How to integrate historic knowledge in defining GES for gravel bed integrity

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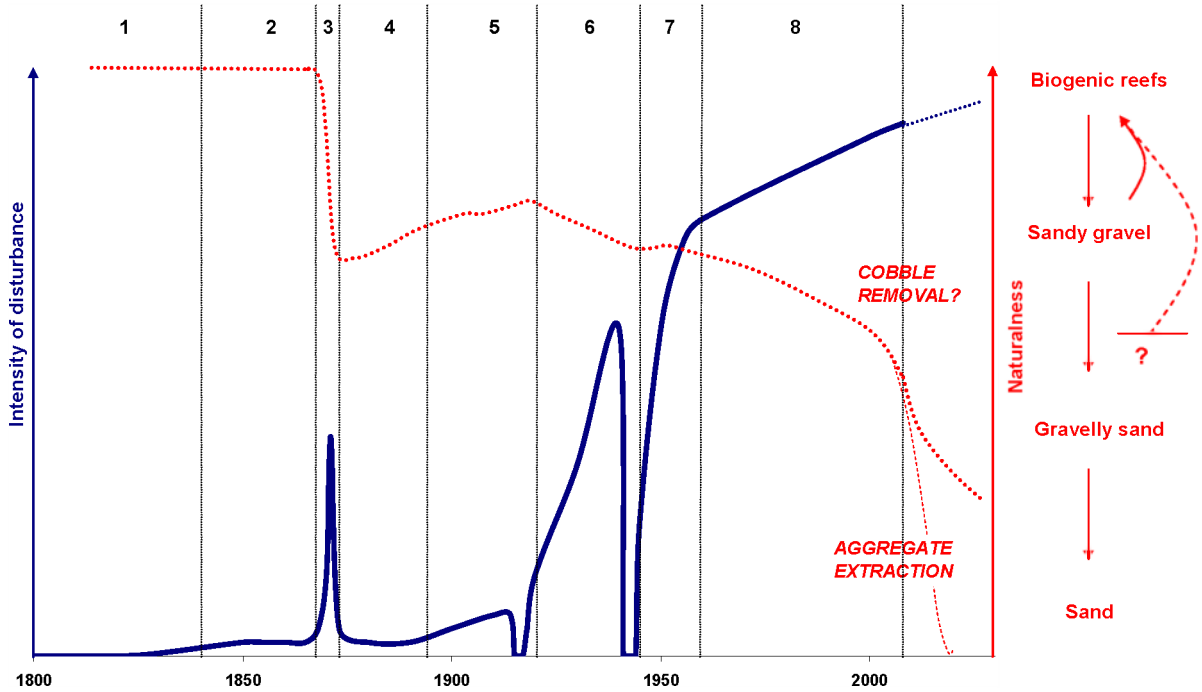
Baseline situation: gravels of the southern bight

- Three main aspects:
  - Hard substratum
    - High levels of associated benthic biodiversity through branching fauna (sponges, hydrozoans, bryozoans, …)
  - European flat oysters: “deep-sea” beds
    - Provision of biogenic reef structures on top of sandy gravel
    - Provision of propagules: “source” populations => ‘seeding’ coastal beds?
  - Down’s herring: gravels used for spawning
    - Herring is a major prey species in the North Sea ecosystem
    - North Sea historic spawning grounds seem abandoned
- One major pressure through time : dredge and trawl fisheries
    - Gravel beds and biogenic reefs are most sensitive (Kaiser et al, 2006)
- Evaluation of long-term changes
    - Historic data (one survey + literature)
    - Chronology of human-induced disturbance
    - Recent data (one survey!)

