環境研究総合推進費
Environment Research and Technology Development Fund

Beyond Population Recovery: Toward Coexistence between Green Turtles and Seagrass Meadow Ecosystems in the Ryukyu Archipelago, Japan

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Introduction: the impact of overgrazing by green turtles

Seagrass meadows

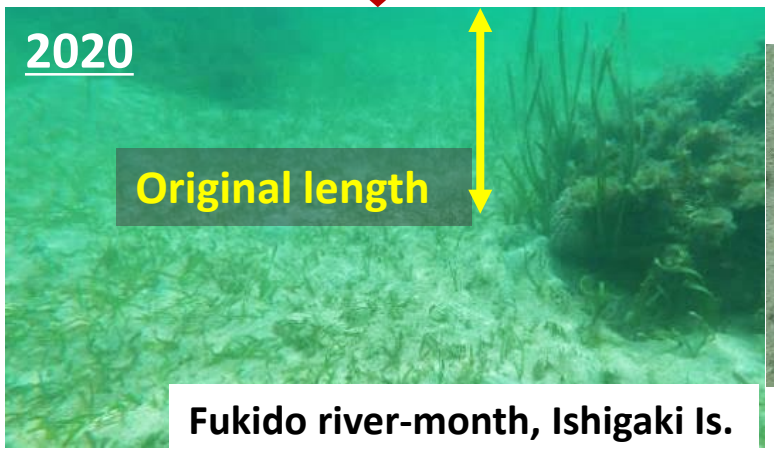
Green turtles

Source : Monitoring site 1000, 2021FYR, Biodiversity Center, Ministry of Environment

Grazing pressure

Overgrazing

Degradation



Fukido river-month, Ishigaki Is.

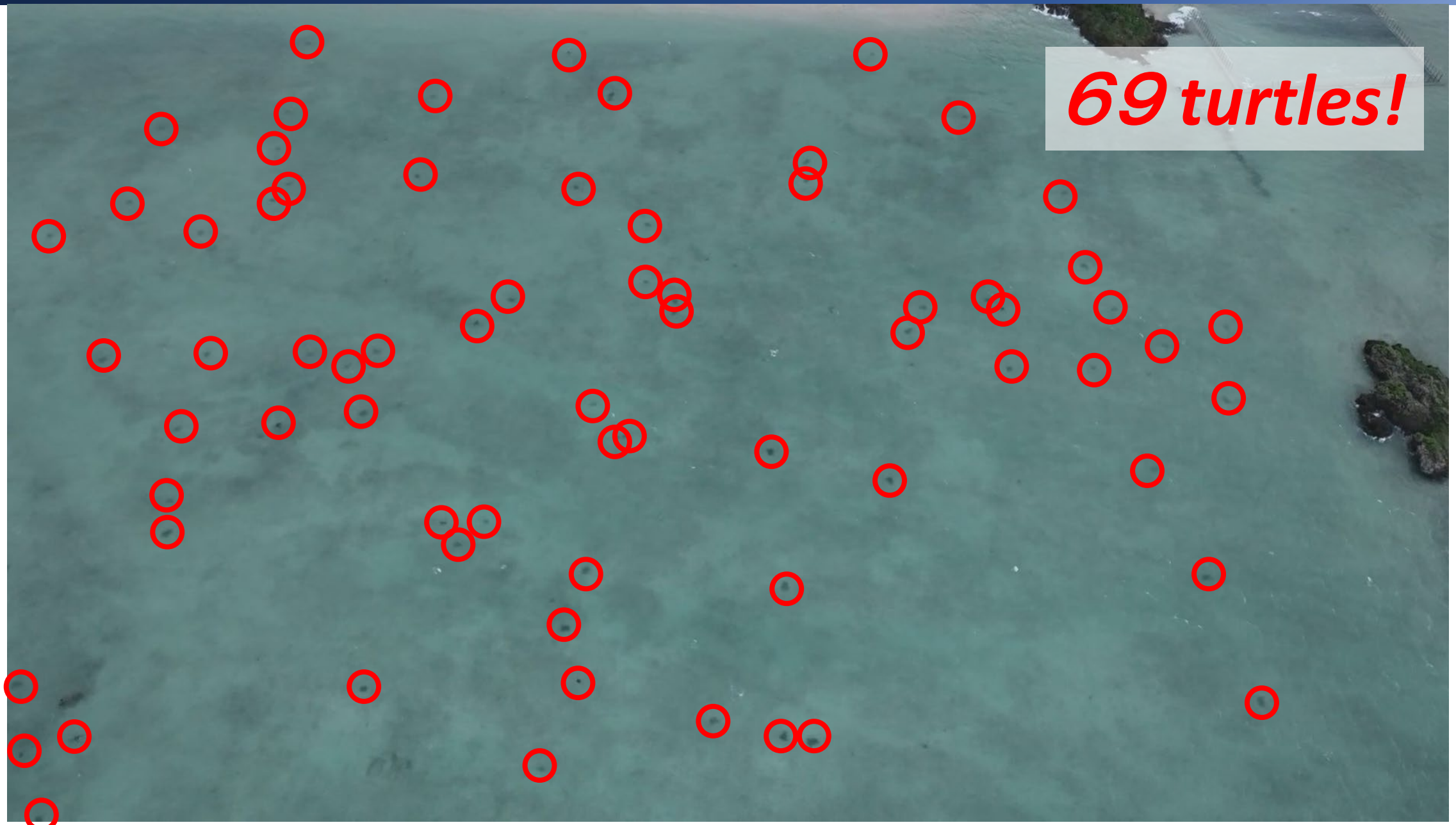
Trace of green turtle feeding

- Recovering the abundance in several subpopulations over the past few decades (IUCN 2023).
- Many seagrass meadows in Okinawa have been reported to suffer collapse or severe degradation

