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Biological Conservation & Marine Protected Areas (MPAs)

Marine Protected Areas as TOOLS for Biological Conservation & Sustainable Development

Mytilene ~ 2019

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The purpose of Marine Protected Areas (MPAs)

MPA aims to Several ecological and socio-economic goals including:

- **Conservation** of Marine Biodiversity
- **Protection** of **threatened**, rare or endangered **species** and populations
- **Protection of commercially** / economically **important species**
- **Preservation of habitats** that are critical for the survival and/or lifecycles of species, including
- **Fisheries management** (reduce fishing pressure, replenish fish-stocks, protect critical stages of species lifecycles, reduce by-catch, reduce competition among fishers)
- **Sustainable Economic** development & Tourism
- **Education & public awareness** (schools, universities, general public, stakeholders)
- **Research** purposes – provide natural laboratories and reference sites (e.g. transplantation of corals, effects of climate change)

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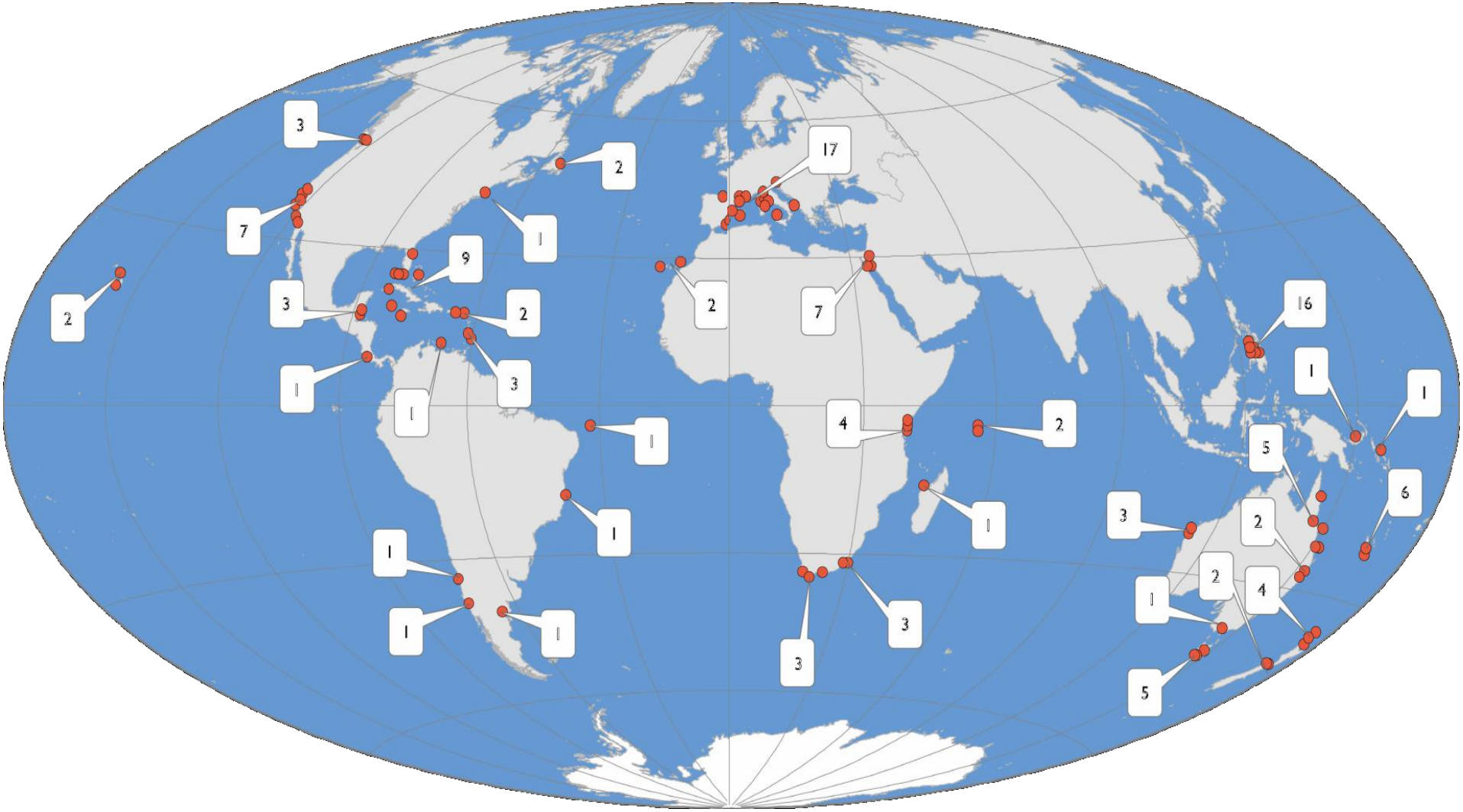
Ecological benefits of Marine Protected Areas (MPAs)

Study in **124 Marine Reserves Worldwide**



Lester et al. 2009 Biological effects within no-take marine reserves: a global synthesis. MEPS 384: 33-46

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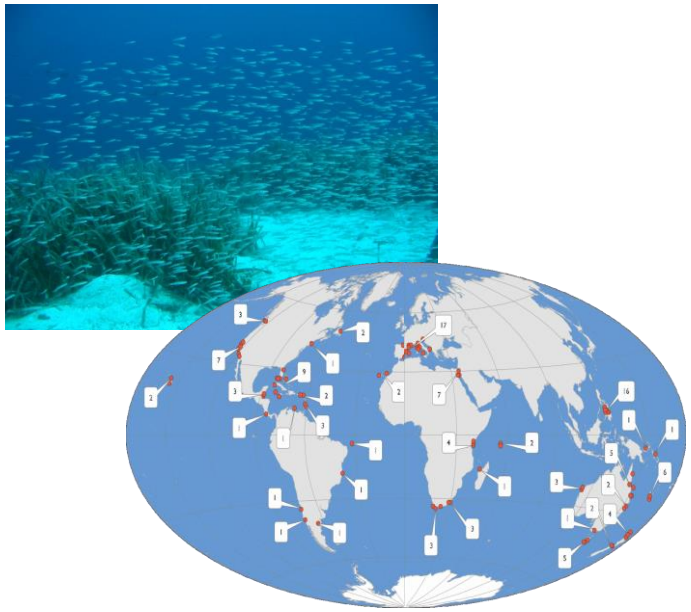
Ecological benefits of Marine Protected Areas (MPAs)

Study in **124 Marine Reserves Worldwide**



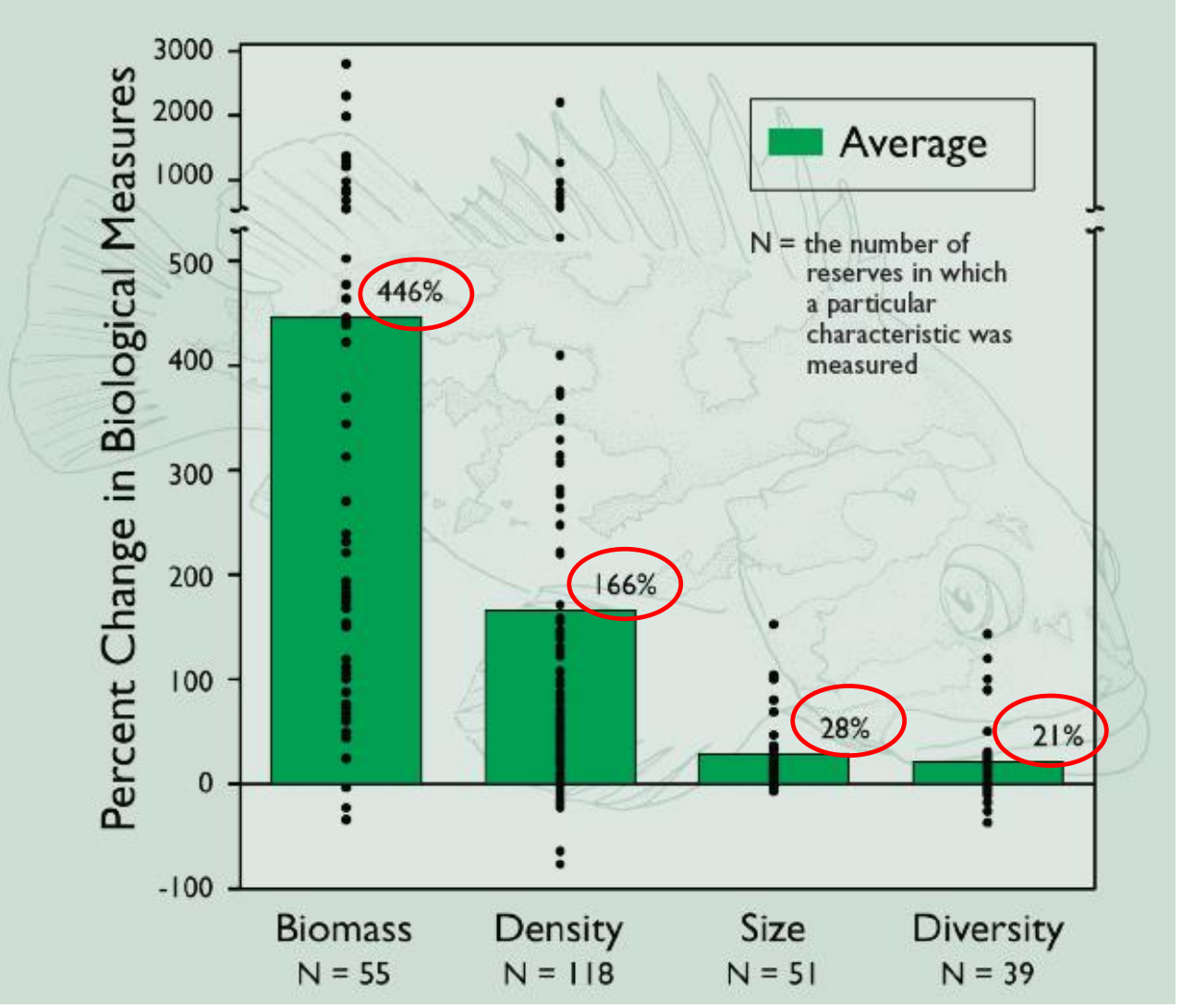
- **Biomass** increased an average of **446%.**
- **Density** increased an average of **166%.**
- **Body size** of animals increased an average of **28%.**
- **Species diversity** increased an average of **21%** in the sample area.
- **Heavily fished species** and **predators** often showed the most dramatic increases (e.g. some fished species had more than **1000% higher biomass or density** inside Marine Reserves)

Ecological benefits of Marine Protected Areas (MPAs)

A main goal of MPAs is to: **Protect the abundance and diversity of marine life -** Lester et al. (2009) showed that **Fully Protected** and **well enforced Marine Reserves** accomplish this goal.

Marine fish, invertebrates & macroalgae show an average increase in MPAs.