Conceptual model of habitat degradation: Westhinder gravels



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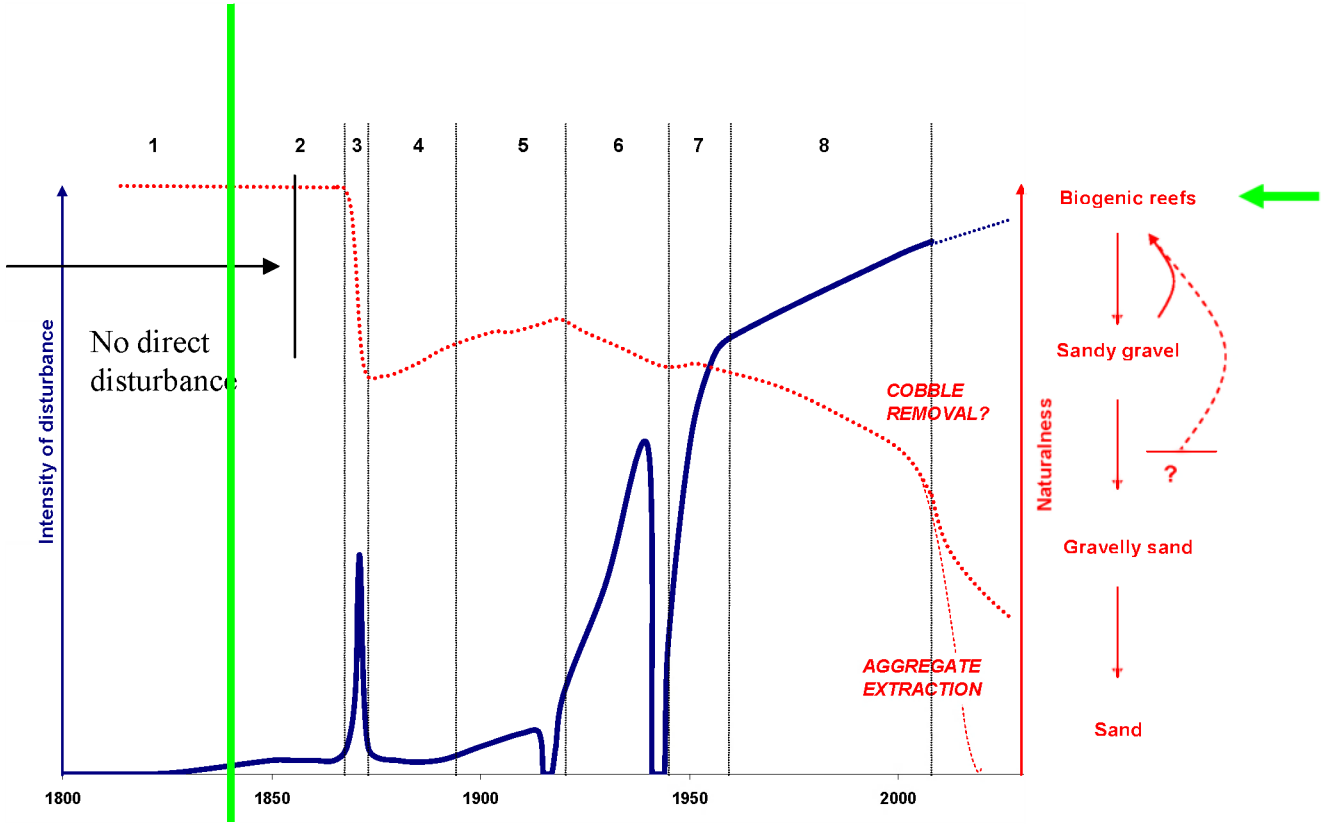