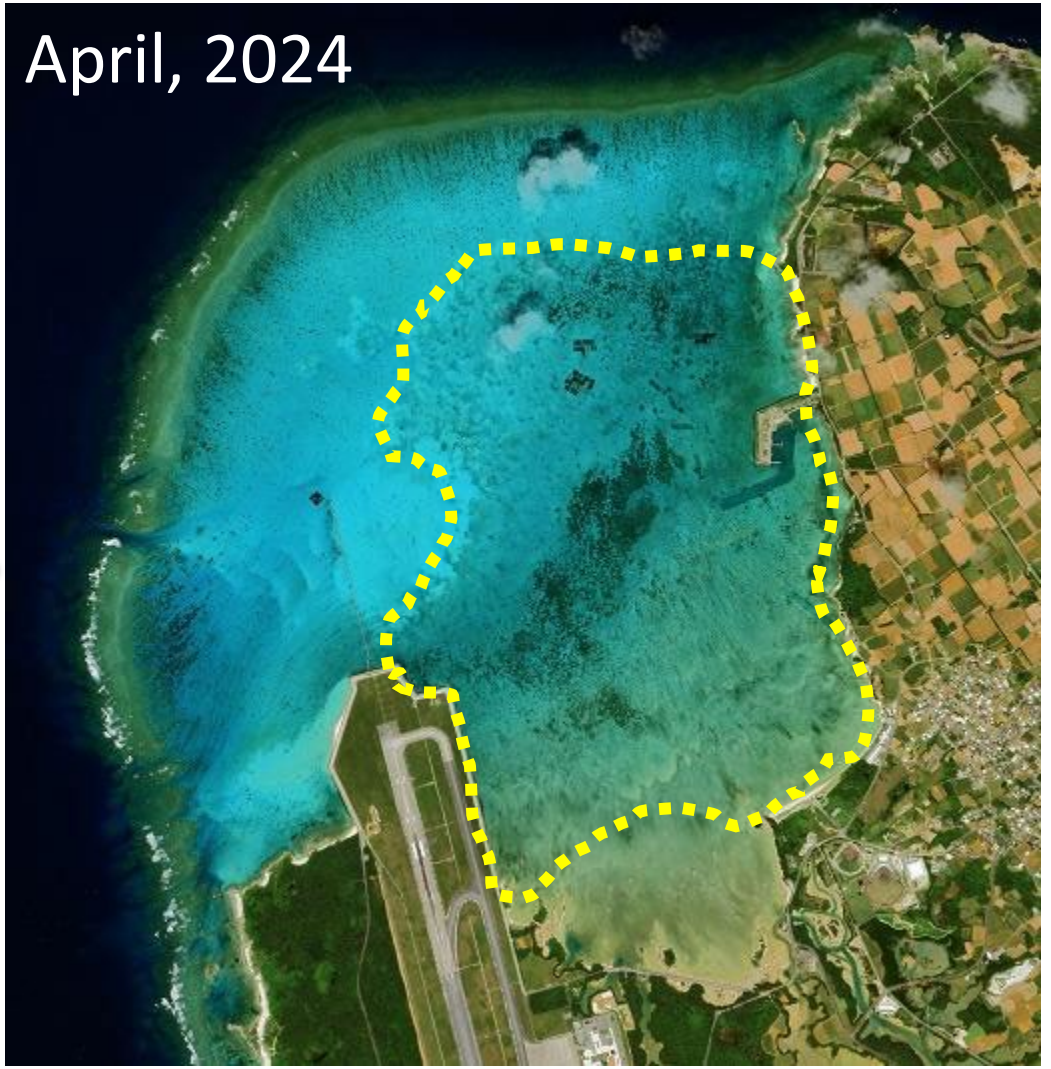
Turtle Exclusion Cage

Ministry of Environment, Japan & IDEA Co.Ltd

Green turtles in Sawada Beach, Irabu Island

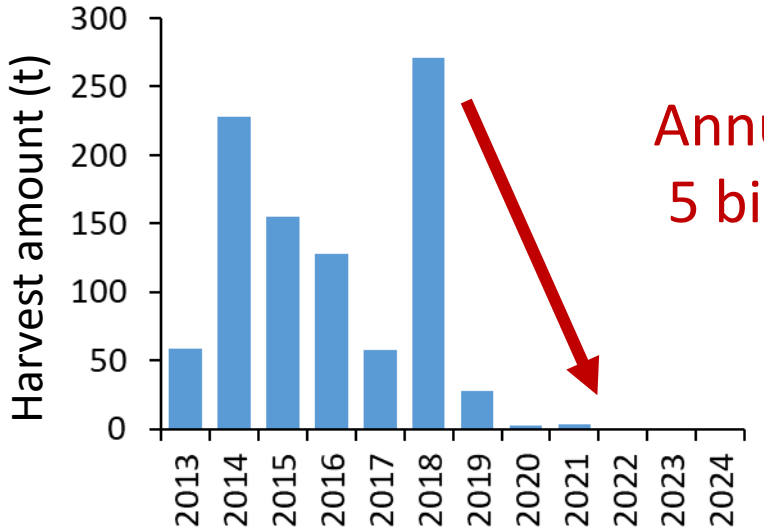


Seagrass distribution in Sawada Beach, Irabu Island



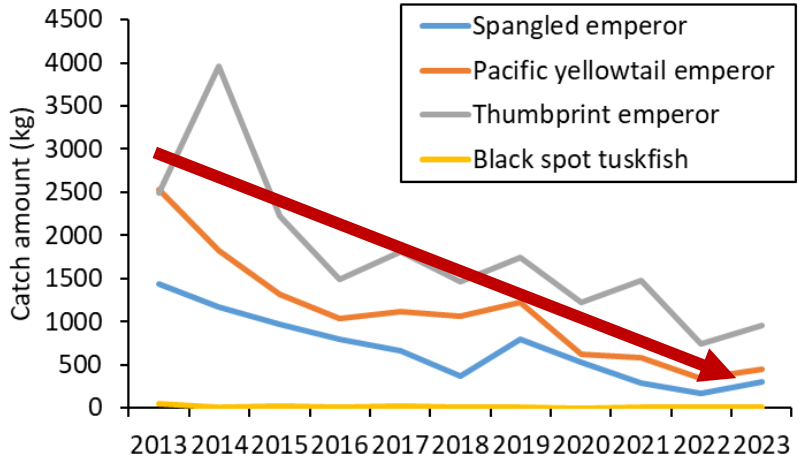
Effect of overgrazing on seagrass ecosystem

Natural *mozuku* harvest in Kume Island



Annual economic loss
5 billion JPY (¥)

