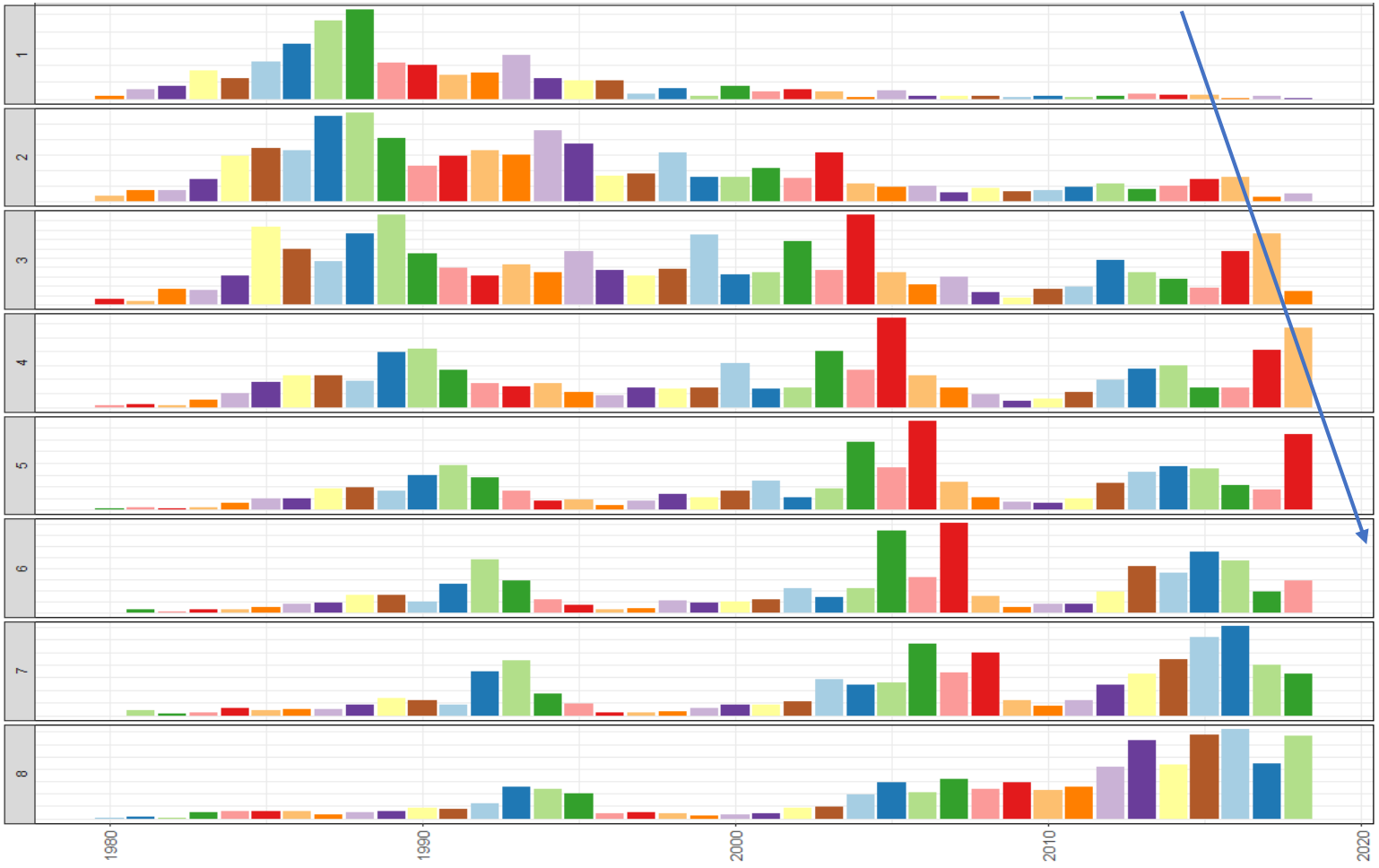
Year/rings									9+	Total
2003									8	4042
2004									2	4298
2005										5209
2006										3885
2007										3009
2008										2336
200										1606
201										1794
201										2168
2012										3341
2013										3461
2014										4323
2015									0	3517
2016									173	4745
2017	4								115	3463
2018	1337								188	4546