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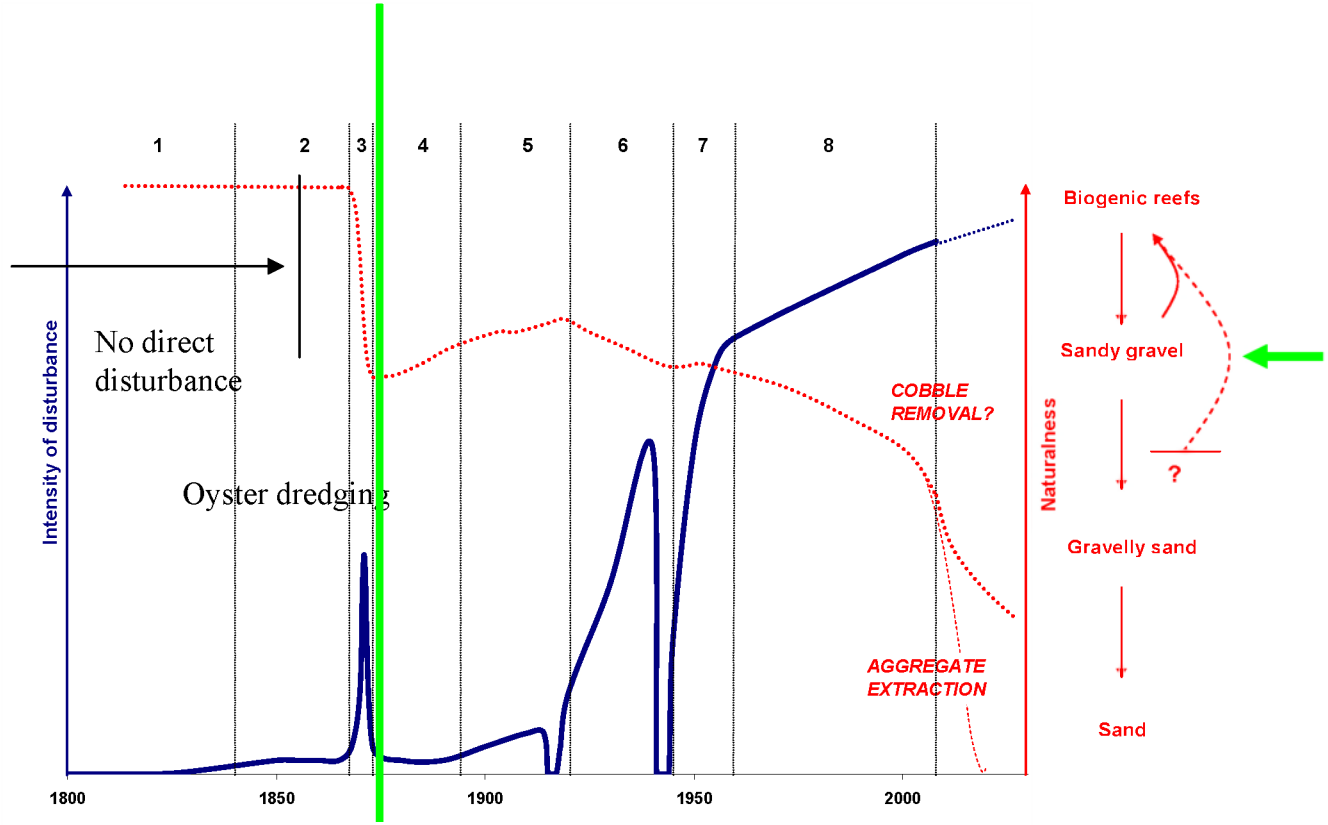

⇒ **Oyster beds exhausted**

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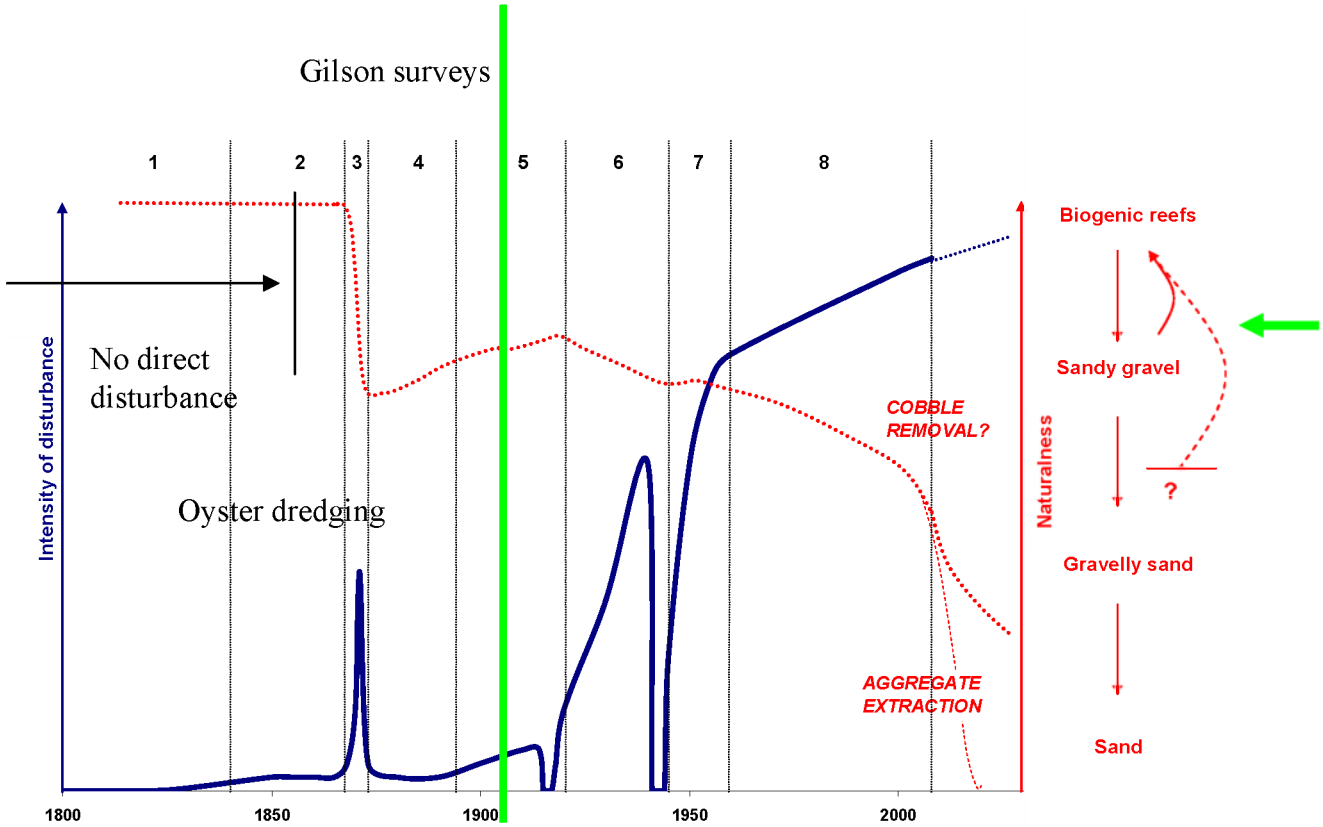