Catch amount of Seagrass-associated fish

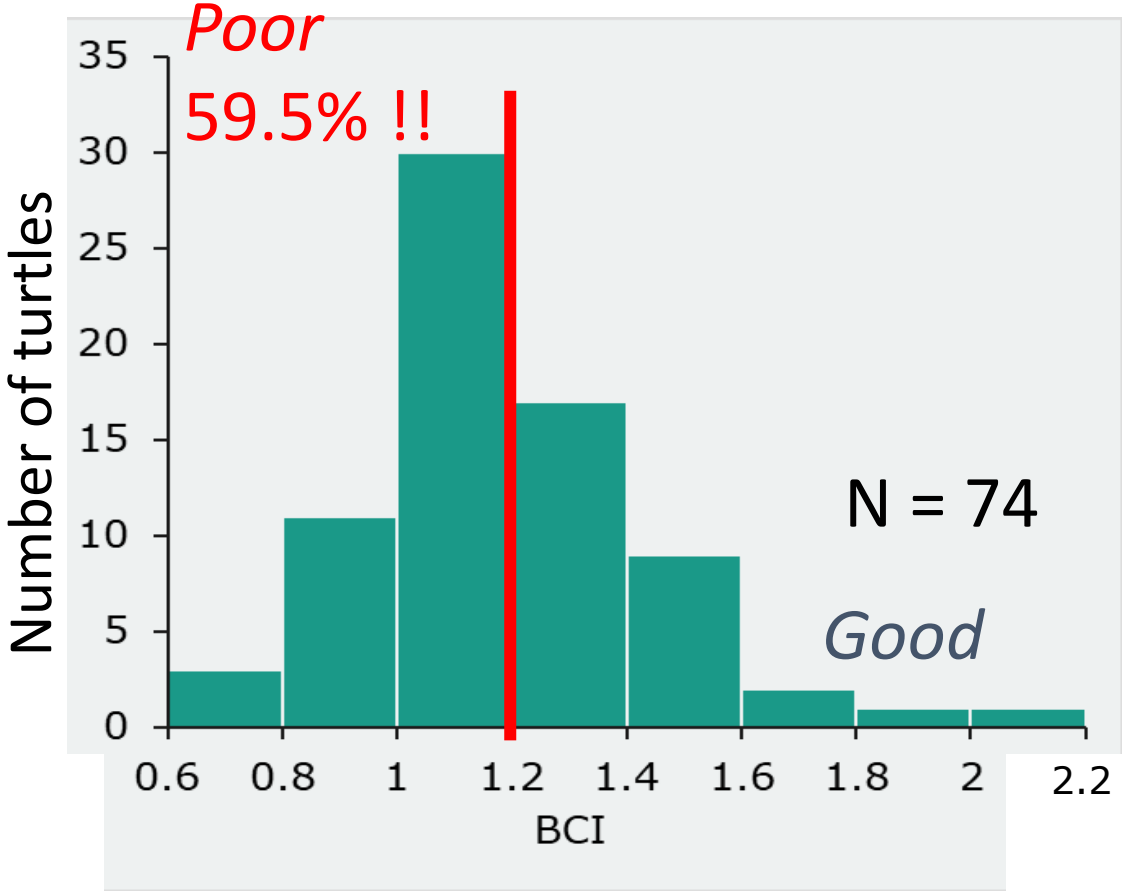


Data Provided by Kumejima Fisheries Cooperative

Effect of overgrazing on green turtles

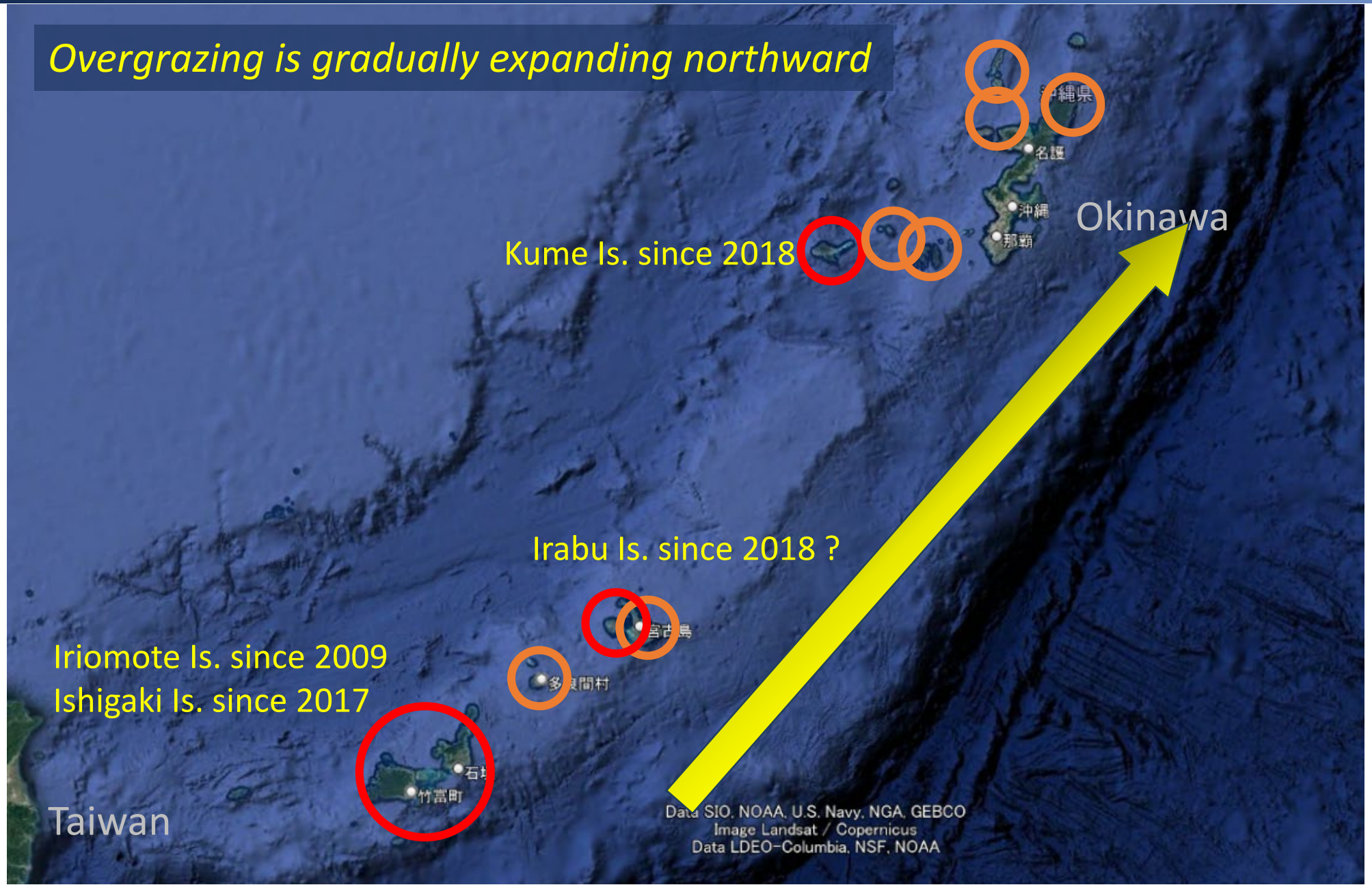
Decline of Body Condition due to a shortage of food