- **Biomass** – total weight of animals and plants
- **Density** – number of plants or animals within a given area
- **Size** – body size of animals
- **Diversity** – number of species



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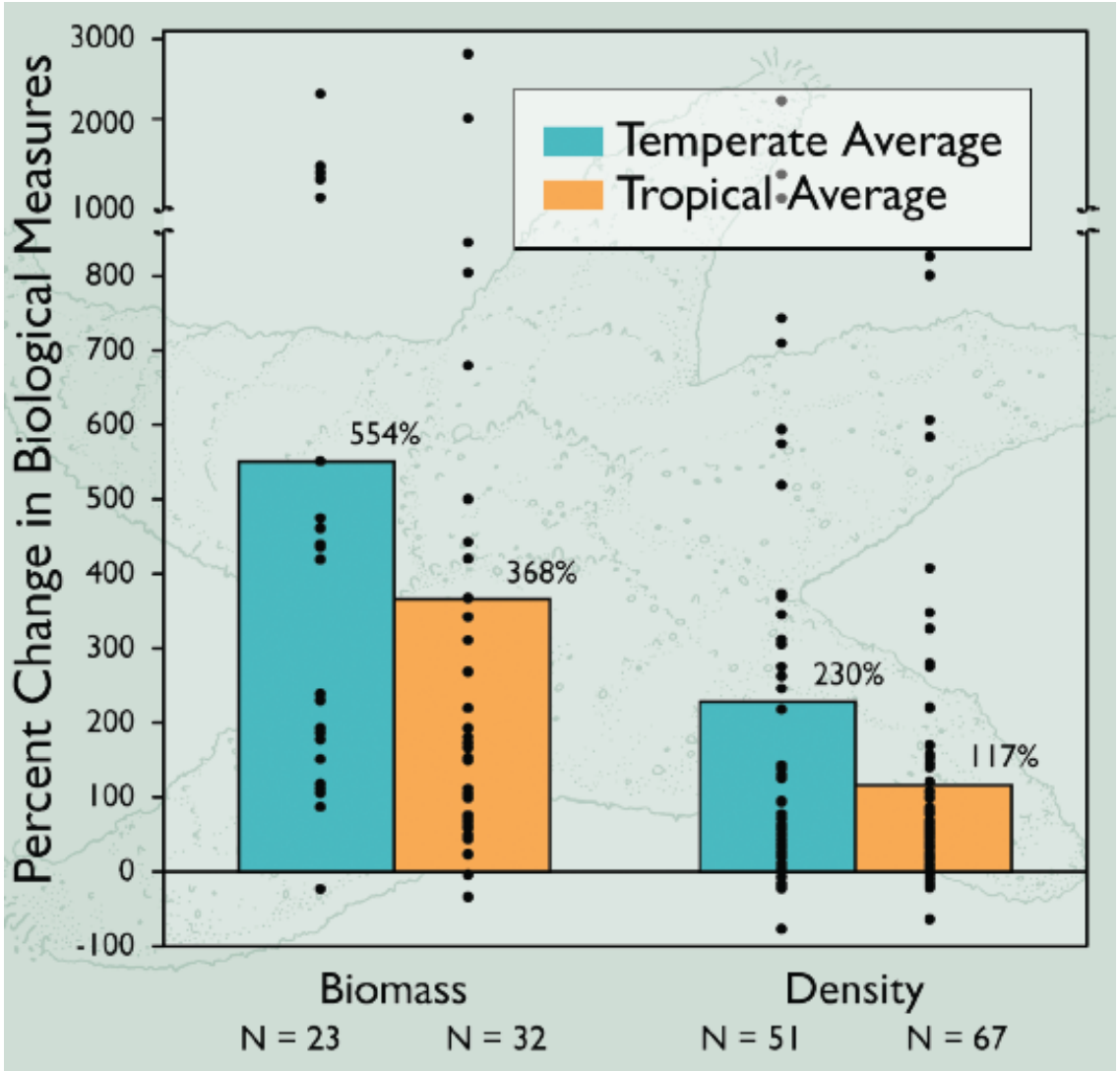
Ecological benefits of Marine Protected Areas (MPAs)

Marine Reserves can be effective **regardless of latitude**



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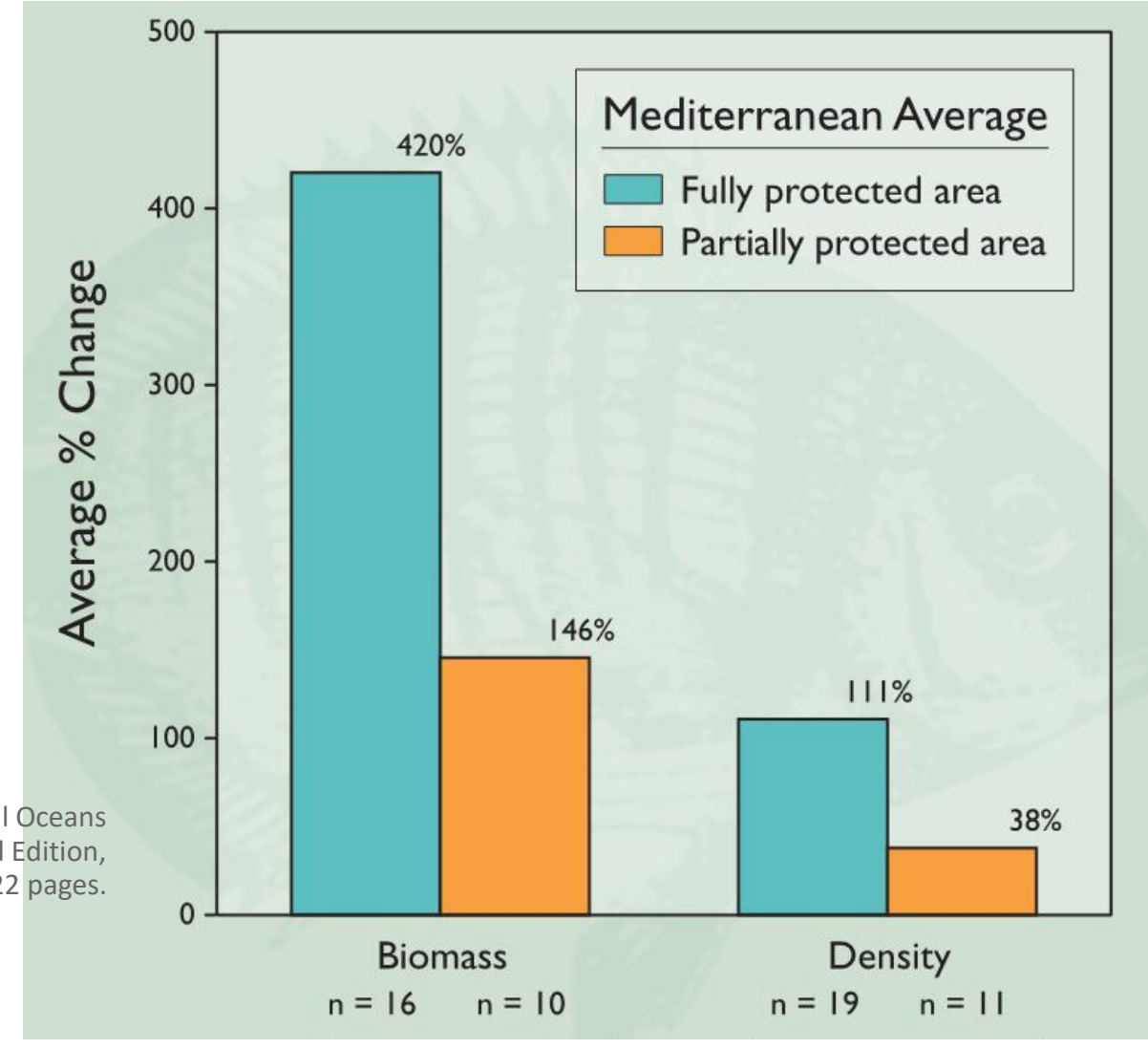
Ecological benefits of Marine Protected Areas (MPAs)

In addition …

A **new review of 24 MPAs in the Mediterranean Sea** showed similar results (Giakoumi et al. 2017) - Both fully and partially protected areas had more and larger fish than areas outside MPAs (i.e. Unprotected Areas).

But ….

- the response of fish species was **greater** in **Fully Protected Areas** than in adjacent **Partially Protected Areas**.



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Ecological benefits of Marine Protected Areas (MPAs)

Bigger Fish = more off-springs (απόγονοι)

Increase in body size

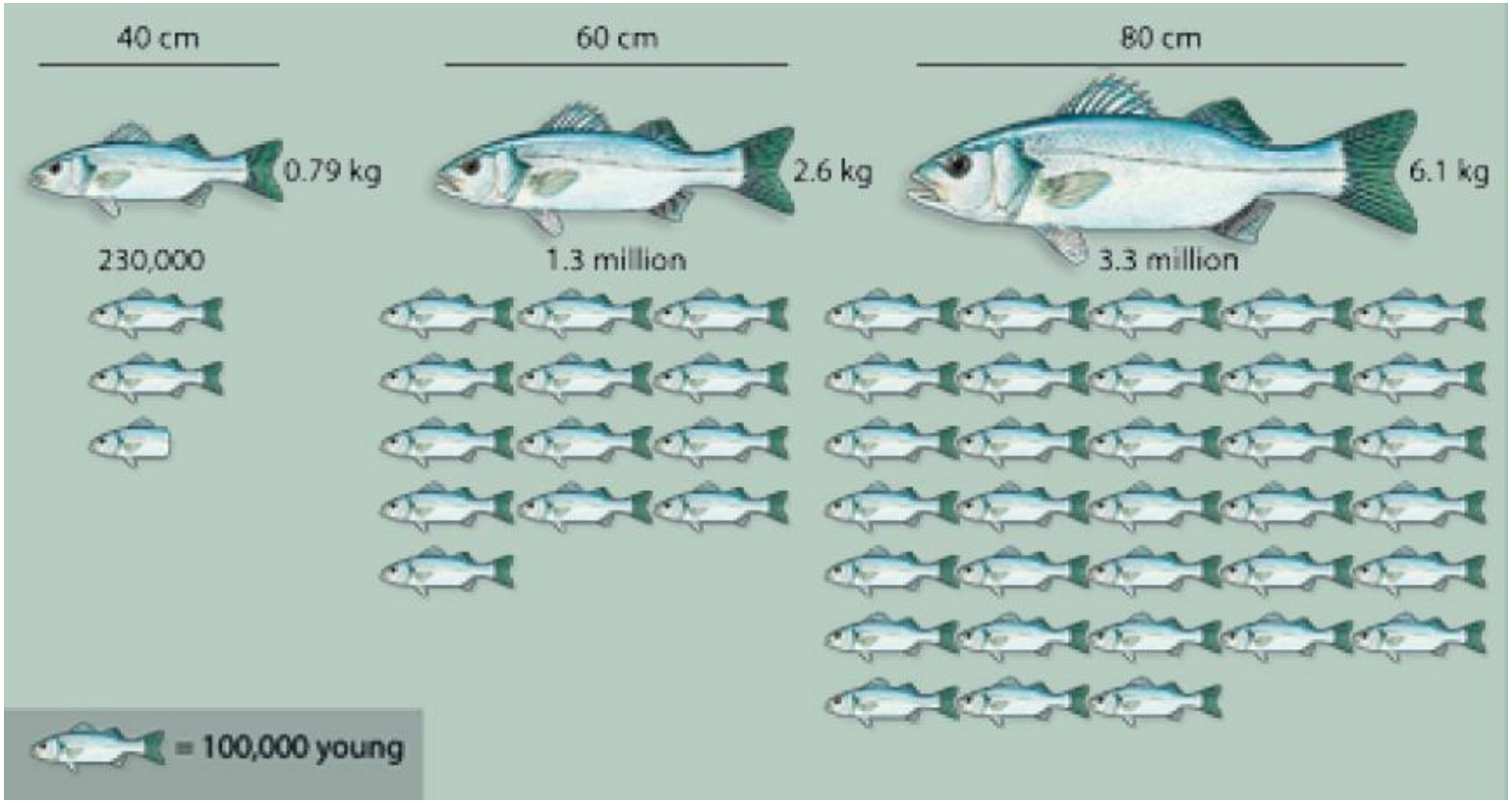
Why is this important?