Catch-at-age (numbers in millio

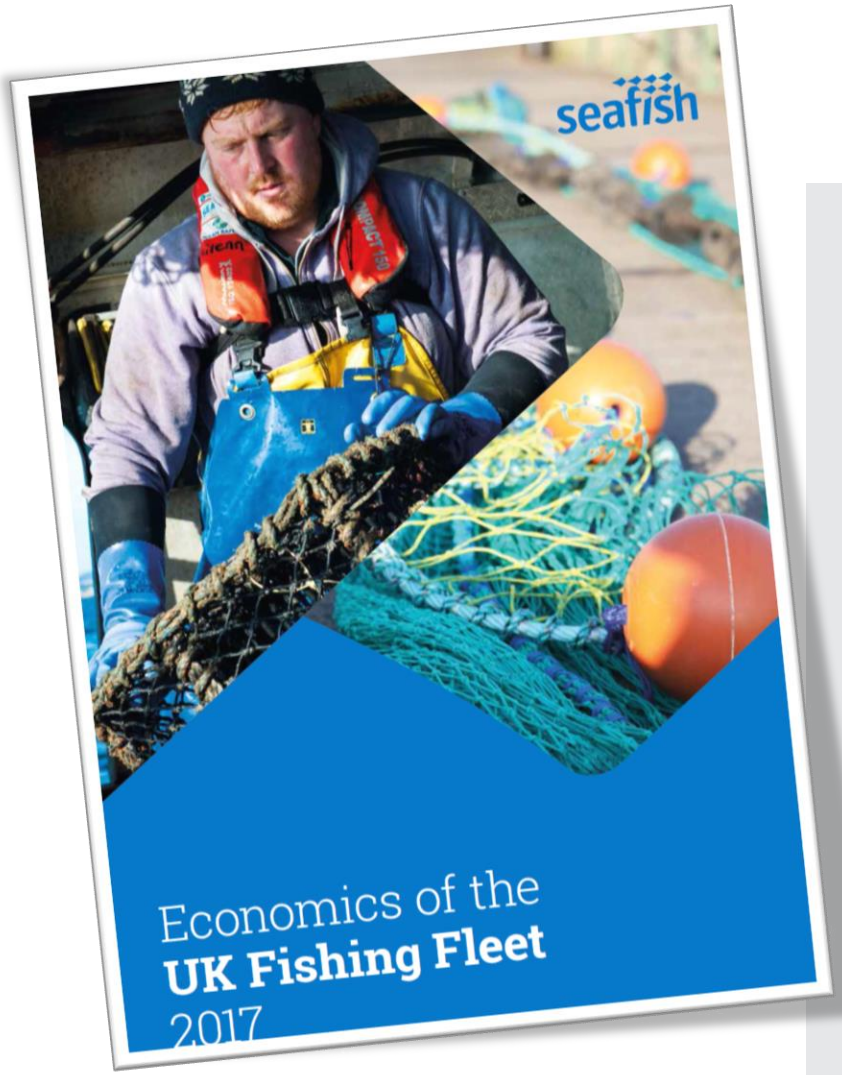
Numbers-at-age matrix: *catch*

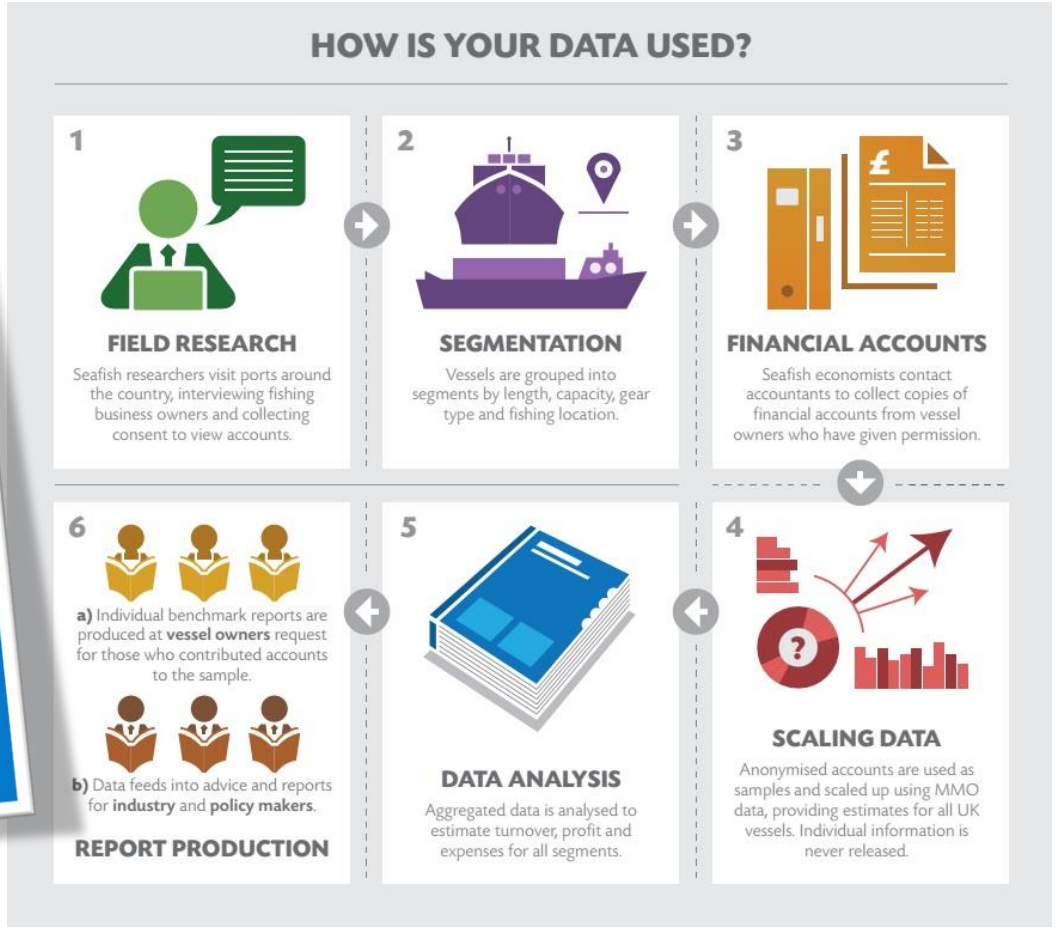
2013 year class
'Recruits' in 2014



Fisheries dependent

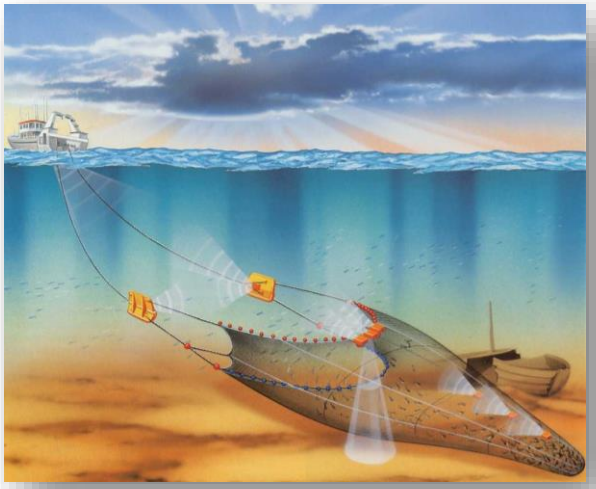
Economic activity





Fisheries independent

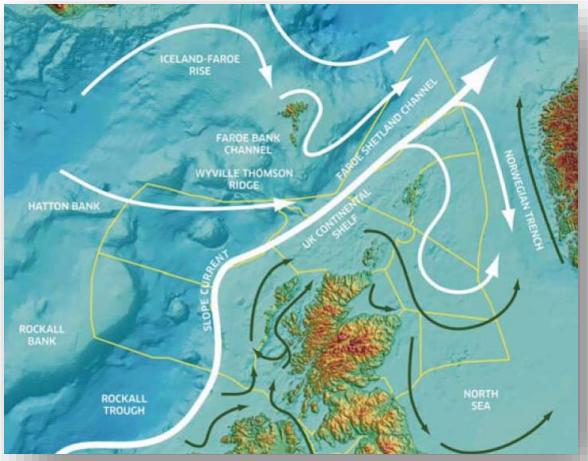
Survey catch



Biology

Environment

Oceanography

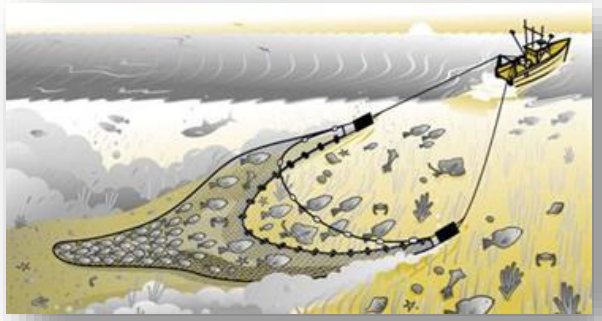


Fisheries independent - methods

Swept area surveys

Use

Monitor change in the density of fish over time and space – an indicator of change in population size. Tuning stock assessment models, where surveys used to provide the patterns over time and catches are used to give size of population.