$$BCI = \frac{BW\ (kg)}{SCL^3\ (cm^3)} \times 10000$$



Reports on overgrazing impacts on seagrass meadows worldwide

Reports on overgrazing on seagrass meadows in the Ryukyu Archipelago



Tolerance of seagrass species/ seaweed to grazing pressure

Large

Regrowth rate: Very slow
Tolerance: Very low

Medium

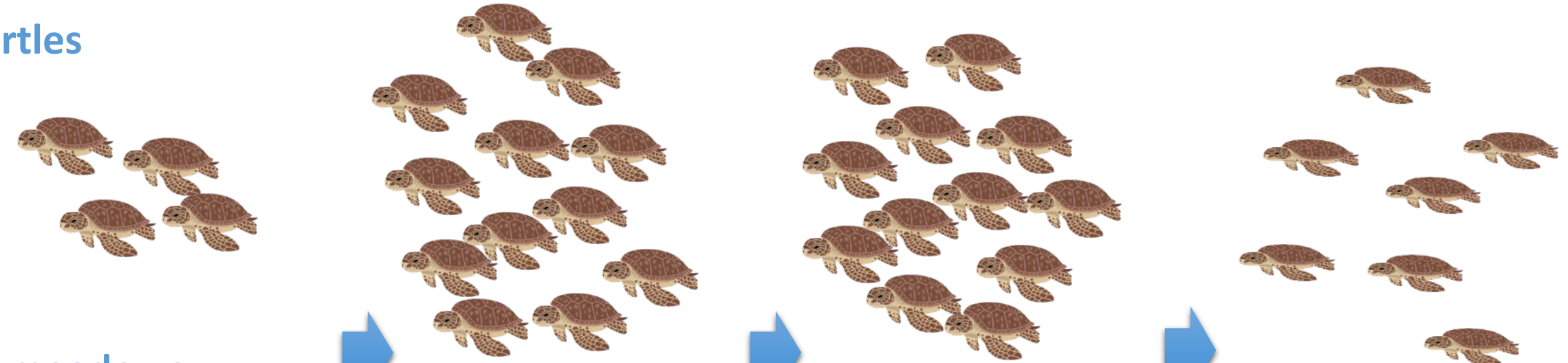
Regrowth rate: Slow
Tolerance: Low

Small Seaweed

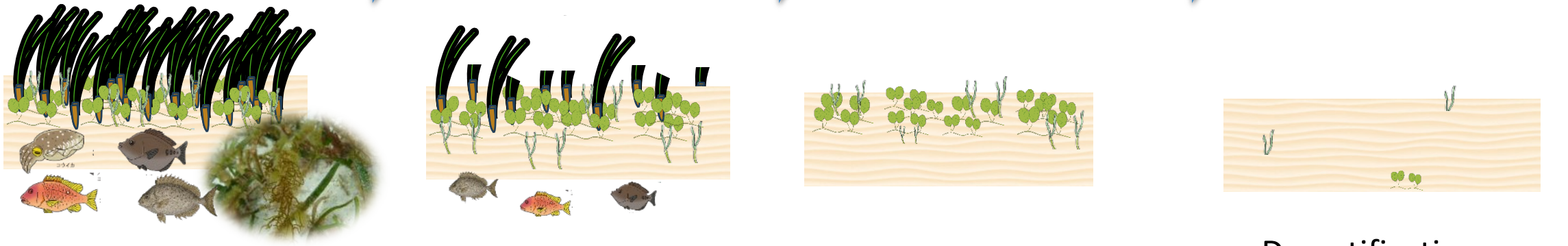
Regrowth rate: Fast
Tolerance: High

Changes in seagrass meadows associated with the increase of green turtles

Green turtles



Seagrass meadows



Various size of seagrass
Fully elongated leaf
Many Fish and invertebrates

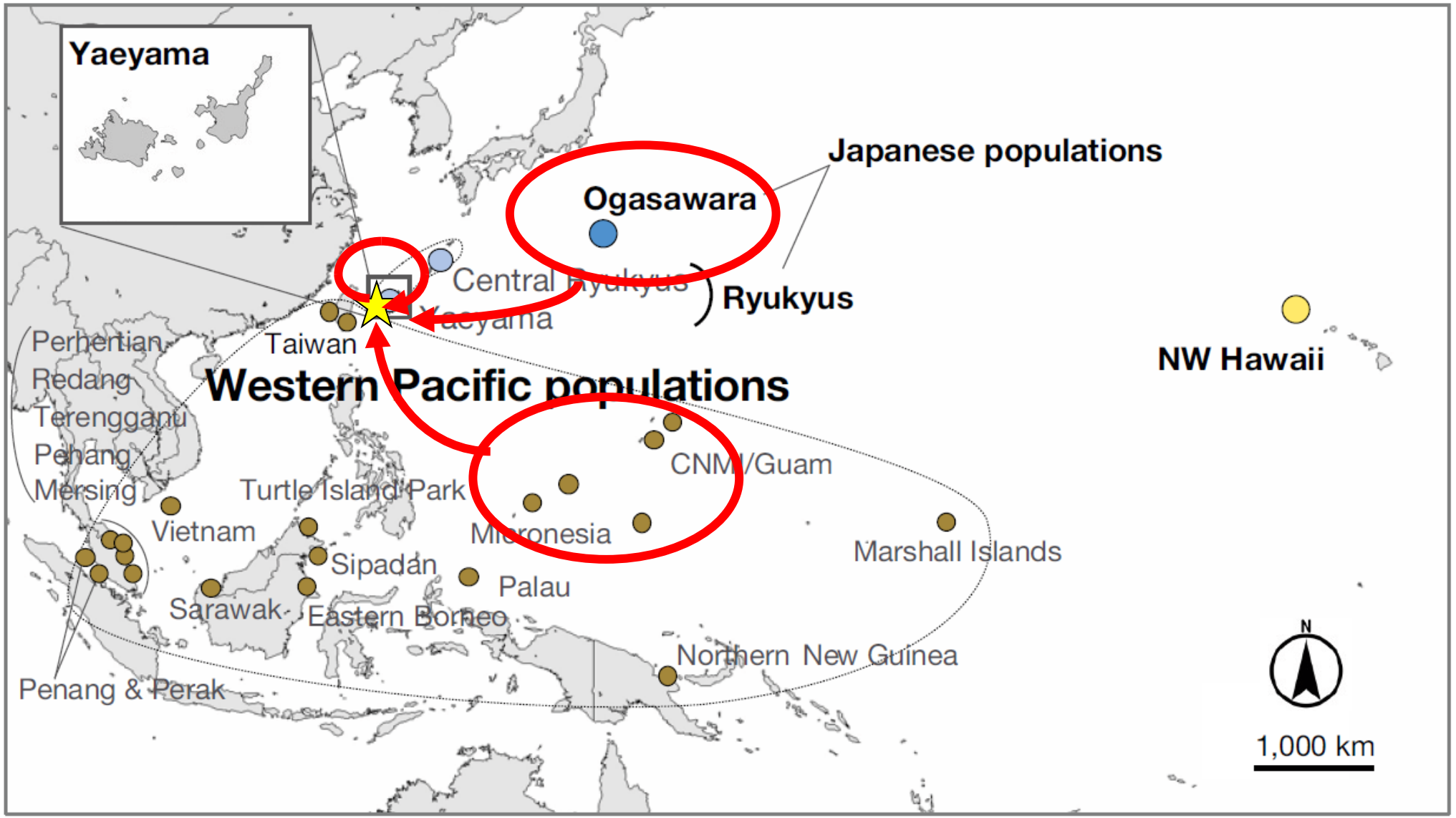
Decline in large/Mid-size seagrass
only small fish and invertebrates

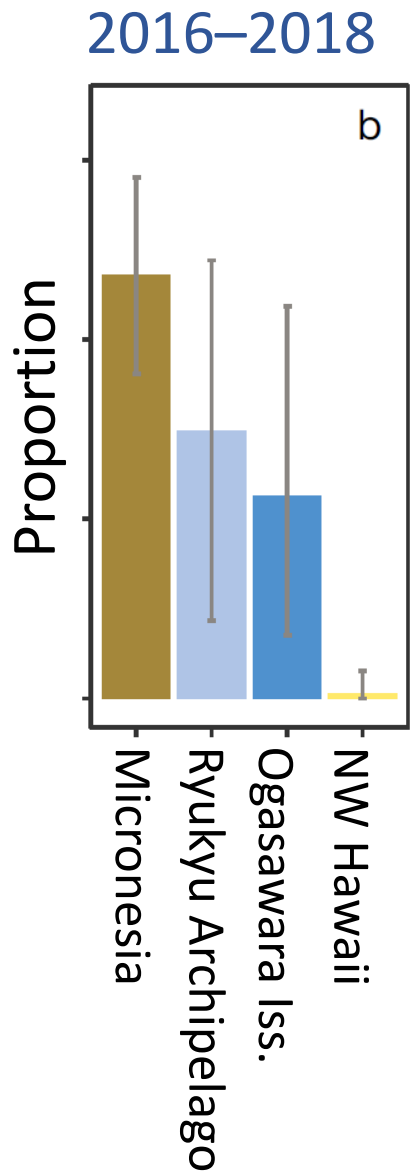
Only small-size seagrass
Fish disappeared

Desertification
Weight loss of turtles
Turtles migrate

Christianen et al. 2021
Gangal et al. 2021

Where do turtles come from?