BOFFFF hypothesis - Berkeley et al. (2004):

***B**ig **o**ld **f**at **f**ecund **f**emale **f**ish*

(*Μεγάλα ηλικιωμένα γόνιμα θηλυκά ψάρια):*

- Produce more larvae,
- Have longer time periods,
- Have more chances of survival



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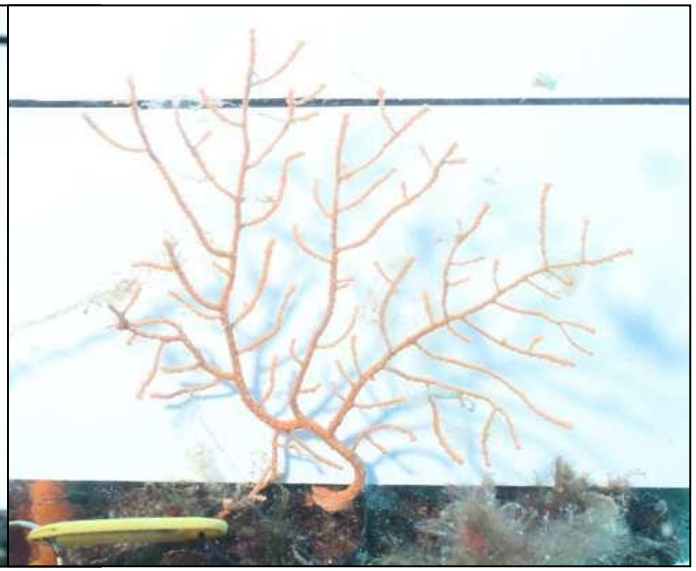
Ecological benefits of Marine Protected Areas (MPAs)

Increase in body size

Why is this important?

The same is also **true for many invertebrate** species, e.g. the yellow gorgonian *Eunicella cavolini*

Bigger Invertebrate = more off-springs (απόγονοι)



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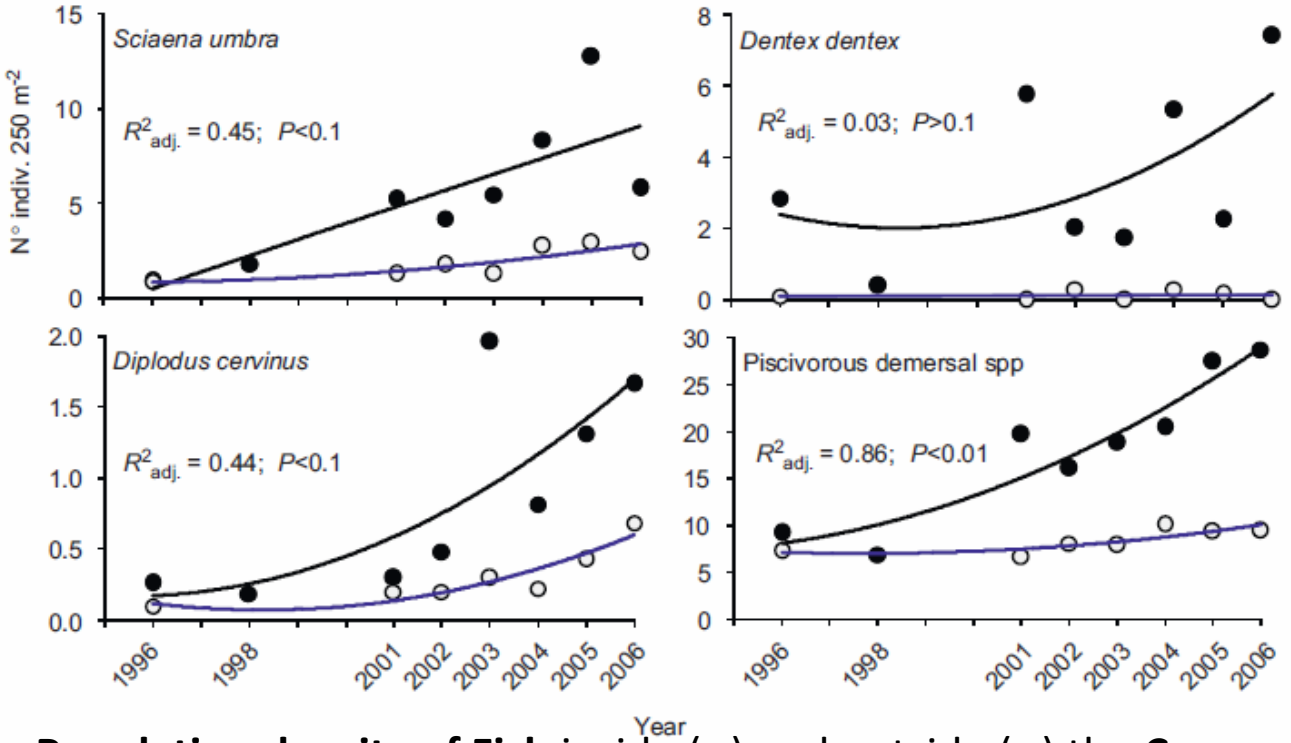
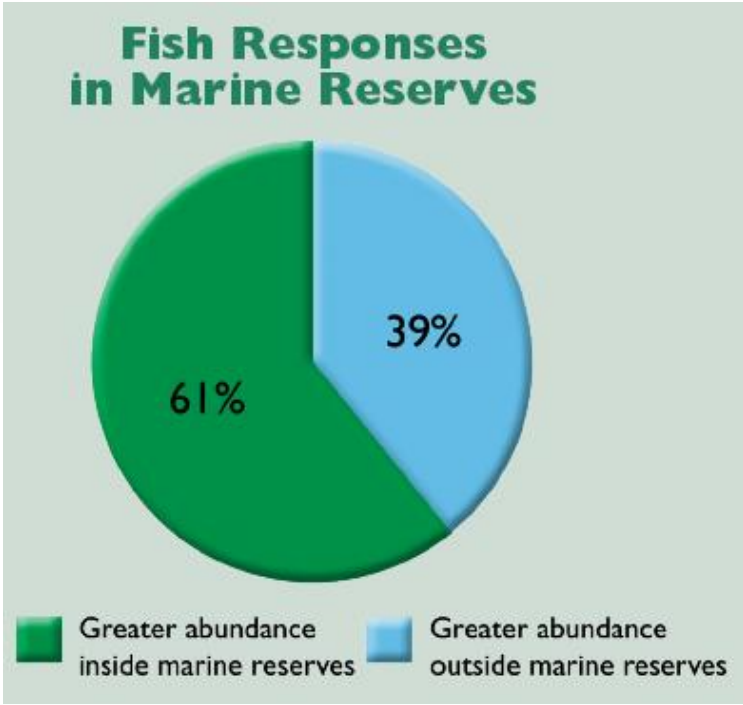
Ecological benefits of Marine Protected Areas (MPAs)

But what do you observe here?



Population density of Fish inside (●) and outside (○) the **Capo de Palos MPA in Spain**. Protection Actions started in 1995.
Source: García-Charton et al. 2008.



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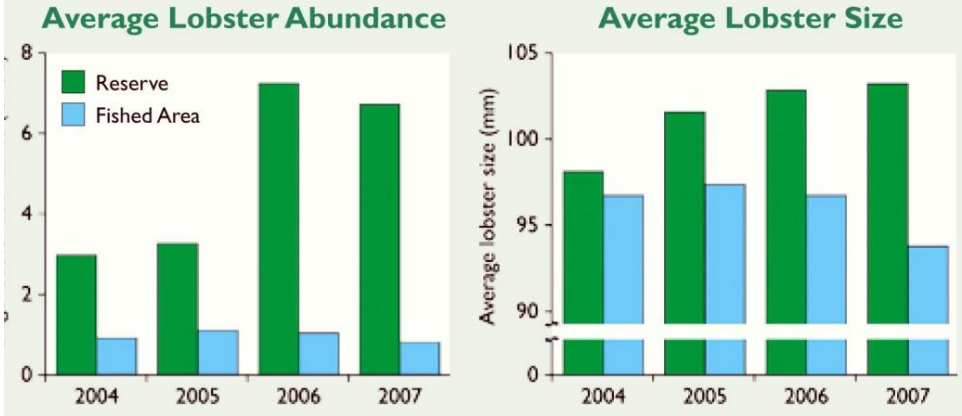
Ecological benefits of Marine Protected Areas (MPAs)

A Marine Reserve Boosts Lobster Abundance and Size

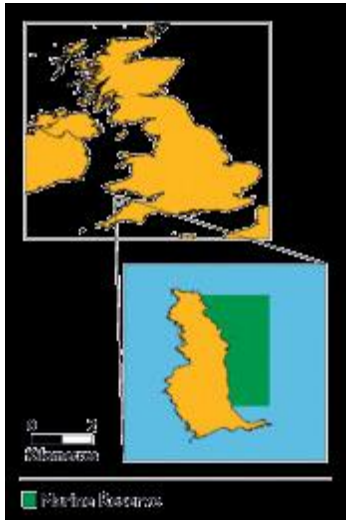
Situated off the southwest coast of England, Lundy is home to species living in diverse habitats, including rocky reefs, sea caves, underwater canyons and sandy bottoms. To further protect habitat and species within a larger existing MPA, a 3.3 km^2 area along the coast of Lundy was designated in 2003 as the first marine reserve in the UK. Some local fishermen supported the Lundy marine reserve in the hopes that they would see higher catches of European lobster, an important commercial species, outside the reserve.

From 2003-2007, scientists monitored lobsters inside the Lundy marine reserve as well as in surrounding fished areas. They detected increases in sizes and numbers of lobster after only 18 months of full protection. By 2007, legal-sized lobsters were 5 times more abundant within the reserve than in fished areas. Scientists also found that lobsters were 9% larger inside the reserve than in the fished areas (see figures below). Legal-sized lobsters adjacent to the reserve had not increased in size or abundance within the 4 years of the study. However, there was an increase in abundance of sub-legal lobsters adjacent to the reserve during the study

The Lundy marine reserve is small compared to others around the globe. The rapid increase in lobster size and abundance at Lundy, however, suggests that even a small reserve may benefit some species. Over time, further increases in size and biomass may lead to increases in the number of lobsters migrating to areas outside the reserve, which would benefit the lobster fishery. In Columbretes marine reserve in Spain, for example, lobsters increased in abundance and biomass for a decade before contributing to increased lobster catches in nearby fished areas.