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⇒ **Recovery : >= 50-100 y !**

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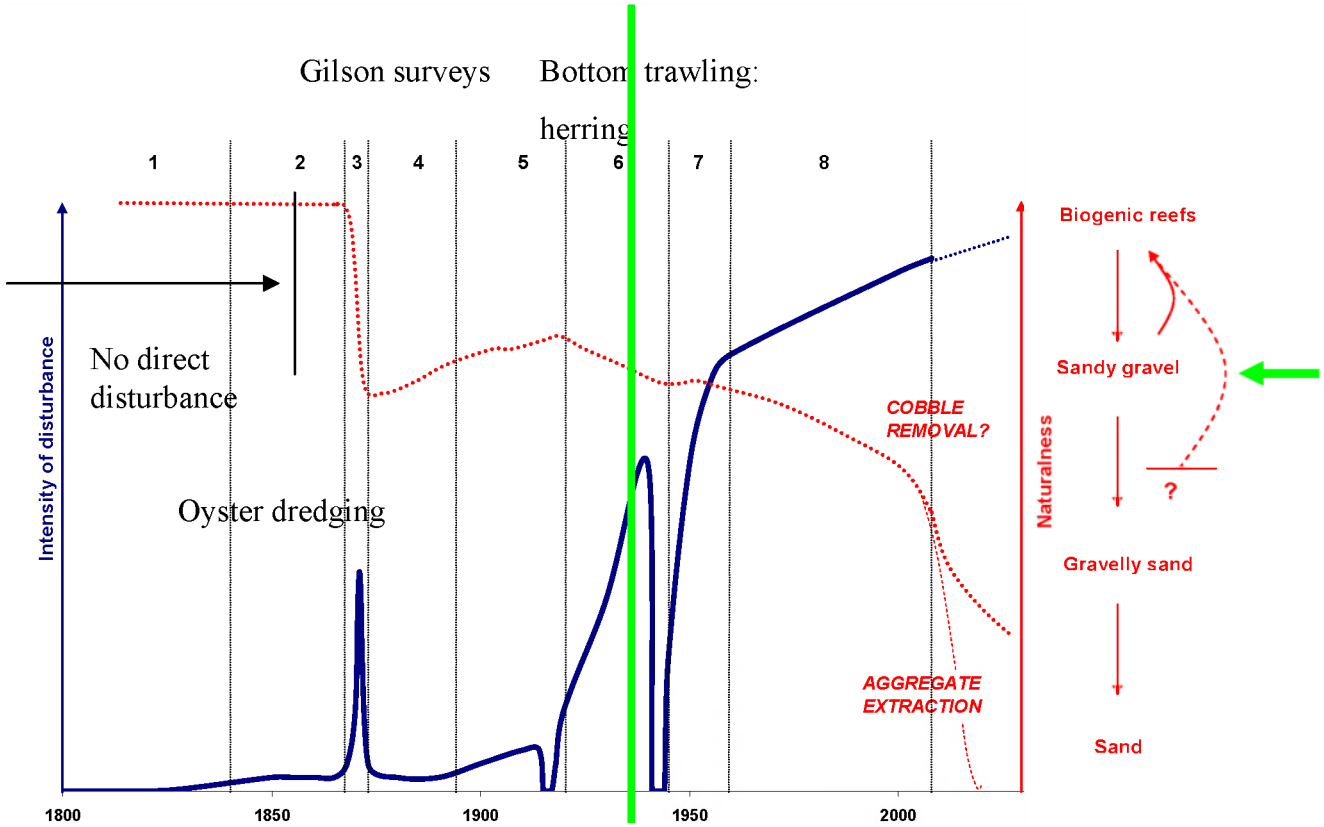