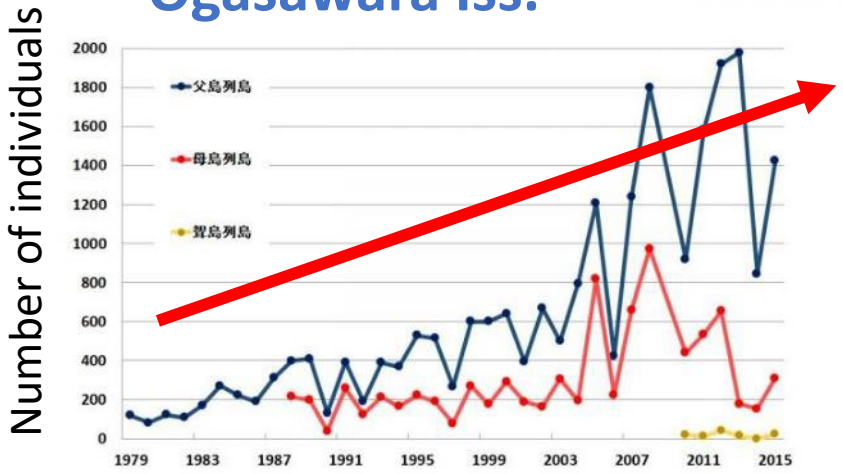




Hamabata et al. 2023 Nishizawa et al. 2013

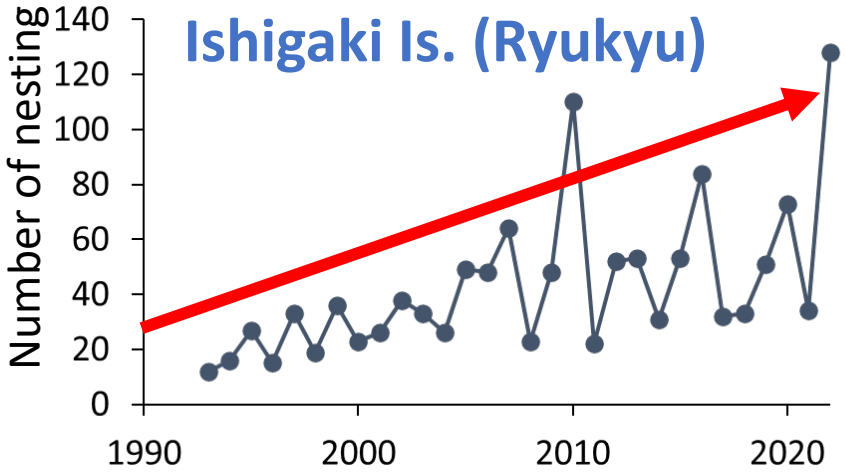
Nesting trends at the natal rookeries of the foraging aggregations

Ogasawara Iss.



Kondo et al.2017

Ishigaki Is. (Ryukyu)



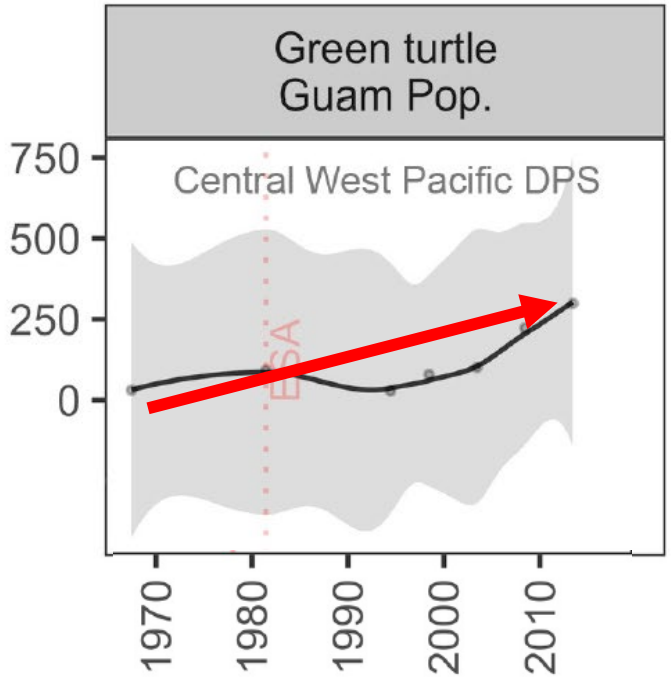
©Ishigaki sea turtle research group

Micronesia

Trend : Unknown
But, large population

SWOT vol. 6 et al. 2011

Guam (CNMI)