International bottom trawl survey (IBTS)

Method principles

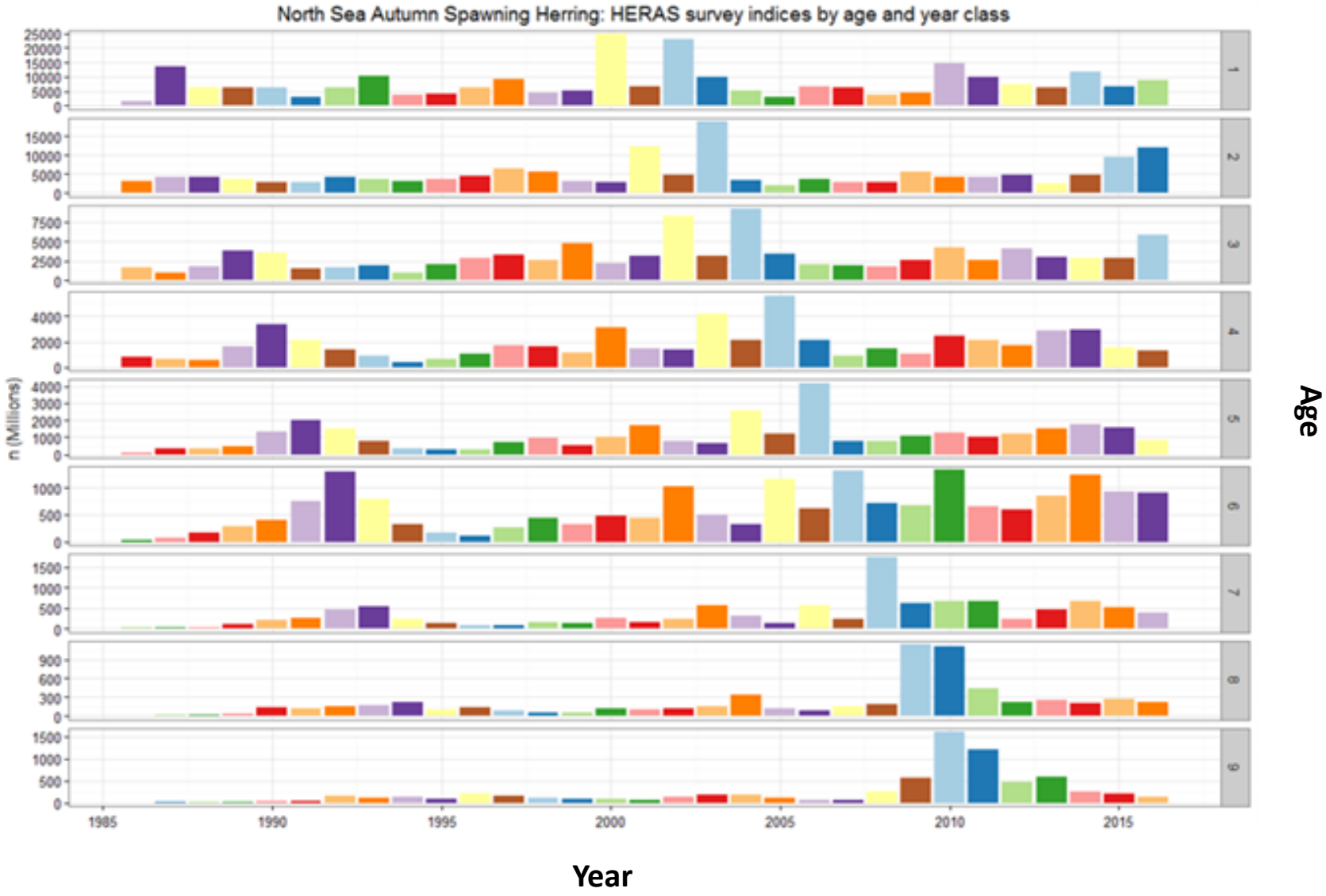
- Not trying to count all the fish, but not trying to avoid them either!
- Uses statistical sampling methods to make a best guess (most accurate estimate) of the fish population in the area.
- Standardized methods so that the density 'signal' doesn't get muddled and multiple surveys are comparable and can be combined.
- Trade-offs: tools (gear) and species suitability, accuracy and precision

The End Game

Abundance of each age group - for use in stock assessment (the survey 'numbers-at-age matrix').

Resource: What is a trawl survey? (USA video)

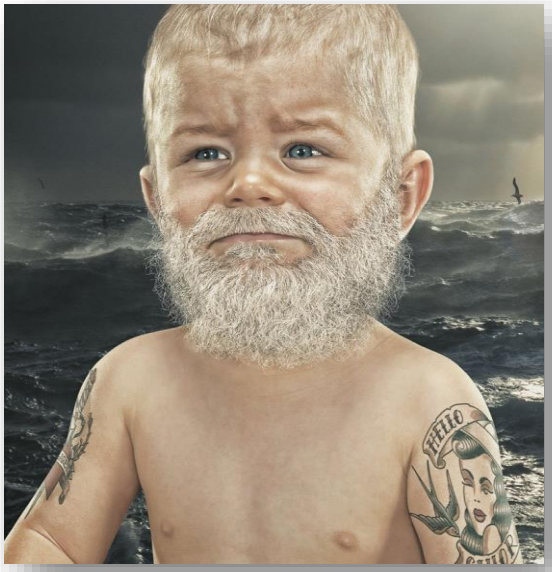
Numbers-at-age matrix



North Sea Herring Acoustic Survey. Time series of numbers-at-age at ages 1-9+. Colours indicate year-classes. All ages are scaled independently and therefore the size of the bars can only be compared within an age.

Common questions about swept area surveys

- Why do you fish in random locations when we know fish aren't random?
- Why use that old sock of a net? It couldn't catch squat.
- How can you tell us how many fish in the sea when you don't see any in your survey?