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(otter trawls)

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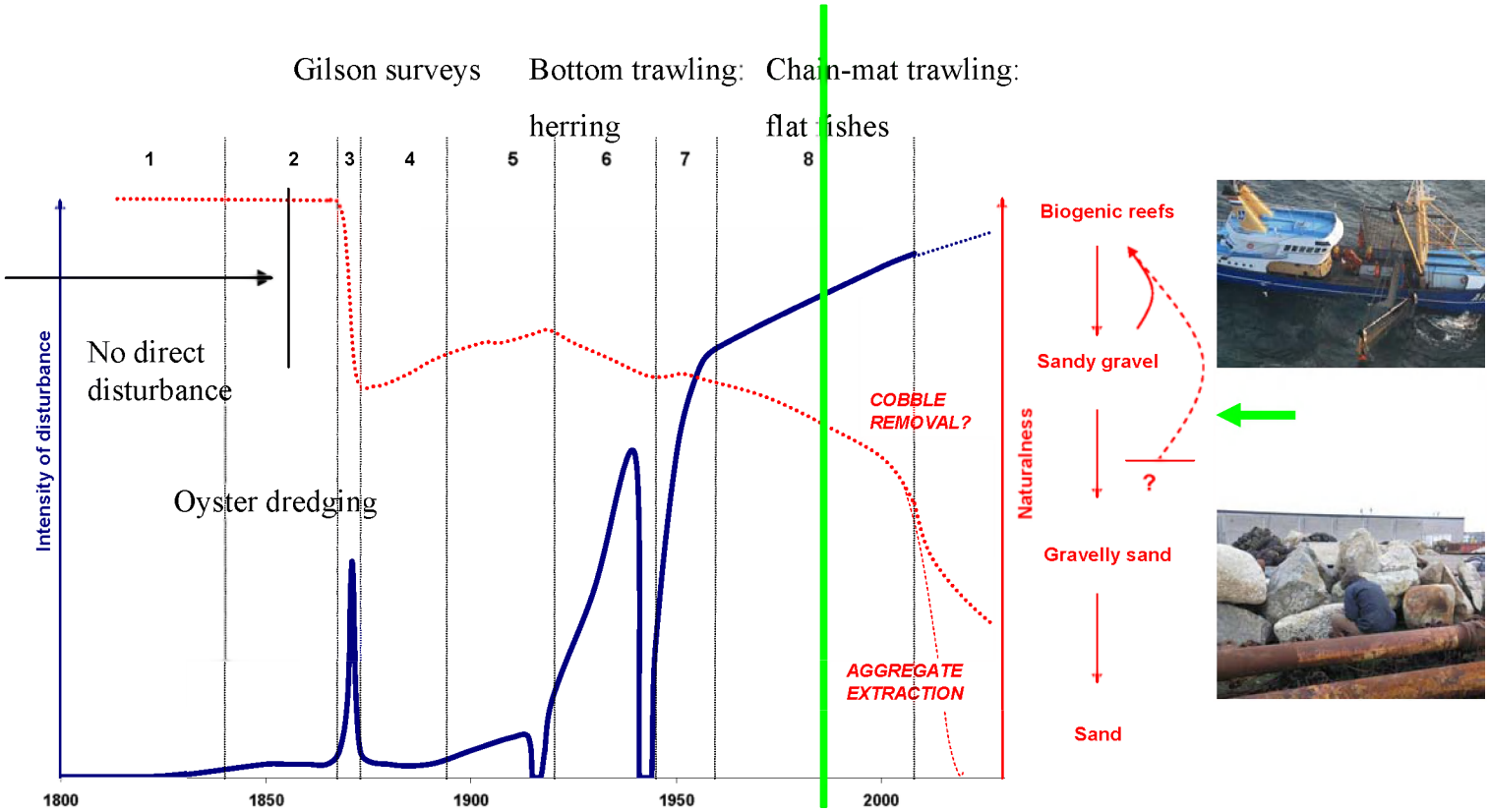