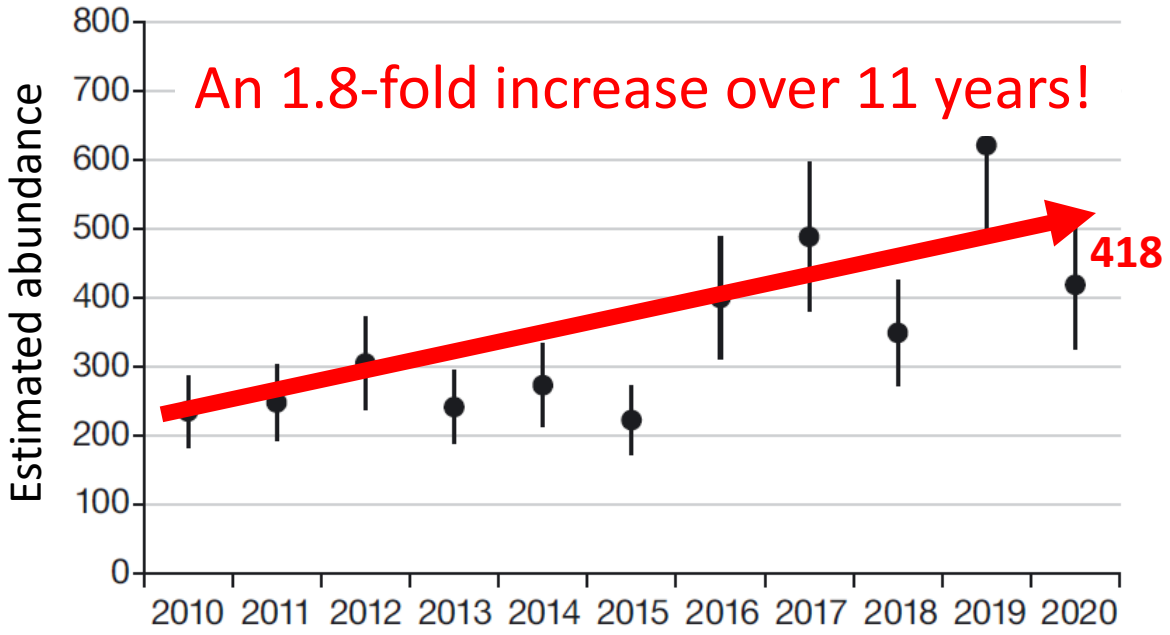


Valdivia et al. 2019

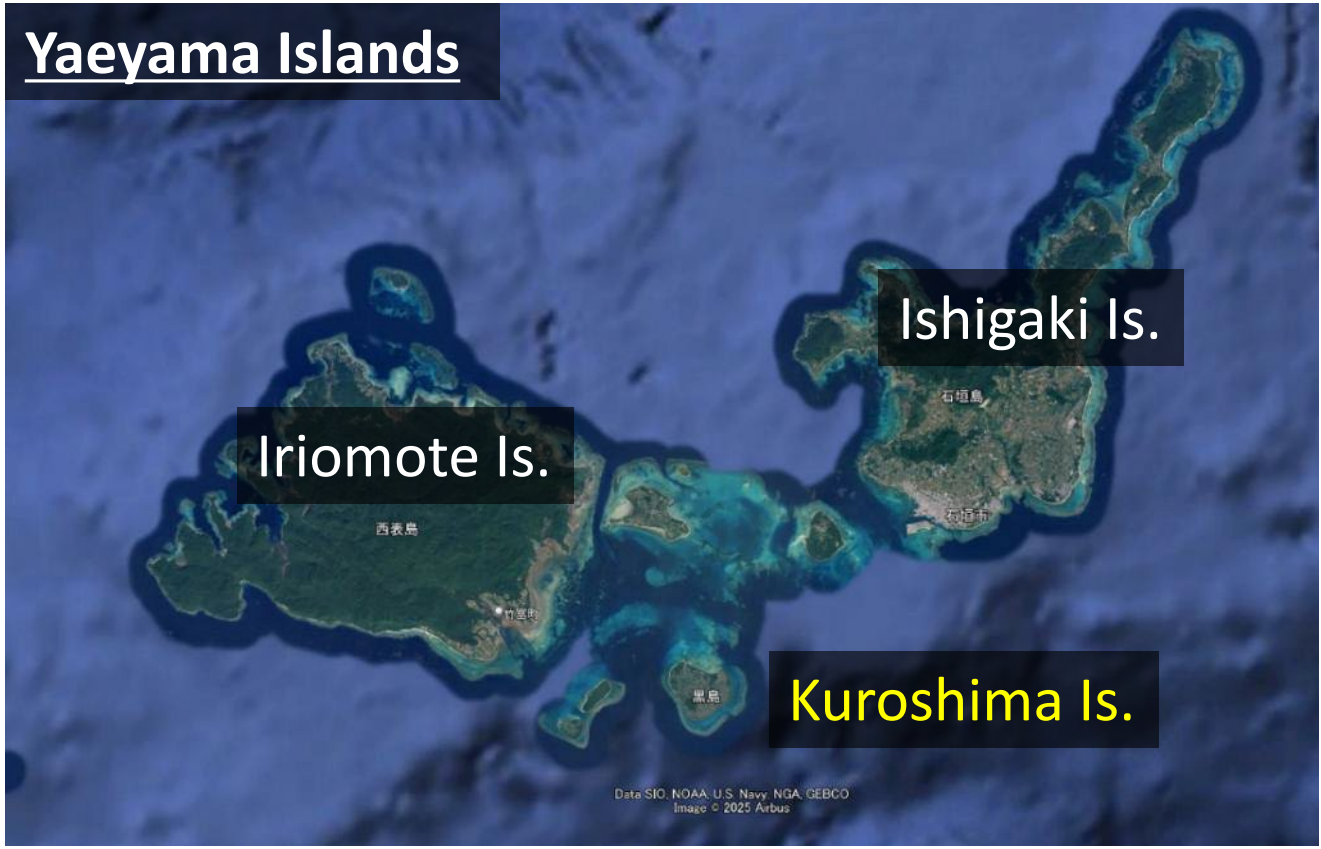
Almost source populations show an increasing trend
More turtles are coming to the Ryukyu Archipelago

Are foraging aggregations indeed increasing?

Capture-Mark-Recapture survey at Kuroshima Is.