Legal sized lobsters at Lundy marine reserve have become more numerous (left graph) and larger (right graph) since full protection started in 2003. CPUE = catch per unit effort. Lobster size = carapace length. *Data: Ref. 28*



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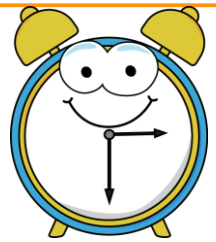
Ecological benefits of Marine Protected Areas (MPAs)



How much time is needed for Population & Ecosystem recovery?

It depends on:

a) a species **life cycle**, growth and maturity rate,

b) a species **fishing status**,

c) species interactions,

d) state of the communities,

e) state of the environment,

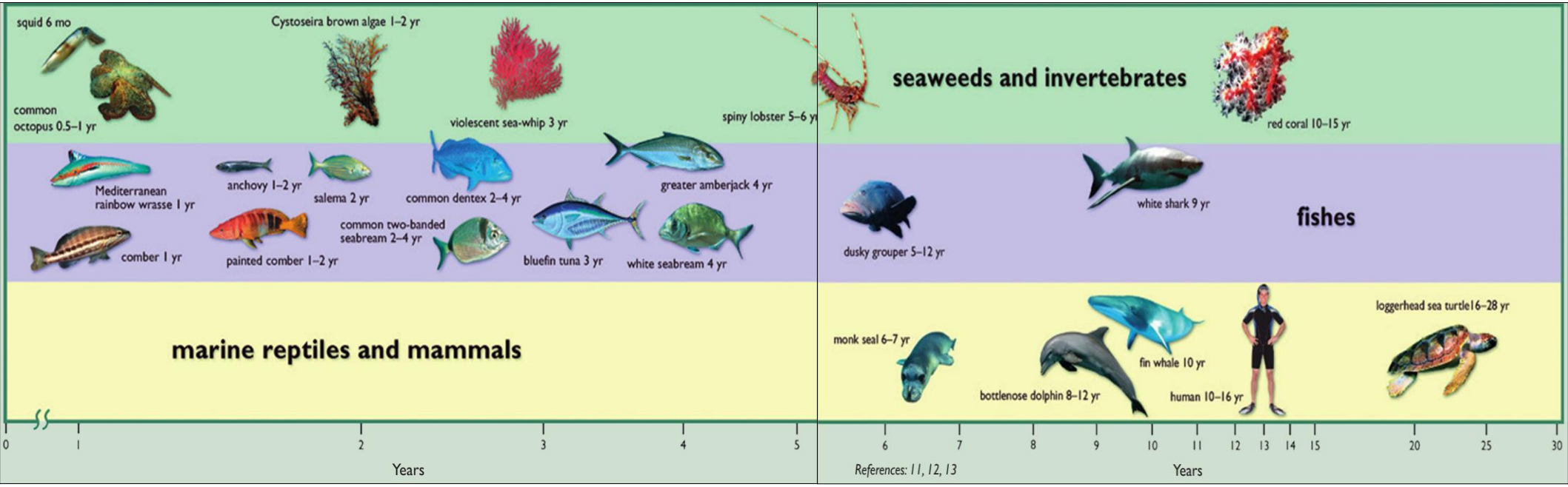
f) existence of other **stressors** (e.g. climate change, regional pollution)

Ecological benefits of MPAs – Effect of species life cycle, growth & maturity

• Effect of a species life cycle, growth & maturity

Different species have **variable responses** according to their **Life cycle**

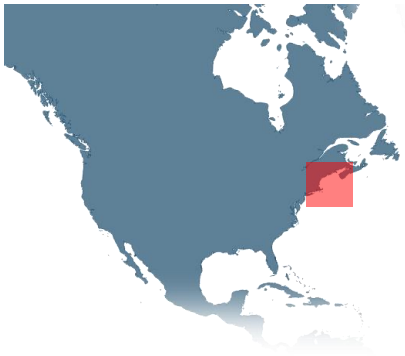
- ❑ Species that **grow** and reach sexual maturity **relatively fast** (1- 4 years): e.g. Scallops (*Pecten* spp.), Squids (*Loligo* spp.), Seabreams (*Diplodus vulgaris*)
- ❑ Species that **grow slow** and need a long time to reach sexual maturity (several years to decades): e.g. Groupers (*Epinephelus* spp.), Cod (*Gadus* spp.), Lobsters (Palinuridae, Homaridae), Sea Reptiles - Turtles, Marine Mammals

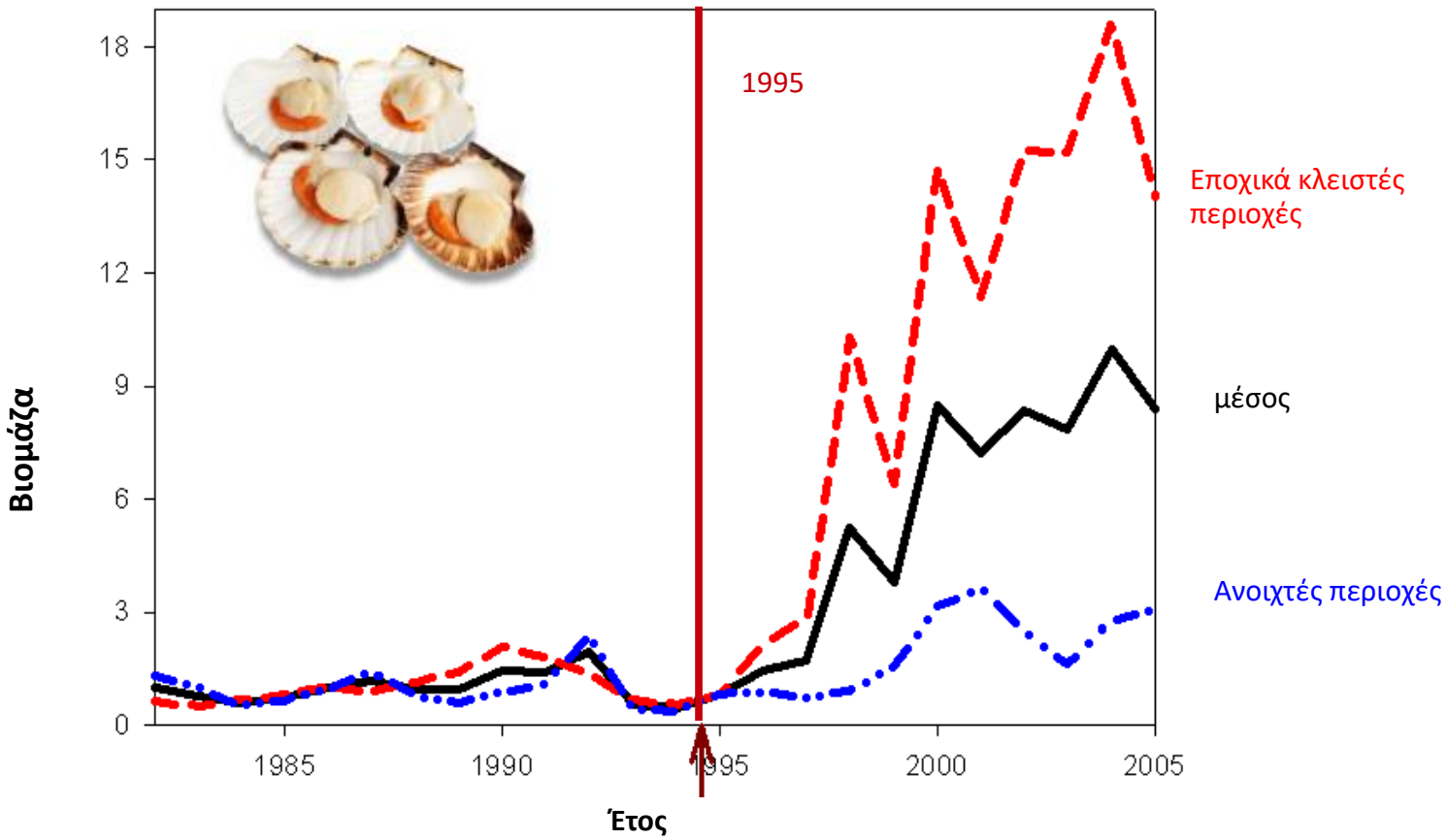


Ecological benefits of MPAs – Effect of species life cycle, growth & maturity

Example 1: George's Bank **Scallops** (*Placopecten magellanicus*)

After several years of overexploitation, in 1994 **seasonal area closures** led to a dramatic **increase** in the **density** and **biomass** of scallops within only a few years.





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Ecological benefits of MPAs – Effect of species life cycle, growth & maturity

Long-Term Benefits of Seabed Protection

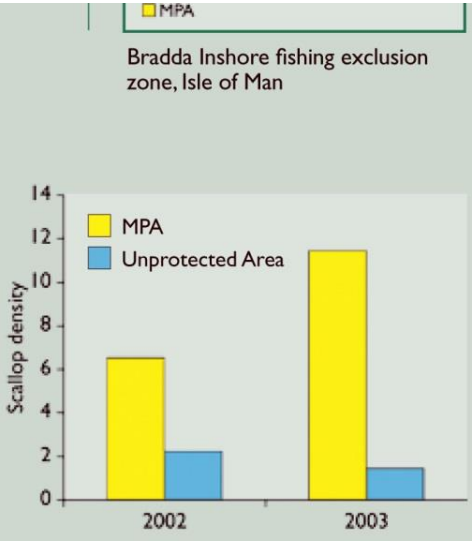
The Bradda Inshore fishing ground off the Isle of Man has supported a major scallop fishery since the 1930s. After 50 years of heavy dredging in the soft sediment habitat, the Bradda Inshore fishing exclusion zone was established in 1989 to protect declining scallop populations and other seabed species by banning trawling and dredging within 2 km^2 of the fishing ground. In 2003, fishermen supported an expansion of the MPA 700 m north of the original boundary.

This area is not a marine reserve because it allows some types of fishing for other species. However, because trawling and dredging—the fishing methods that most impact the seabed—have been banned for over 20 years, it offers an opportunity to study how long-term protection of the seabed benefits resident species and habitats.

Scientists monitored scallops and other seabed species from 1989-2003. Areas protected from dredging supported a more complex and diverse seabed community. Recovery following protection, however, was slow; it took over a decade to see significant increases in scallops within the closed area. After that, scallop numbers increased rapidly, and local fishermen became more supportive of the exclusion zone as scallops rebounded. By 2002, the density of legal-sized scallops had risen to 2.9 times higher and scallop biomass was 4.7 times higher than in nearby fished areas. A year later, density and biomass were 7.8 and 11 times higher, respectively. This pattern of increasing biomass and density over time illustrates the importance of long-term protection.

Scallops within the fishing closure are much larger than those outside, which is significant because larger scallops can produce more offspring, potentially helping to enhance surrounding scallop populations. In 2003, over 50% of scallops in the closed area exceeded 130 mm, compared to only about 12% of scallops in nearby fished areas.