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(heavy chain-mat beam trawls)

(+ Eutrophication)

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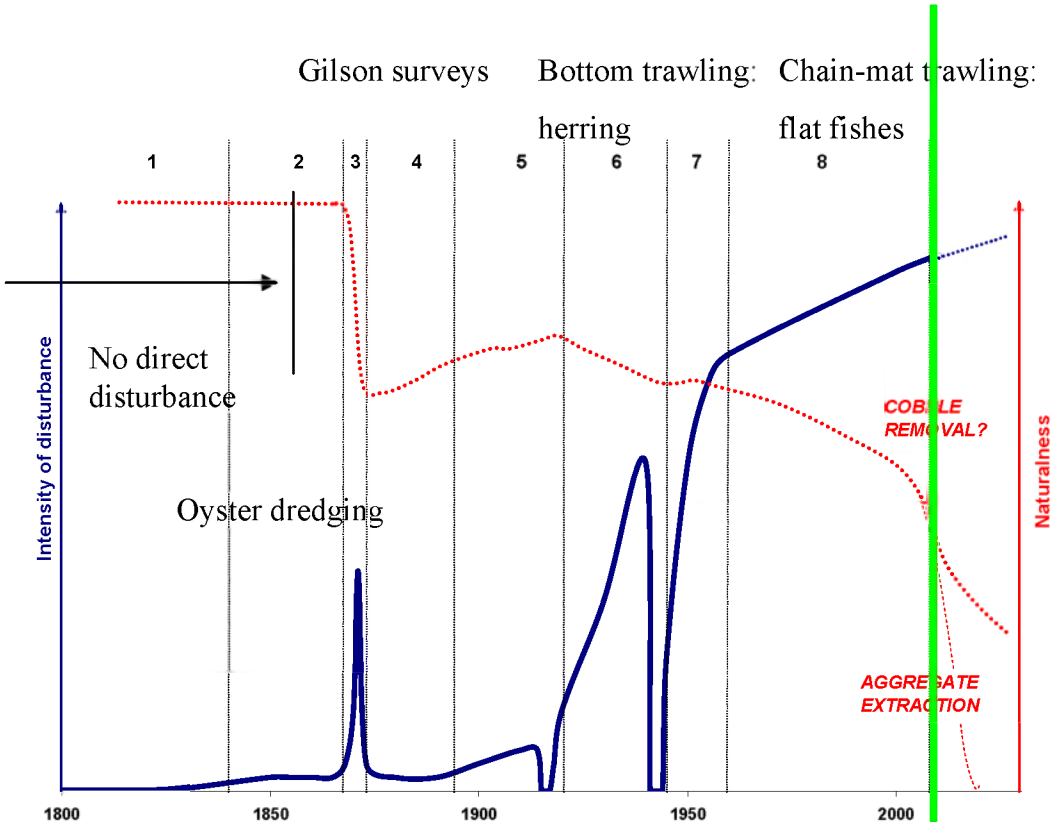
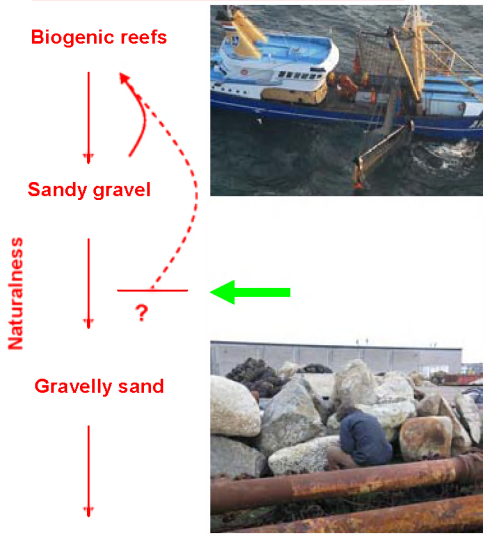


Recoverability threshold?