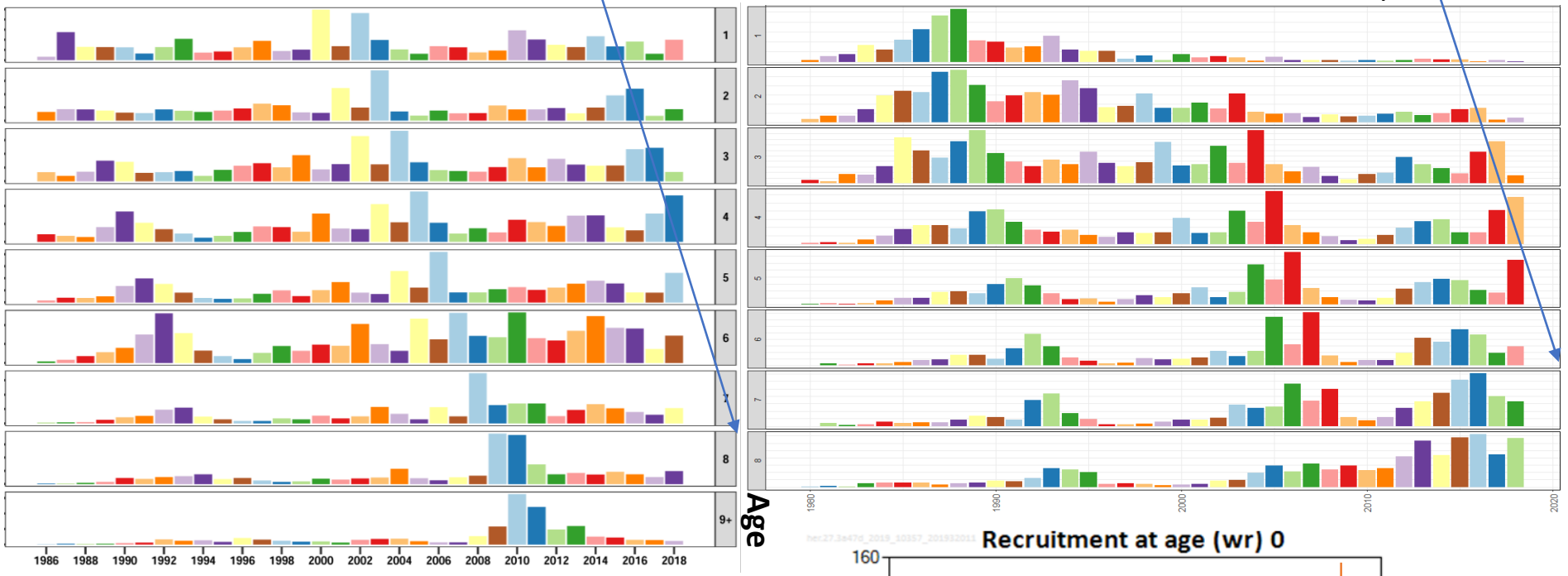
Numbers-at-age matrix: *surveys and catch*

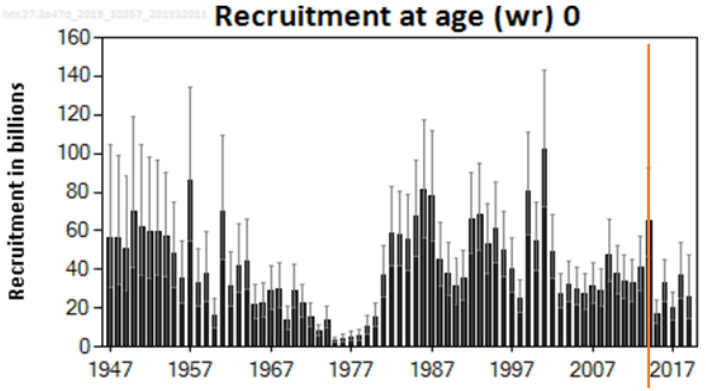
Survey

2013 year class
'Recruits' (0-wr) in 2014

Catch

2013 year class





Fisheries independent

Nephrops surveys

Use

Stock density in each functional unit

Survey Principles

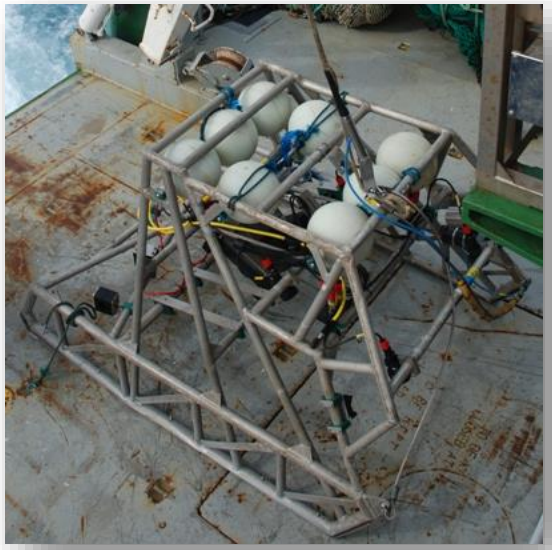
- Swept area principle, where the sweeping is how many burrows per area of seabed

Tools

- Sledge mounted TV cameras
- Different ground types and 'functional units' are surveyed because burrow density varies

Method

- The TV goes down and records over a swept area.
- Someone watches TV and counts the burrows.
- Catch samples used to determine mean weight and sex ratios
- Numbers are converted to stock biomass
- Other organisations do the same and compare and combine



Resource: How *Nephrops* surveys work

Fisheries independent

Acoustic surveys

Use

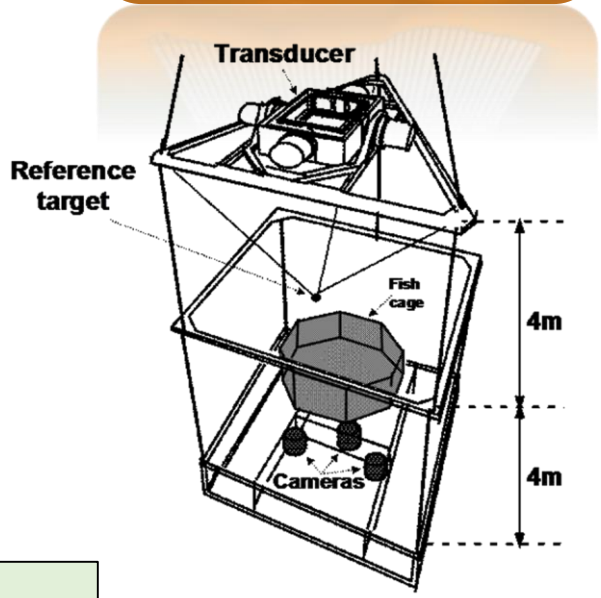
Stock size and distribution. Behaviour and migration.