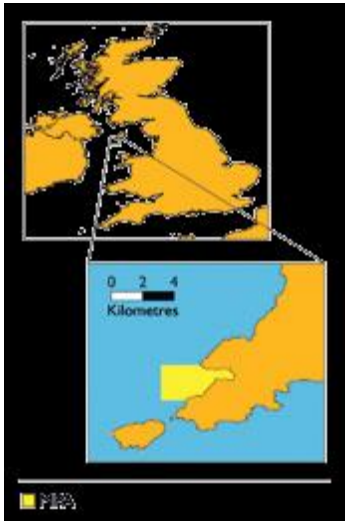
At left: Scallop sizes within the Bradda Inshore fishing exclusion zone (left) and in surrounding fully fished areas (right) in 2003. *Data: Ref. 31*



Average densities of legal-sized scallops per 100m both inside the Bradda Inshore fishing exclusion zone and outside in adjacent fully fished areas during the years 2002 and 2003. *Data: Ref. 31*

Lessons Learned

- MPAs that prohibit trawling and dredging can have positive effects on target species and habitats.
- After 14 years of protection, scallop density was 8 times greater and biomass was 11 times higher inside a fishing closure than in nearby fished areas.



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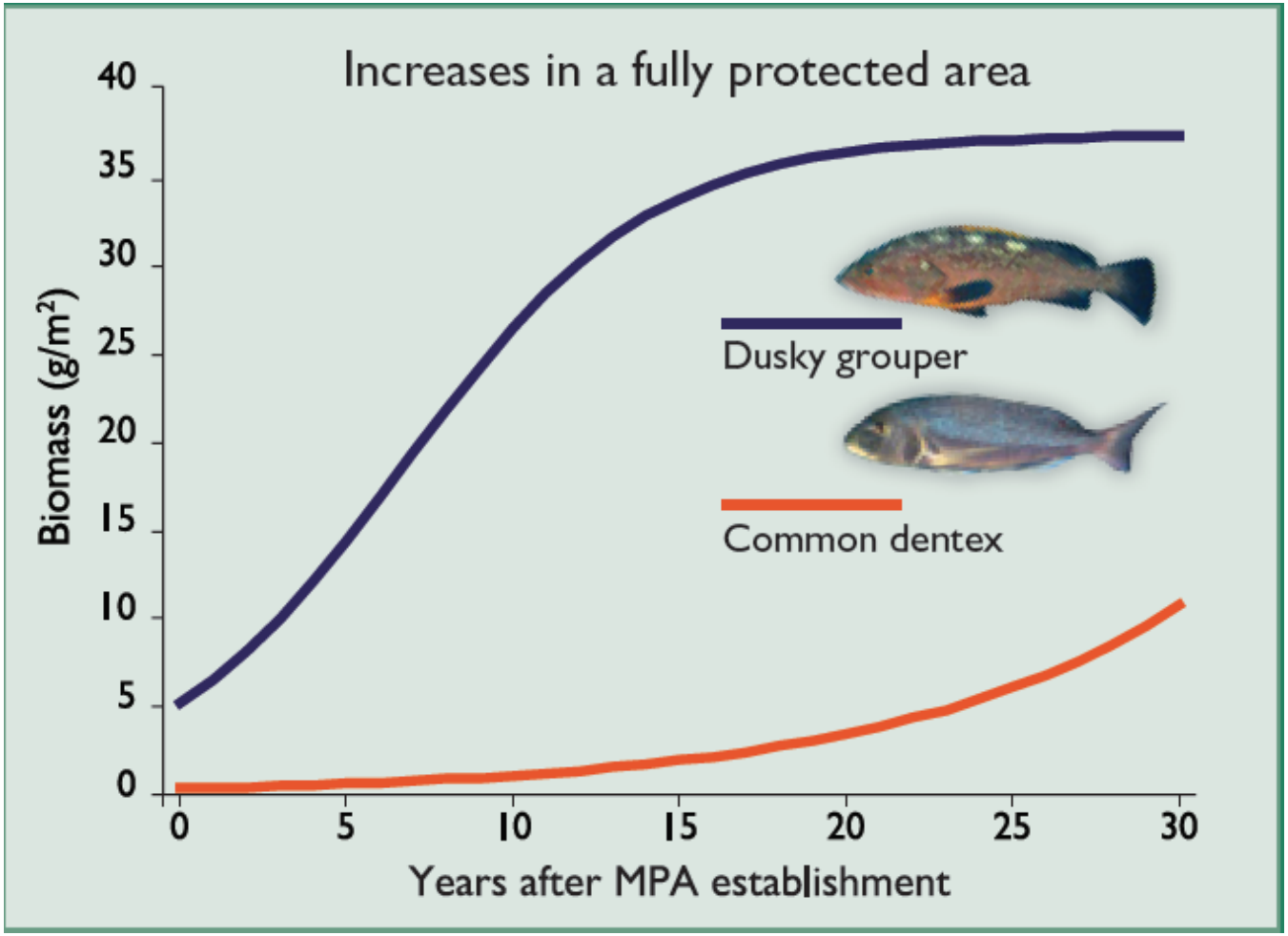
Ecological benefits of MPAs – Effect of species life cycle, growth & maturity

Example 2: Medes Islands, Spain - ***Epinephelus marginatus*** versus ***Dentex dentex***



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- The biomass of ***E. marginatus*** increased for **15 years** and stabilized about 20 years after protection.
- The biomass of ***D. dentex*** increased **more slowly**, but continuously, and is **still increasing 30** years after protection.

- Long term protection is needed for full ecosystem recovery.

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Ecological benefits of MPAs – Effect of Fishing status & Species Interactions

• Effect of Fishing Status & Species Interactions

• A worldwide analysis has revealed that:

~ **61% of fish species** were **more abundant inside** Marine Reserves than outside

~ **39% of fish species** decline following protection.

• Some species increase, some decrease, and some stay the same in abundance within an MPA. **Can you imagine Why?**

❑ **Species interactions:** Prey species will increase in the absence of their predators, and will decrease when they re-appear due to protection.

❑ **Fishing status:** Species subject to fishing in Unprotected areas tend to increase in Fully Protected MPAs.

~ **Example 1:** a decline of **juvenile Lobsters** in Medes Islands MPA, Spain (Diaz et al., 2005).

~ **Why?** ✓ **Increase of predators** that feed upon juveniles.

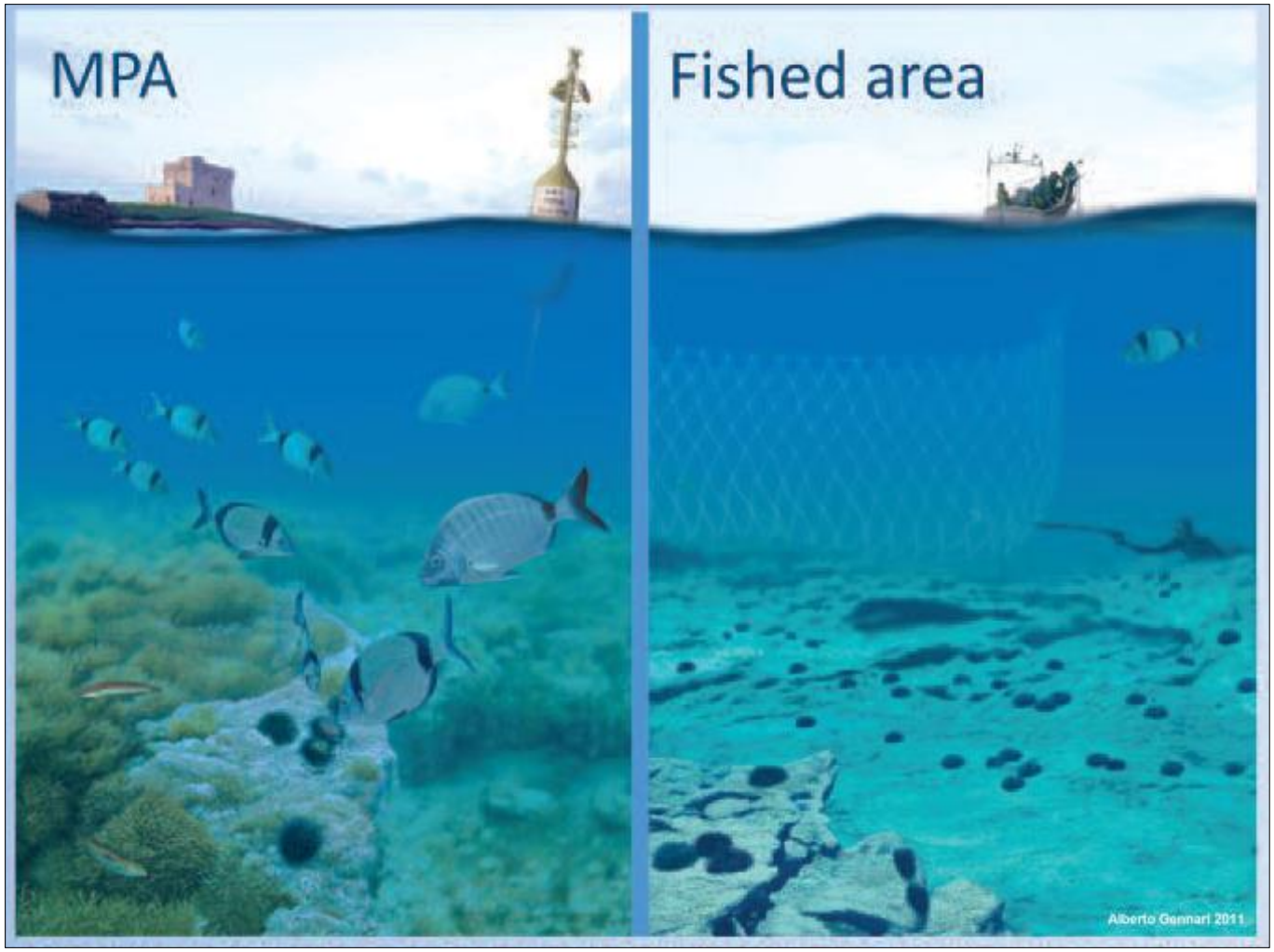
Ecological benefits of MPAs – Effect of Fishing status & Species Interactions

- **Example 2**: a study in New Zealand, showed that **Lobster abundance** was **higher in Marine Reserves** than in multi-purpose MPAs. **Why?**
  - ✓ Recreational fisheries were allowed in multi-purpose MPAs. This kept population numbers low.

- **Example 3**: a review of Marine Reserves in New Zealand, Australia, USA, Kenya, Philippines showed that **Fish species targeted** by **fishing** generally **responded within 5 years of Protection**. **Unfished species** took an average of **13 years to respond**. Why?
  - ✓ Unfished species were not responding to the absence of fishing but to changing abundances of other species (i.e. **species interactions**)

Ecological benefits of MPAs – Previous State of the Ecosystem

- **Effect of the Previous State of the Ecosystem**



Ecosystem restoration is possible but it needs a l**ong time for all ecosystem components** to respond.