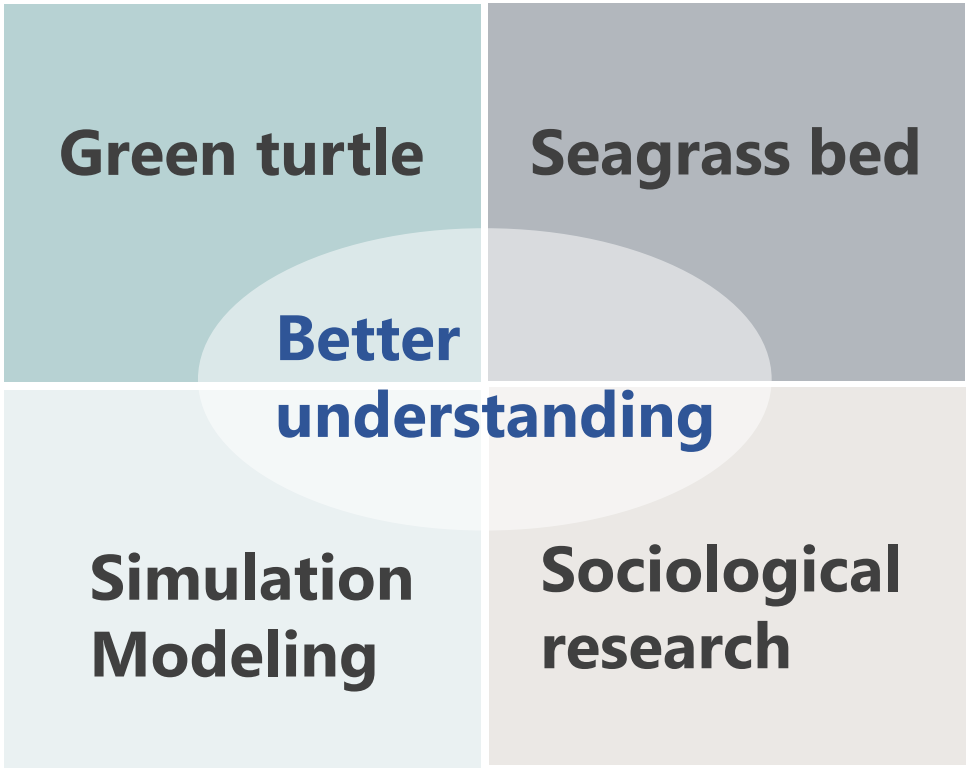


Kameda et al. 2023



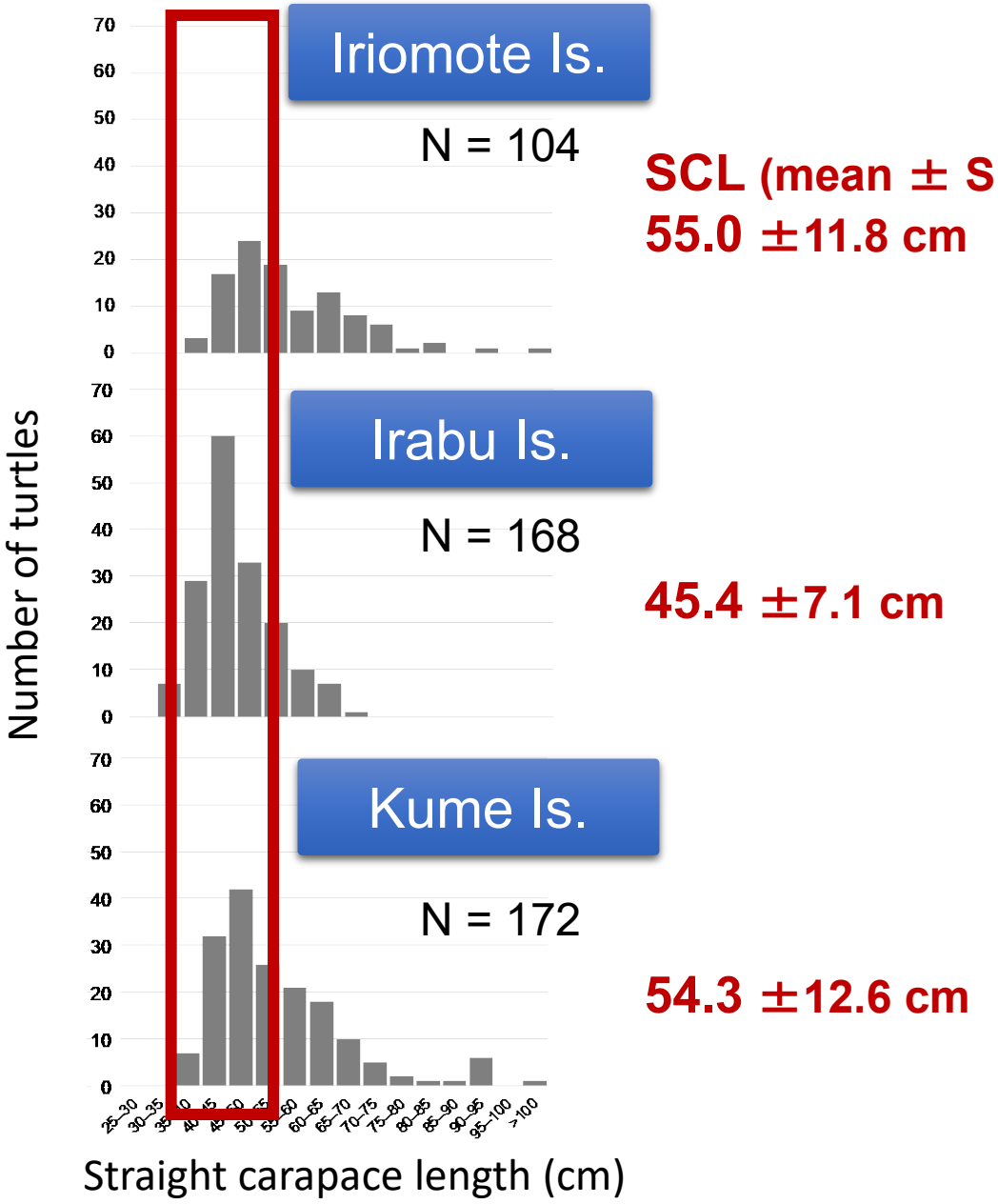
Project Objectives

1. Comprehensive studies on current status/foraging ecology of green turtle
   - Population size, Size/Age structure
   - Habitat use in seagrass meadows
   - Grazing amount per a turtle
2. Seagrass conservation and restoration
   - Protection of Seagrass meadows
   - Restoration of Seagrass meadows
3. Simulation modeling to evaluate the effect of coexistence policy
4. Sociological study on stakeholders inside/outside local community