Survey Principles

- Not trying to count all the fish, but not trying to avoid them either
- Unbiased estimates of average density within the area surveyed

Tools

- The scientific sounder – calibrated so quantifiable and comparable
- Operates at multiple frequencies (18, 38, 120, 200, 300kHz (same as fishermen)
- Frequency response helps determine species, but it's still largely reliant on expert knowledge
- Future is multibeam and broadband for greater discrimination near the bottom and more accurate sizing



Method

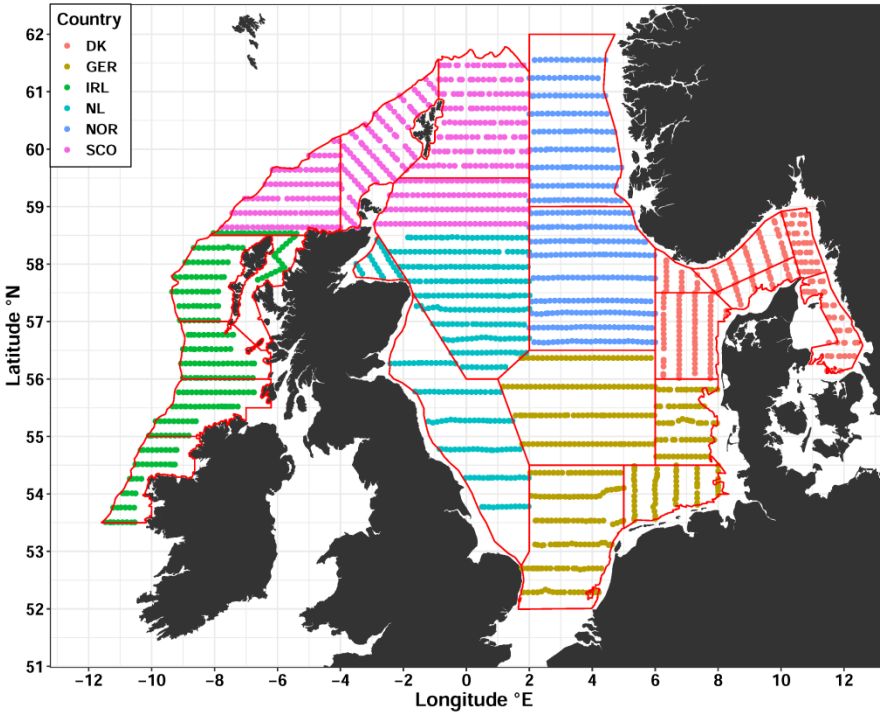
- The acoustic backscatter (the strength of the 'echo') is assigned to species
- The backscatter (target strength) of one fish is known (from experiments), so backscatter can be converted to numbers of fish.
- Trawl samples give the numbers and at size (age), so total number can be partitioned to size (age) groups.

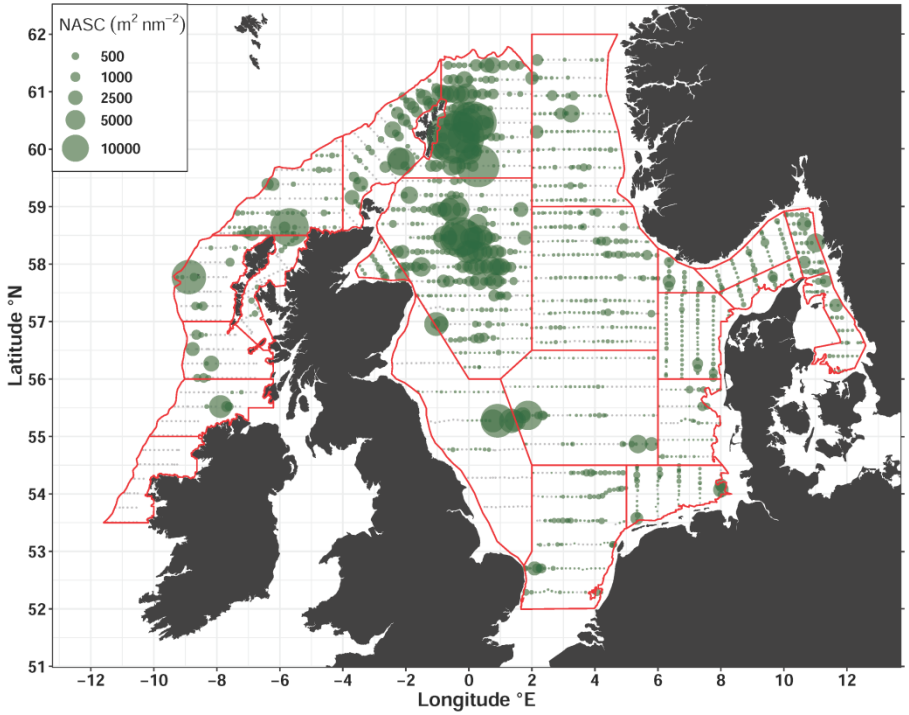
Resource: Canadian acoustic survey example

Fisheries independent

Acoustic surveys

International Herring Acoustic Survey 2018





Resource: Why acoustic surveys go against the grain

Fisheries independent

Tagging programmes

Use

Estimate population size and movement patterns

Survey principles

- Tags Released/Popn = Tags Recaptured/Catch
- Geolocation to reconstruct migration

Methods

- Tag fish and put them back – catch them again later
- Plastic, metal and RFID
- Simple data storage and advanced satellite
- Rewards required

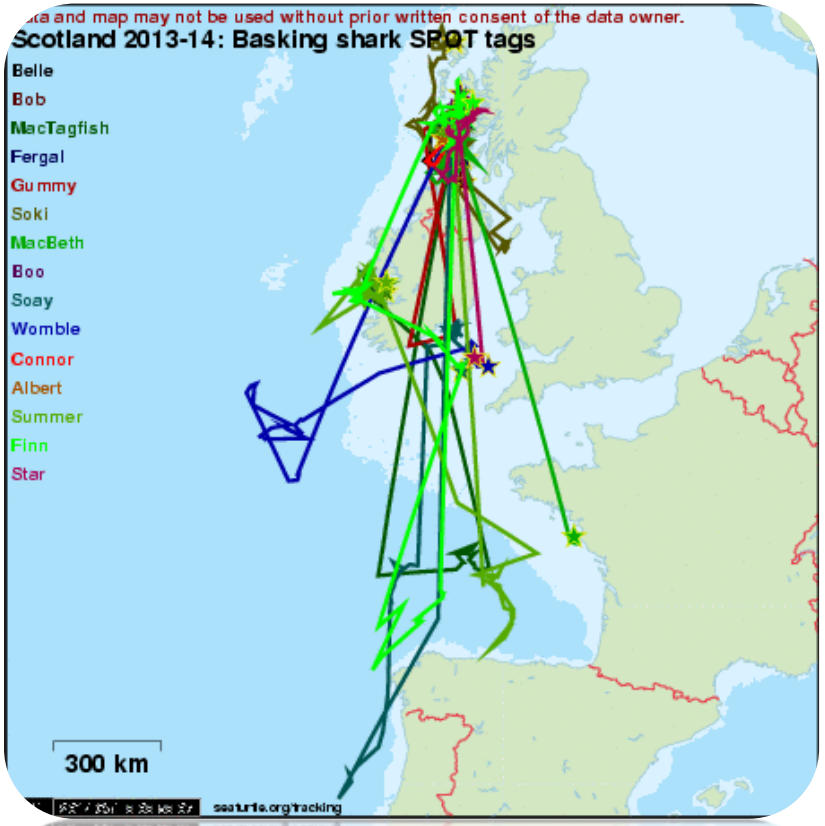
Examples

- Mackerel RFID and how it's being used in stock assessment
- Tracking behaviour – tuna, plaice – tidal stream transport, cod

Resource: How tagging programmes estimate fish abundance

Fisheries independent

Tagging programmes



How is the information used?