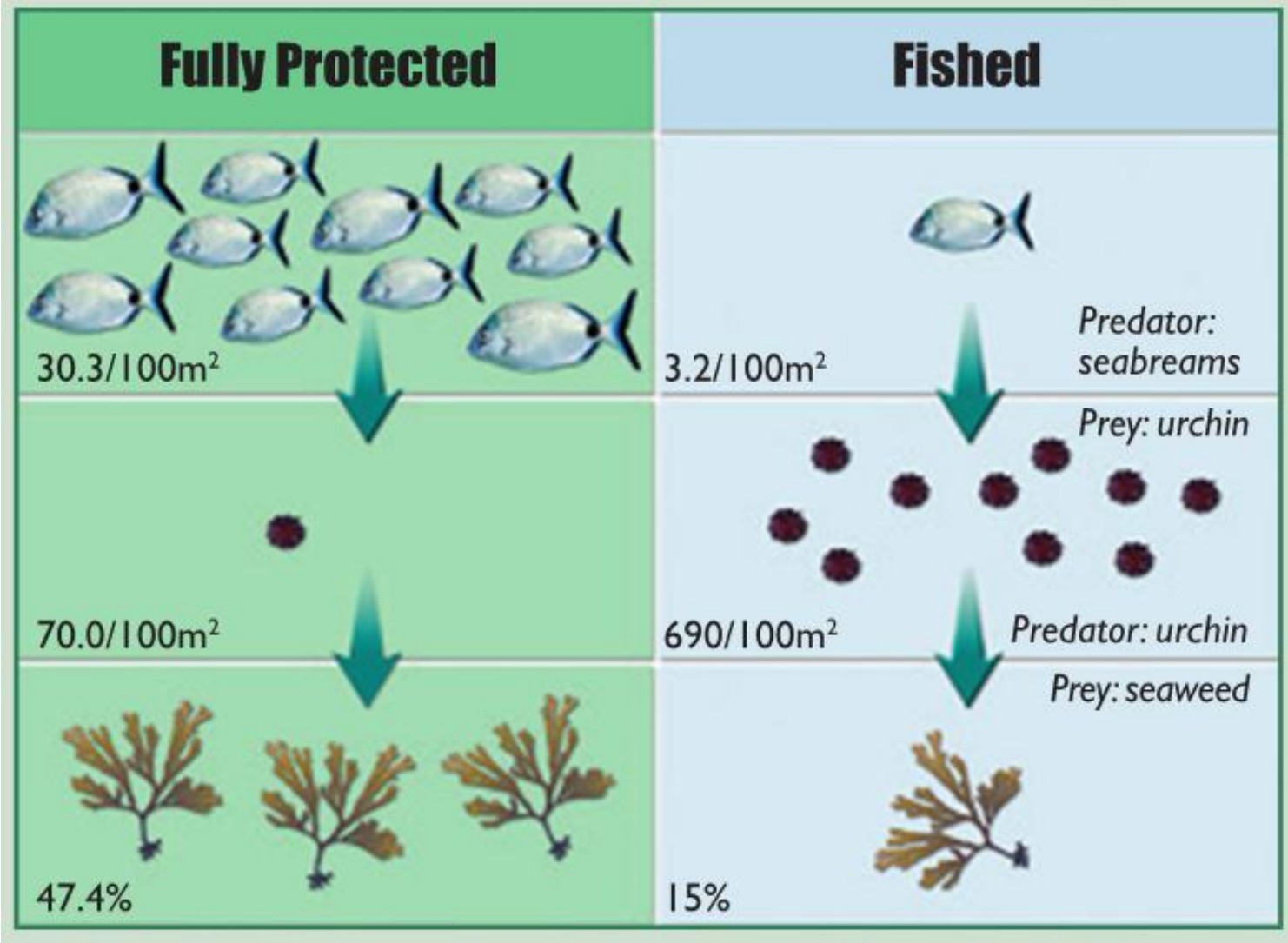
Ecological benefits of MPAs – Previous State of the Ecosystem

- **Example 1**: Torre Guaceto (ITALY) Marine Reserve

Commonly fished sea-breams (e.g. ***Diplodus sargus*)** became **2-10 times** more abundant in the Marine Reserve, after **10 years of protection.**

Seabreams ate sea urchins, which became **10 time less** abundant.

With less sea urchins, **macroalgal communities** showed a **3 times** cover increase.



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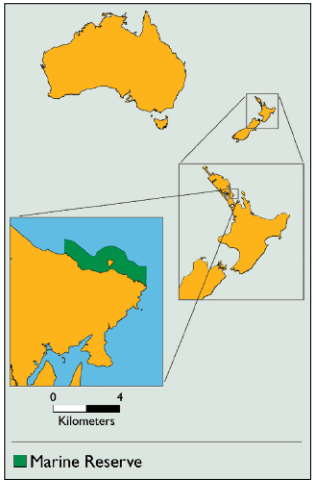
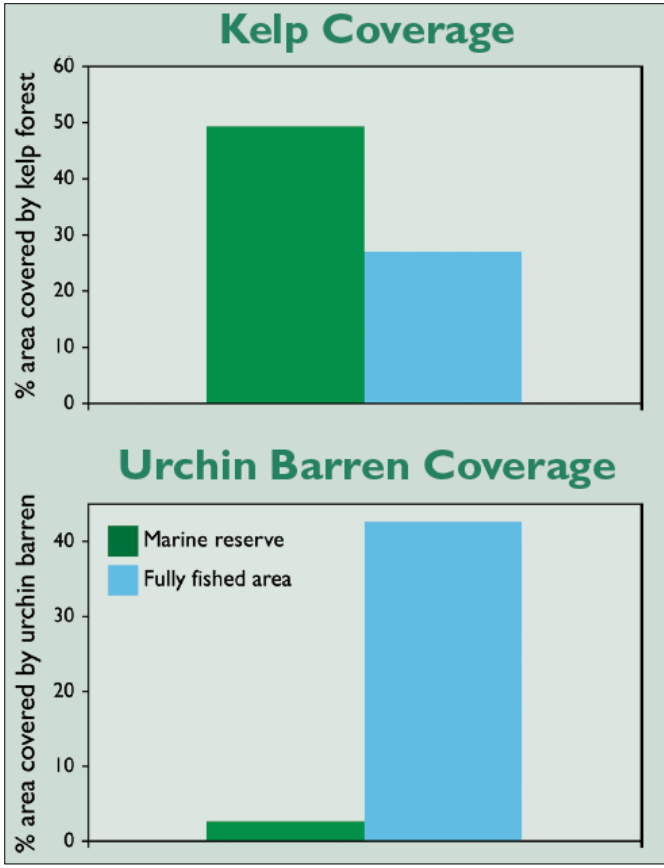
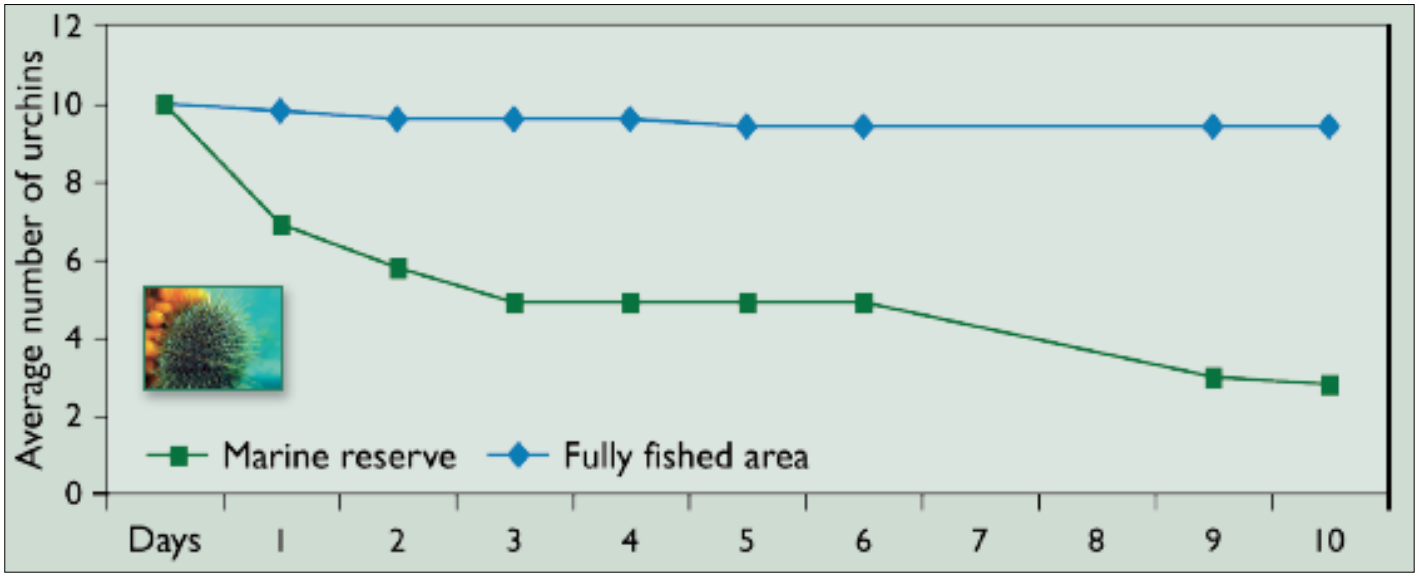
Ecological benefits of MPAs – Previous State of the Ecosystem

Example 2: Leigh Marine Reserve, New Zealand





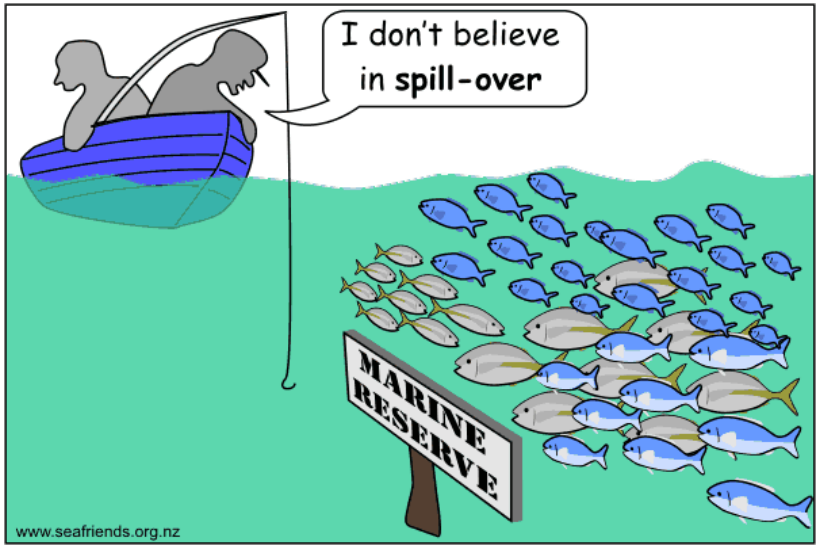


Shears NT, Babcock RC, 2002. Marine reserves demonstrate top-down control of community structure on temperate reefs. Oecologia 132:131–142