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=> Recoverability of seafloor integrity?

Characteristic and numerically dominant species

'PRISTINE' (< 1860):

Flat oyster beds -biogenic reef structures + sandy gravel +

- **Invertebrates:**
  - **Ostrea edulis**
  - => PATCH REEFS
  - **Alcyonium digitatum** (octocorallia) LARGE
  - **Pomatoceros triqueter** (worm)
  - **Sabellaria spinulosa** (worm)
  - Cliona cellata (a sponge)
  - Hydrozoans (Tubularia, Sertularia, Abietinaria, Hydrallmania, etc)
  - Ascidians (e.g. C. intestinalis)
  - Paguridae (hermit crabs)
  - (… + Large array of associated less common species)
- **Fishes**
  - Large rays!
    - **R. clavata thornback**
    - **D. pastinaca eagle**
  - **Herring (spawning)**
  - Flat fishes in sandy gravel patches?
  - Gobies
  - Young cod?

Moderately disturbed (1900s):

Scattered oyster aggregates + sandy gravel

- **Invertebrates**
  - **Ostrea edulis** (aggregates)
  - **Pomatoceros triqueter**
  - **Sabellaria spinulosa**
  - **A. digitatum**
  - **Pisidia longicornis** (small crab)
  - **Flustra foliacea** (a branching bryozoan)
  - **Mytilus edulis** (common mussel)
  - **Galathea intermedia** (a decapod crustacean)
  - **Paguridae** (hermit crabs)
  - **Lepidonotus squamatus** (a typical worm)
  - Hydrallmania (a hydrozoan)
  - Bryozoan eating sea-slugs
- **Fishes:**
  - Lesser spotted dogfish (egg case attachment to branching colonies
  - **Herring (spawning)**
  - Flat fishes – dab, sole
  - Gobies
  - Young cod?

Heavily disturbed (2000s):

Disturbed sandy gravel

(+ eutrophication effect?)

- **Invertebrates**
  - **Asterias rubens**
  - **Ophiura albida**
  - **Pomatoceros triqueter (*)**
  - **Tubularia indivisa (* C)**
  - **Tubularia larynx (* C)**
  - **Psammechinus miliaris**
  - **Electra pilosa (* C)**
  - **Paguridae**
  - Swimming crabs (Liocarcinus)
  - Necora puber
  - **Pisidia longicornis**
  - (Actiniaria) Metridium senile (*)
  - Ciona intestinalis (*)
  - Alcyonidium digitatum (* C) SMALL
  - **Ophiothrix fragilis**
  - Hydrozoan-eating sea-slugs
- **Fishes:**
  - Flat fishes – Dab, Sole
  - E. vipera
  - Gobies
  - Sea horses observed!

"Good Ecosystem State" for open-sea gravels: lessons from the past

- Occurrence of **biogenic reef structures** formed by branching epifauna and/or flat oysters

- *Large proportion of seafloor occupied by hard substratum,* i.e. *limited sand content*
(metrics: percentage cover - how to evaluate what is 'good'...?)

- **High level of diversity and evenness in the associated species**, not numerically dominated by opportunistic species, occurrence of older / larger animals, no impact by invasive species
(metrics: species composition; diversity indices, biomass and species size spectra; natural history / sensitivity traits proportions = functional composition)

- Optimum habitat for **herring** to spawn? (=> effect on recruitment – link with herring stock management)
(metrics: herring larvae densities, targeted autumn monitoring?)

- Optional? Occurrence of **beds of the European flat oyster**
(metrics: oyster densities, reef height, reproductive activity + associated biodiversity monitoring)
=> Provision of larger "reef" structure above the seafloor (elevation level?)
=> Metapopulation of oysters; source / sink dynamics on the larger scale?

- **Natural fragmentation: Connectivity** with other similar habitats (larvae spreading)

=> Integration of targets and measures at regional level !