Where does it go?

Key information needs and its use

How many fish in the sea?

Setting fishing quotas and conservation measures.

How many get caught?

Estimating how many fish of each age group are in the sea and whether fishing pressure is sustainable.

The 'biology'- age, length and weight composition of the **population** and **catch.**

Where boats fish and how much (effort, catch per unit effort).

Translating goals for maintaining stocks in to the amount of fishing effort required for good average long-term catches. Indicators of the fishery performance and stock availability. Partitioning impacts by fleets.

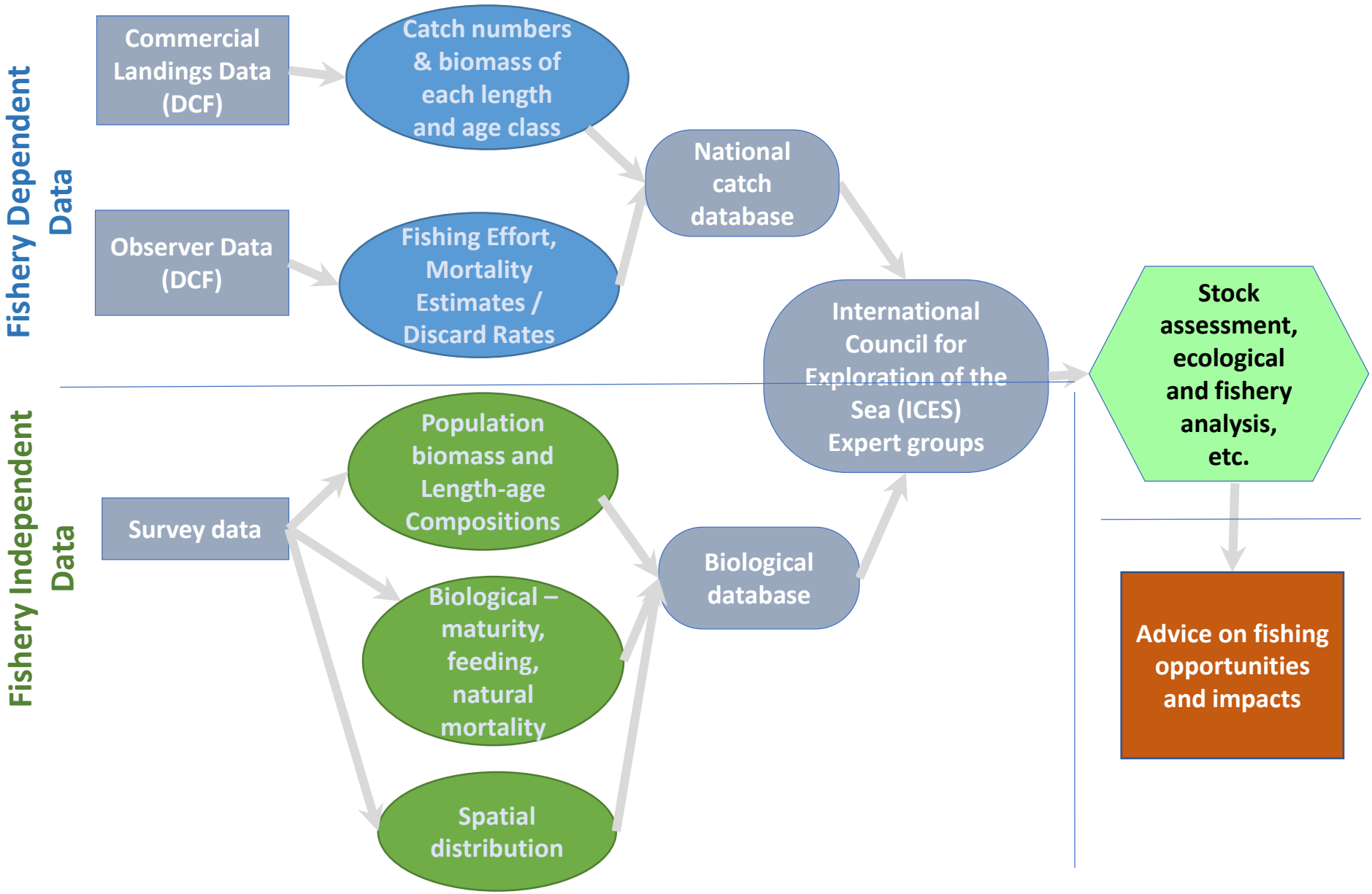
Where fish are, where they go and why?

Fish migration and distribution patterns used in defining stocks, estimating abundance, fishing opportunities and spatial management measures.

How changes in the environment affect fish.

How changes in availability and productivity affect sustainable harvest rates and fishing opportunities

Fishery data flows



Fisheries dependent – summary takeaway

*– meaning information **about catches and fishing activity** collected from the industry during the course of their normal operations.*

Data needed	How it's collected	What it's used for
Landings (or Catch)	Logbooks, landing slips	How many fish of each age were removed from the population – required in stock assessment.
Discards	Logbooks, observer programmes, cameras	How many other fish were removed from the population (depending on survival)
Effort	Satellite monitoring (VMS), logbooks (fishing duration)	Fishing capacity and efficiency (catch per unit effort, CPUE). CPUE a proxy for changes in fish availability. Used to determine relative sources of mortality and sustainable harvest rates.
Biological data – lengths, weight and age in each group	Market sampling and Age reading from otoliths in the laboratory	Tracking the size and age composition of the population (cohorts), which is used in stock assessment to estimate the numbers and biomass of each age group. Also reveals biological and ecological changes, such as changes in growth due to feeding conditions.
Economic	Economic surveys	Economic performance of fleets, sectoral contribution national and local economy. Development objectives

Fisheries independent – summary takeaway

*– meaning **information about the fish population and environment** collected during scientific surveys, using sampling designs that provide the best estimate of stock density.*