Ecological benefits of MPAs – Beyond MPA borders

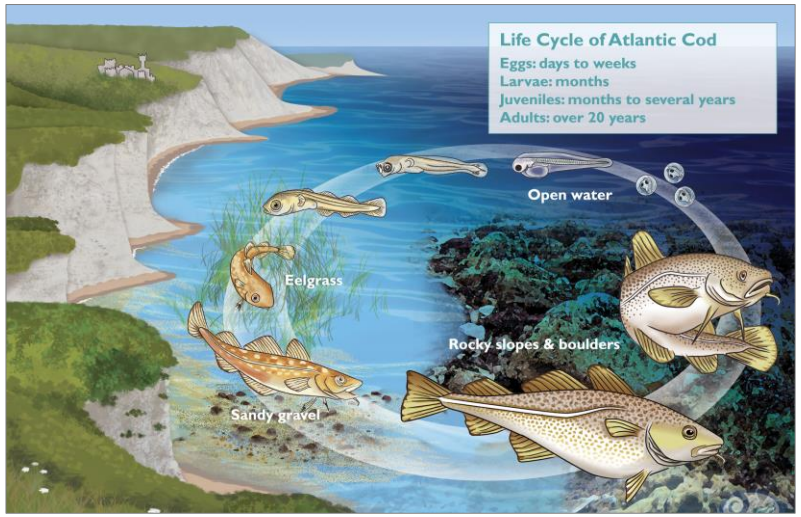
Benefits beyond MPA borders

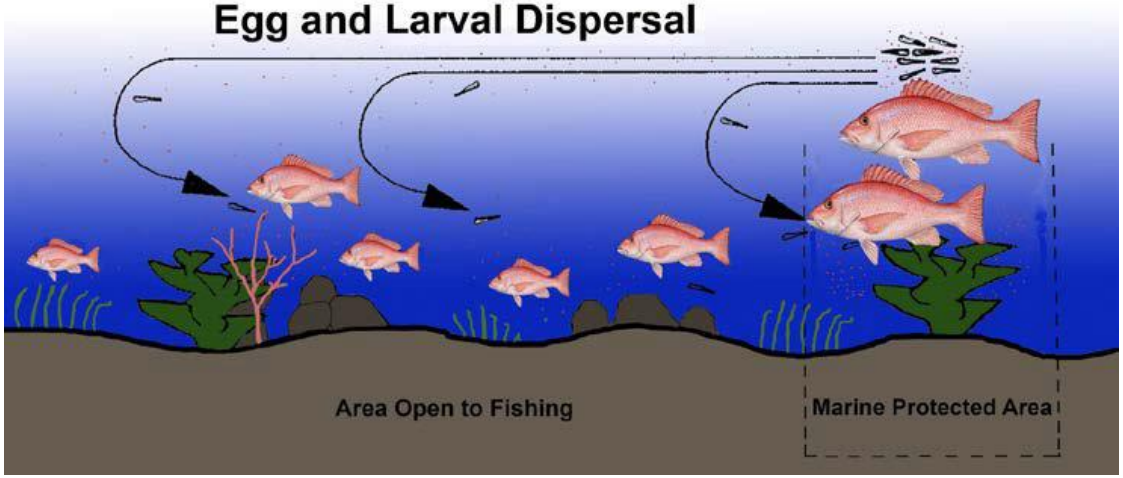
a) Spillover effect



Increases in the number and size of species may **affect positively nearby** un-protected areas through a the process of the **Spillover effect**.

- As animals become more abundant in MPAs and resources become limited, some adults may move to other places to look for food and space to settle.
- As animals grow, they may need different types of habitats or food items.

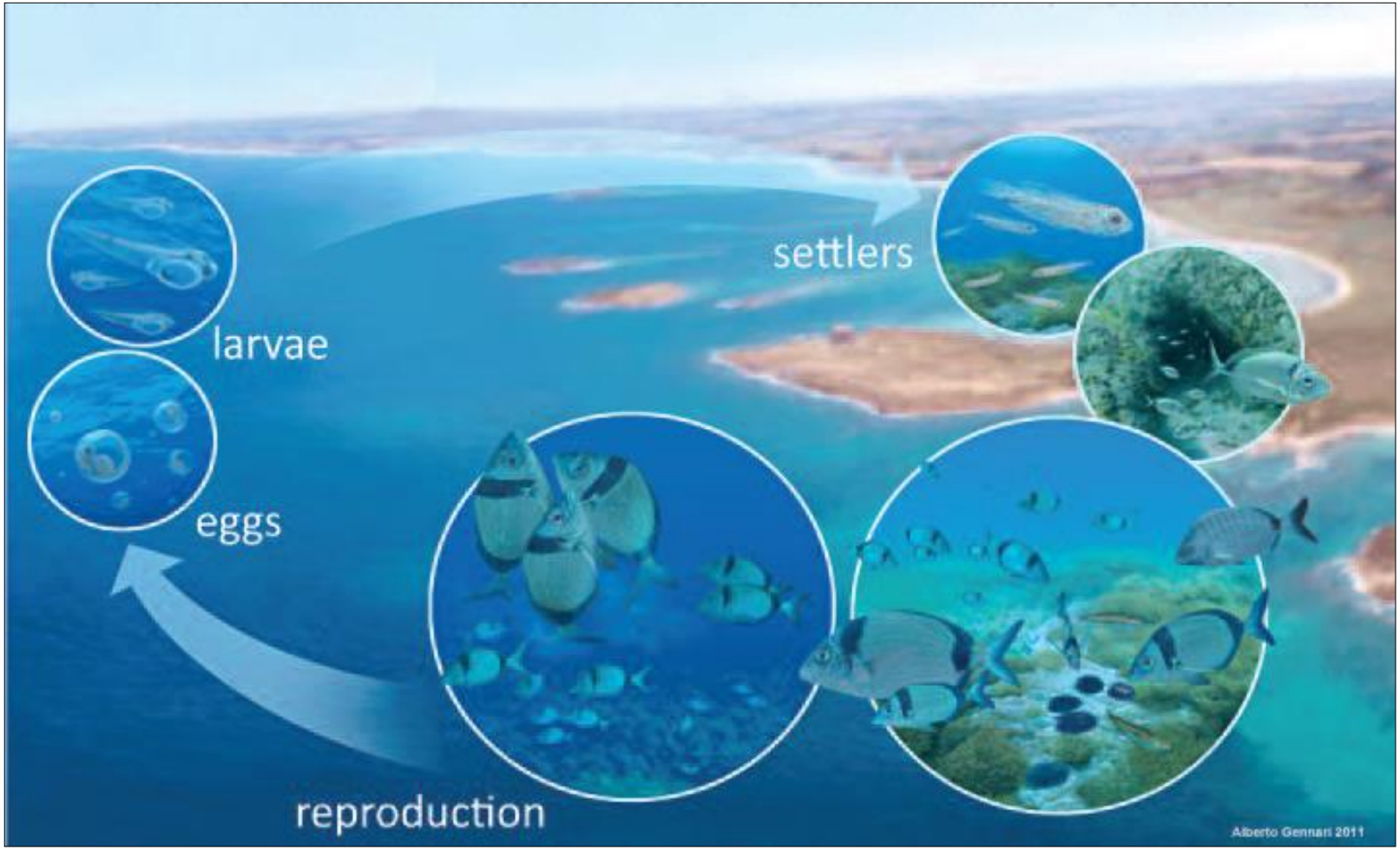




Ecological benefits of MPAs – Beyond MPA borders

b) Dispersal of early stages

Fish & Invertebrates release a large number of eggs. After fertilization, eggs hatch into tiny larve. Eggs and larvae can stay in the water for days or months traveling along with water currents. This process is called **dispersal**.



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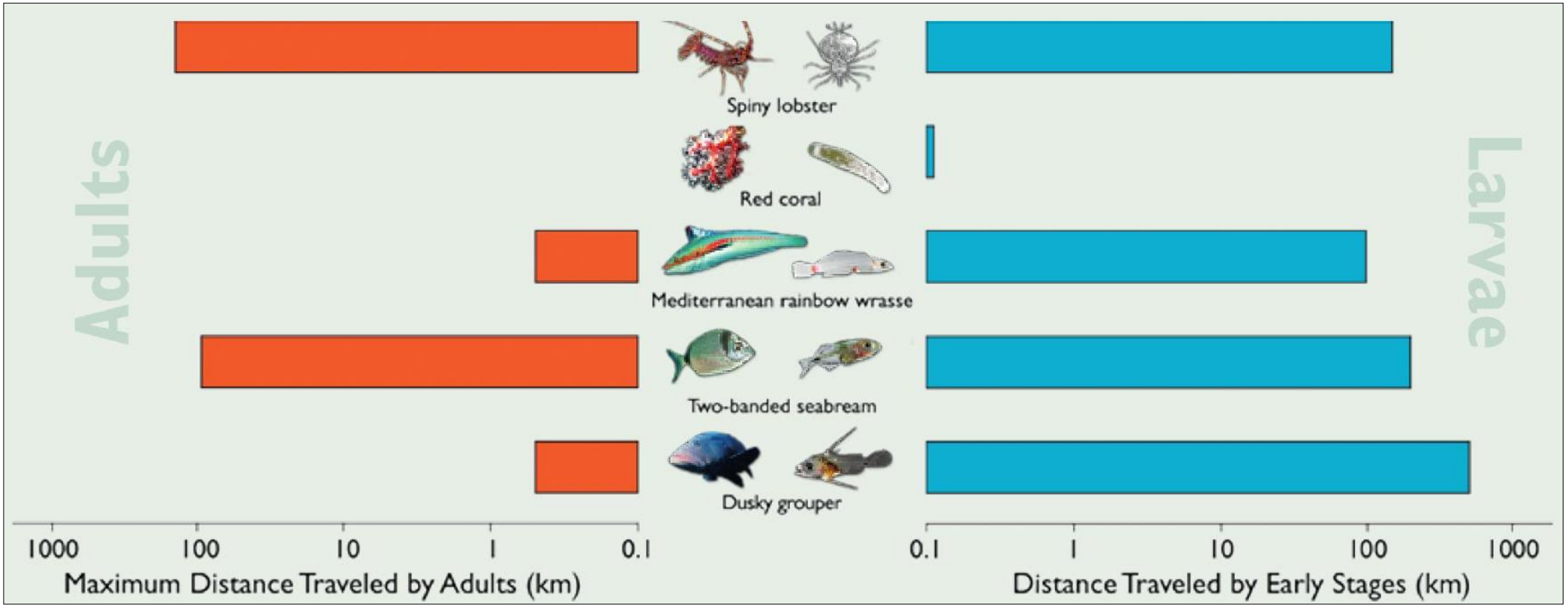
Ecological benefits of MPAs – Beyond MPA borders

b) Dispersal of early stages

Dispersal distance in nature may range from **1 km** for macroalgae to >**100 km** for Fish (Kinlan & Gaines, 2003).



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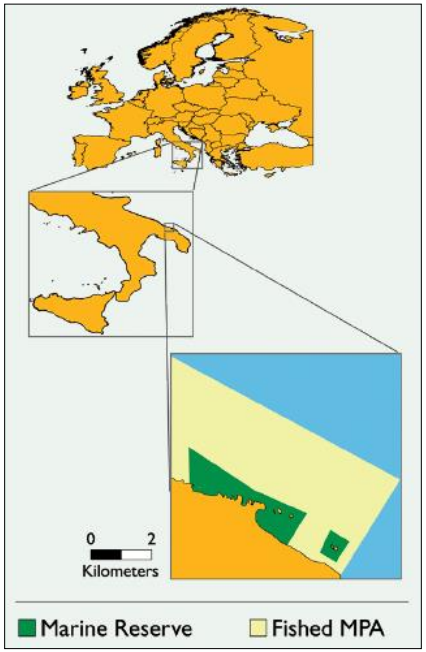
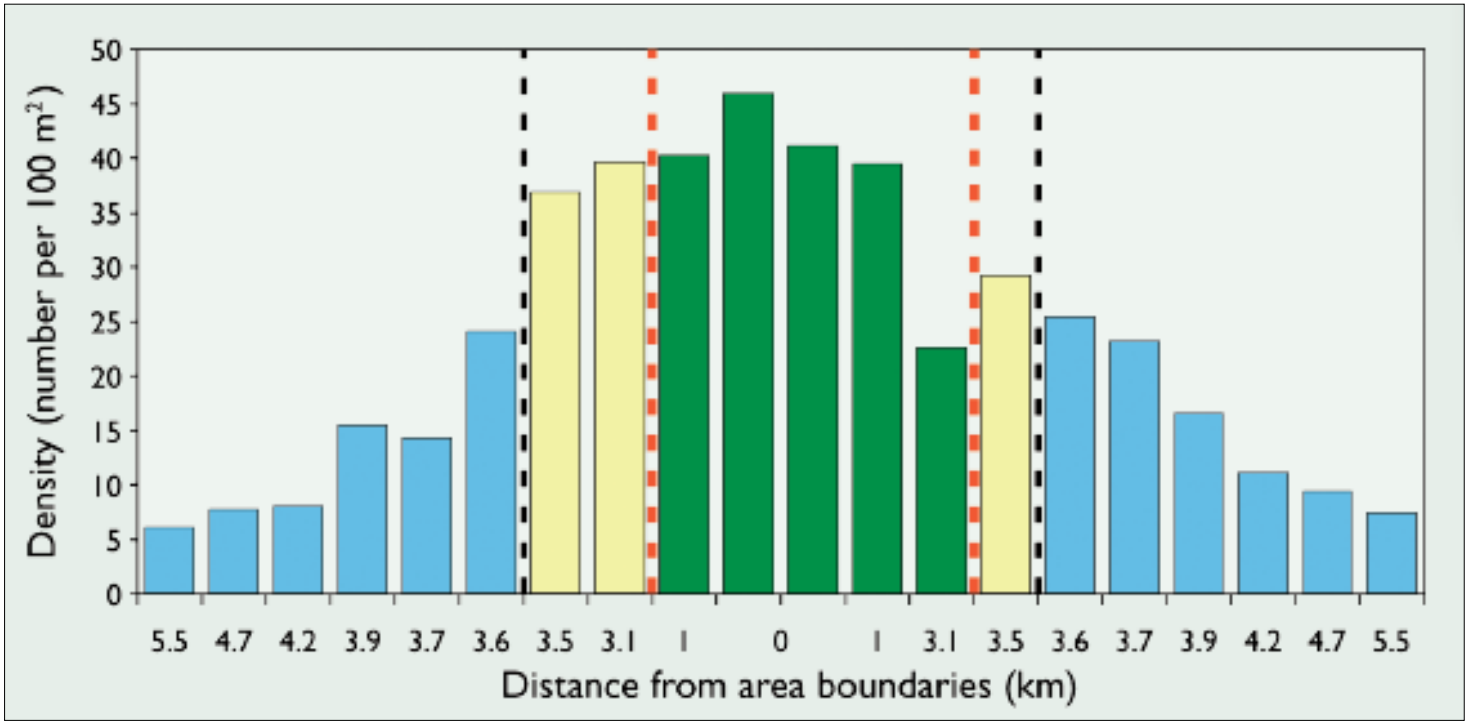
Ecological benefits of MPAs – Beyond MPA borders

Spillover & Dispersal

Torre Guaceto, MPA, Italy





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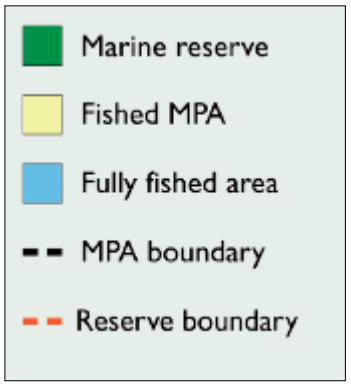
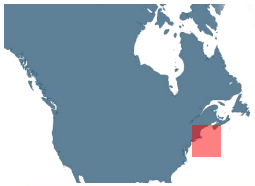


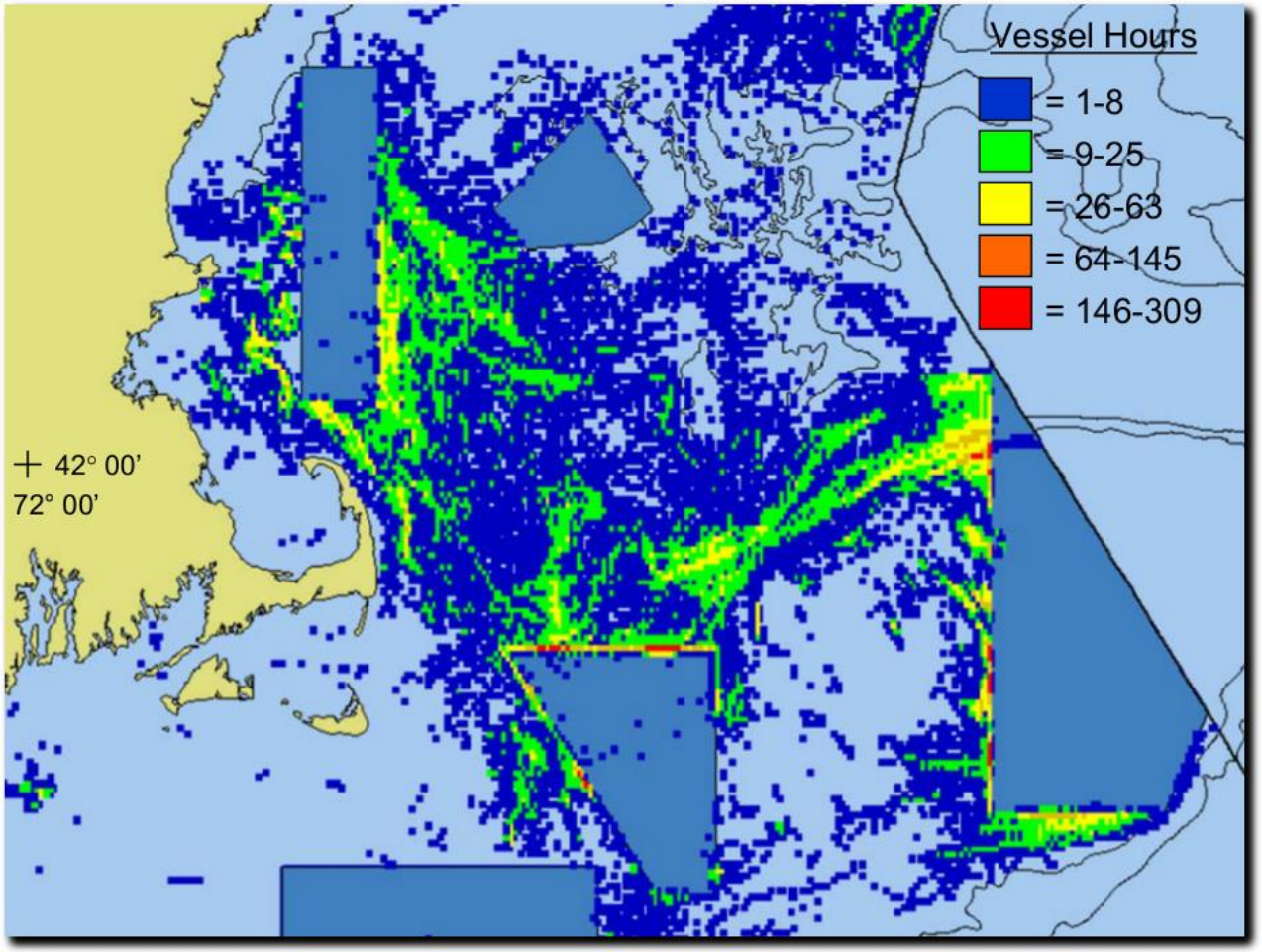
Ecological benefits of MPAs – Beyond MPA borders

Spillover & Dispersal is hard to assess.

Evidence comes from the **“fishing the line”** phenomenon



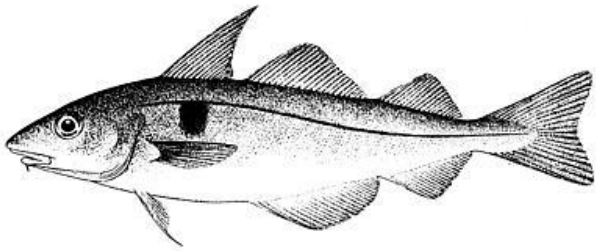
… back to George’s bank



Between 2001-03:

42% of haddock catches were within 0.6 nm of closed areas

73% within 3.1 nm



NOAA Fisheries

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Ecological benefits of MPAs

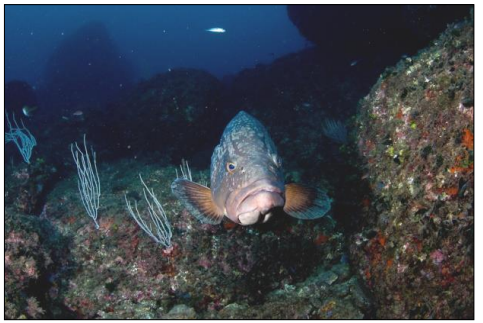
How long does it take to see a response?

Some changes happen fast, but other processes may be slow.

This is why it takes many years before the full effects of MPAs are evident.

The time of the response is influenced by the following factors:

- The level of MPA protection, compliance and enforcement.
- The availability of breeding adults.
- Growth rate of different species.
- The age of sexual maturity of different species.
- The number of youngs produced.
- The availability of suitable habitats for juveniles.
- Level of mobility / dispersal ability during each life stage.
- Interactions among species (e.g. predators and prey).
- Human impacts prior to MPA establishment (how big is the damage).
- Ongoing impacts from climate change and regional pollution.
- The habitat's and species ability to recover after an impact.



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Ecological benefits of MPAs

Thank you for your protection!

The Science of Marine Reserves, PISCO:

- ✓ video: www.piscoweb.org/publications/outreach-materials/film/science-of-marine-reserves-video
- ✓ booklet: www.piscoweb.org/publications/outreach-materials/science-of-marine-reserves/smr-booklet-versions

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