Data type	How it's collected	What it's used for
Survey trawl catches	Bottom trawl surveys (Q1 and Q3) (Demersal or beam trawl) - Swept area method	Density index, catchability, population composition, distribution. Used in tuning stock assessment models.
Acoustic density (and trawl for ID/ samples)	Calibrated split-beam scientific echosounders (Simrad EK60 or EK80)	Acoustic density at age. Particularly for pelagic species – herring, sprat. Abundance index for stock assessment models. Also changes in distribution patterns.
Burrow density for Nephrops	Underwater TV Cameras and image analysis processing	Relative abundance of Nephrops. Sex ratios.
Biological data – lengths, weight, age in each group	Survey catch sampling followed by lab analyses	Changes in the size and age composition of the population, proportion mature, growth rates. All used in stock assessments.
Tagging	Tagging – markers and trackers	Relative abundance estimates at age and estimating total mortality for use in stock assessment. Migration patterns and consequences for spatial management and zonal attachment.
Larval and egg counts	Various nets and samplers	Estimate abundance of that parent population (spawning sock size), determine spawning locations from timing, forecast likely recruitment
Environmental	Various physical and chemical sensors, water samplers and acoustic devices for seabed characteristics. Plus grabs and cores for sediments.	Relating patterns to environmental conditions. From population biology to ecological understanding necessary to make predictive models.

How can industry contribute?

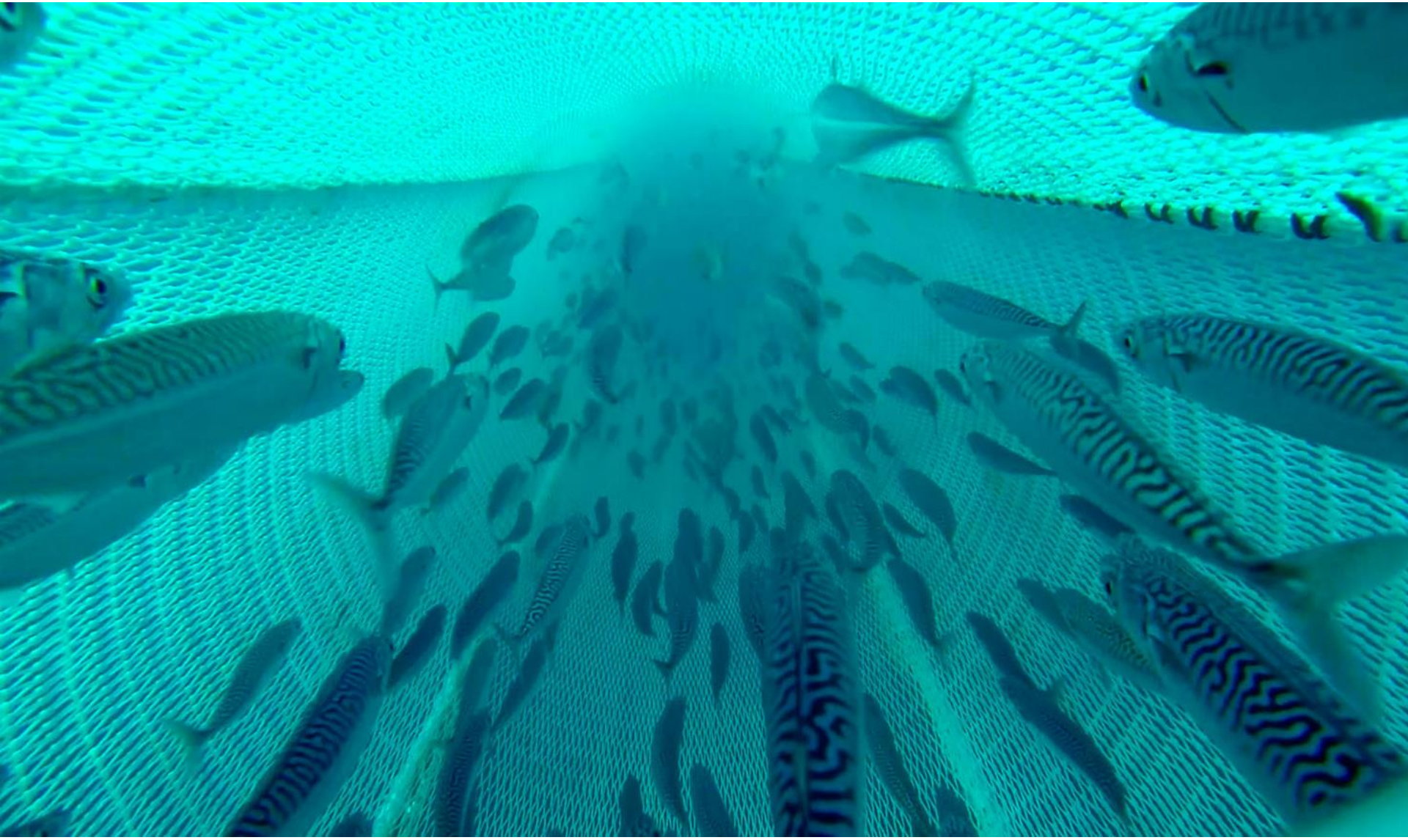
Guidelines on Industry-Science Data Collection

Feasibility study into a scientific self-sampling programme for the pelagic sector

ICES Workshop on Industry Science Initiatives (June 24-26 2019)

More resources

- Fish stocks: counting the uncountable
- Fisheries Dependent Information conference – lots of presentations about science and industry working better together



Swept area survey game

RV I.C.Fish

Swept area survey game

RV I.C.Fish

The survey game – how it works

Three surveys, 1 each year

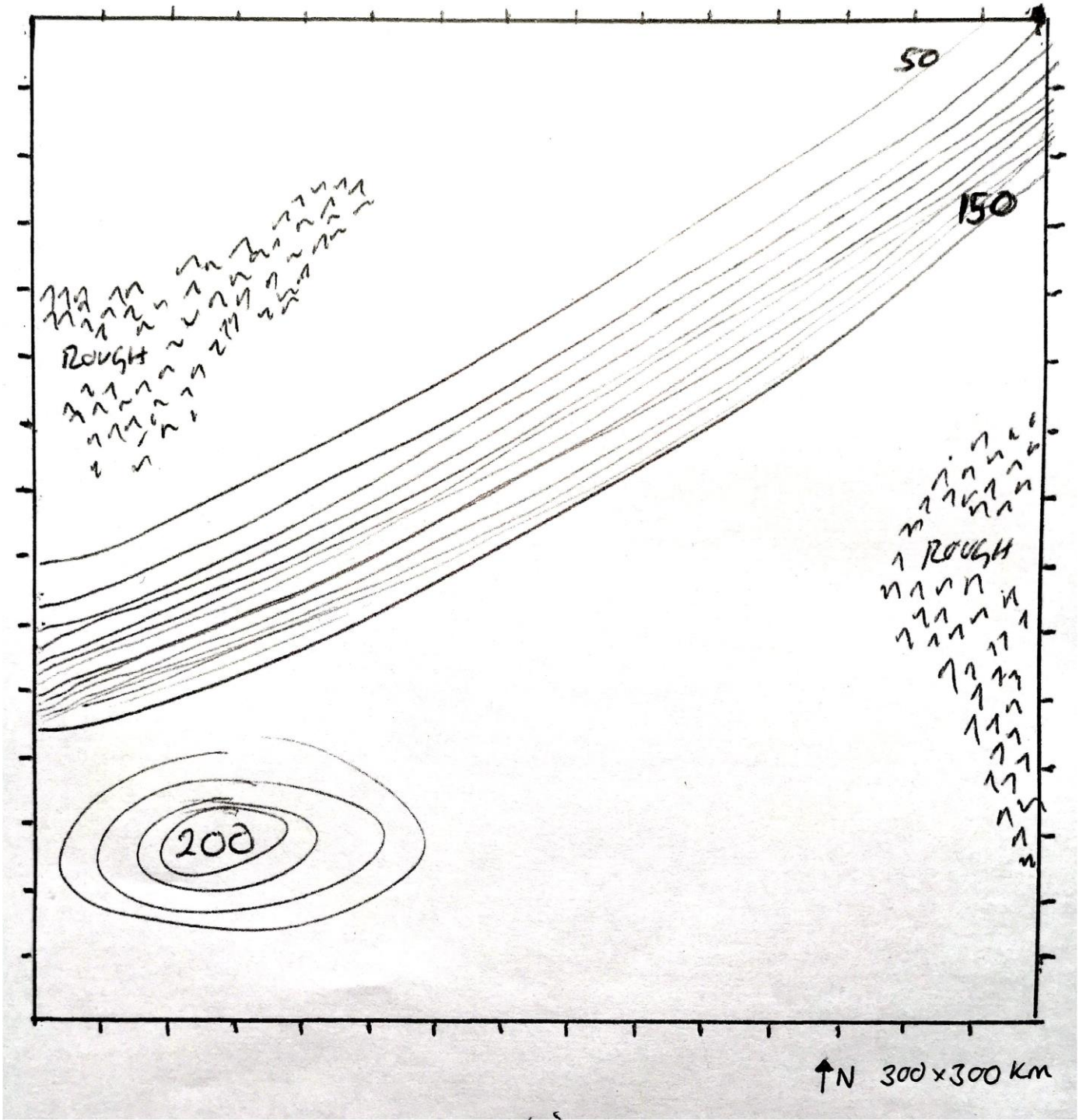
Design the survey – choosing where and how many sample hauls to take

You record the survey catches

Estimate how many fish in the sea

See how it went and do another survey the next 2 years

We compare approaches and results !


50
150
ROUGH
ROUGH
200
↑N 300×300 km

Swept area surveys: Tools

1. Density of the population in an area (the numbers per unit area). Often referred to as the Catch per unit effort (CPUE)

$$Density(CPUE) = \frac{Survey\ catch}{Area\ swept\ by\ trawl}$$

2. Total abundance of species in the area

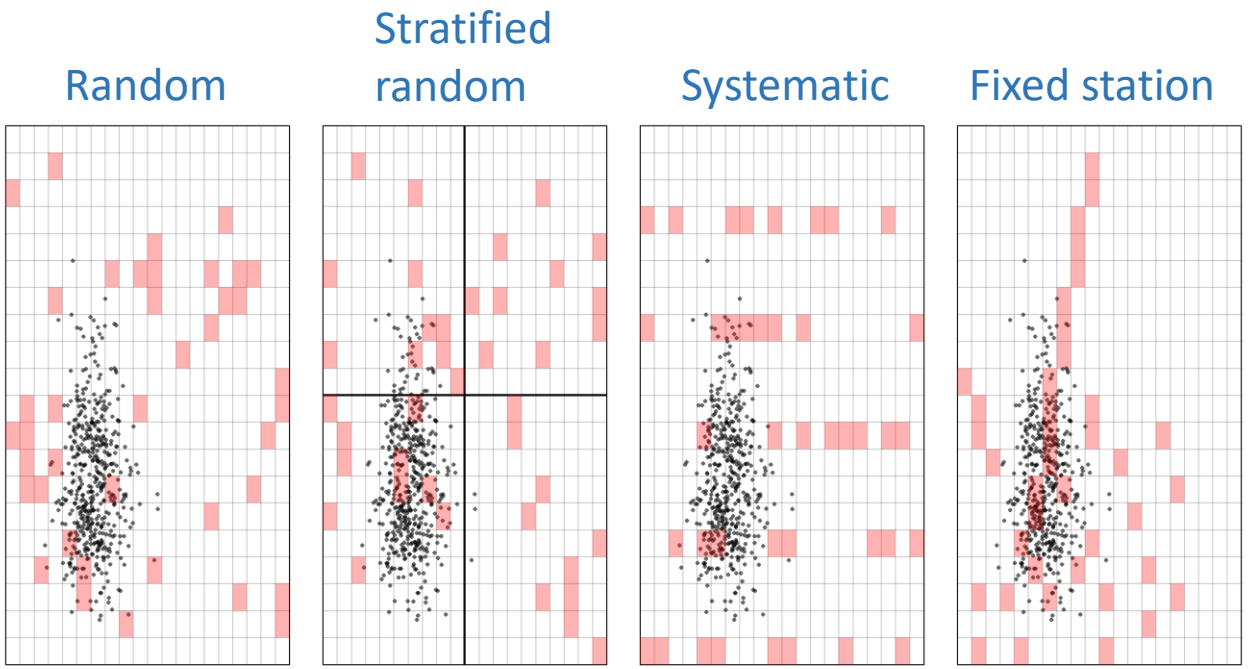
$$Abundance = Density \times Survey\ area$$

Use the spreadsheet to design your survey and calculate the abundance

Fisheries independent

Swept area surveys: ***Methods***

- Design – ways to divide up the sampling of the survey area efficiently and to get the best estimate even when unexpected things happen.
- Sampling protocols – reproducible so comparisons can be made
- Sampling the catch - biological information
- Raising the sub-sample to the sample catch
- Raising the survey catch to the total area



Acknowledgement: Allan Hicks, MREP workshop