Commissioned by ERCA

Population size & structure of foraging aggregations



SCL (mean ± S.D.)
55.0 ±11.8 cm

45.4 ±7.1 cm

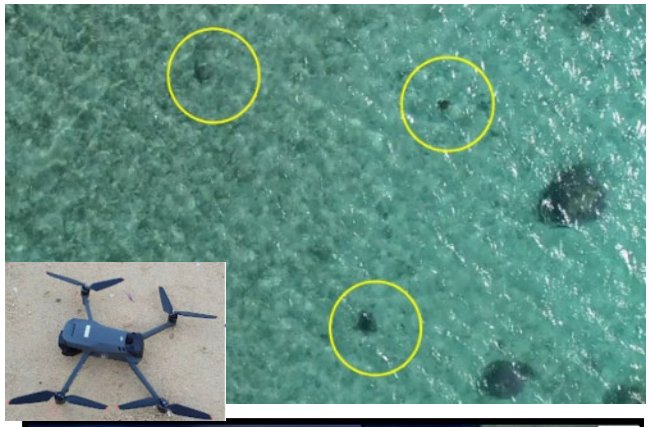
54.3 ±12.6 cm

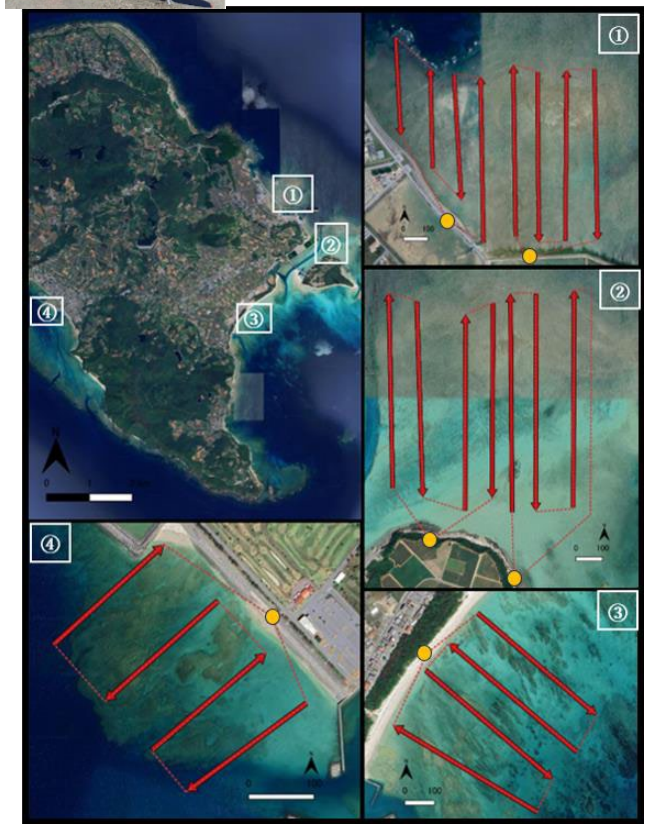
Capture-Mark-Recapture survey

- Population structure
- Population size estimation
- Growth rate
- Movement

Majority of foraging aggregations consist of small juveniles

Drone-based line transect surveys





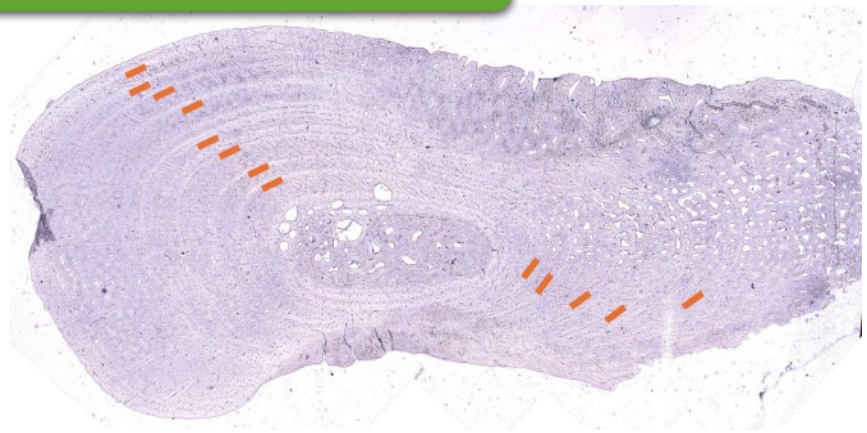
Location	Area (km^2)	Density (turtles/km^2)	Year	Method	Reference
Kume Is., Japan	0.178	334.9–452.6	2023–2024	Drone	Our study
Iriomote Is., Japan	0.395	330	2019	Drone	Ministry of Environment
Taiping Is., South China Sea	0.16–0.19	381–681	2019	Drone	Hsu et al. 2024
Derawan Is., Indonesia	na	1540–2060	2008–2011	Boat	Christianen et al. 2014
Lakshadweep Iss., India	na	1114, 2334	2007, 2013	Boat	Gangal et al. 2021
Florida Key West, USA	30	119.8	2006-2018	Boat	Welsh & Mansfield (2022)
Guam, USA	2.58–15.70	0.03–2.08	2008–2012	Aircraft	Martin et al. (2016)

Comprehensive studies on green turtles

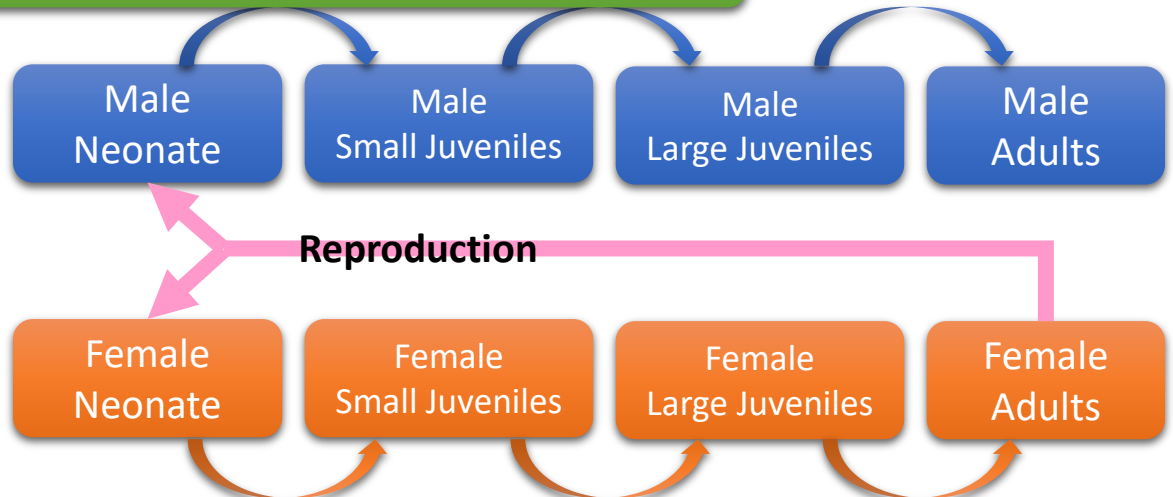
GPS tracking

Feeding experiment

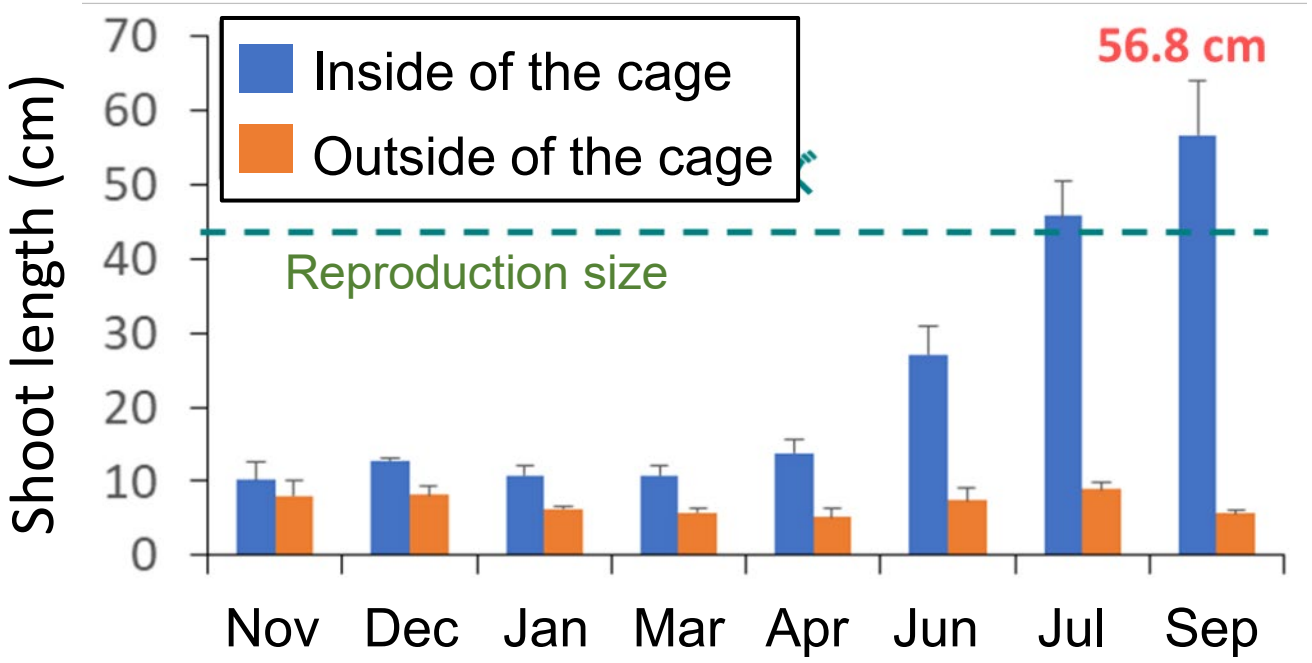
Skeletochronology



Population dynamics model

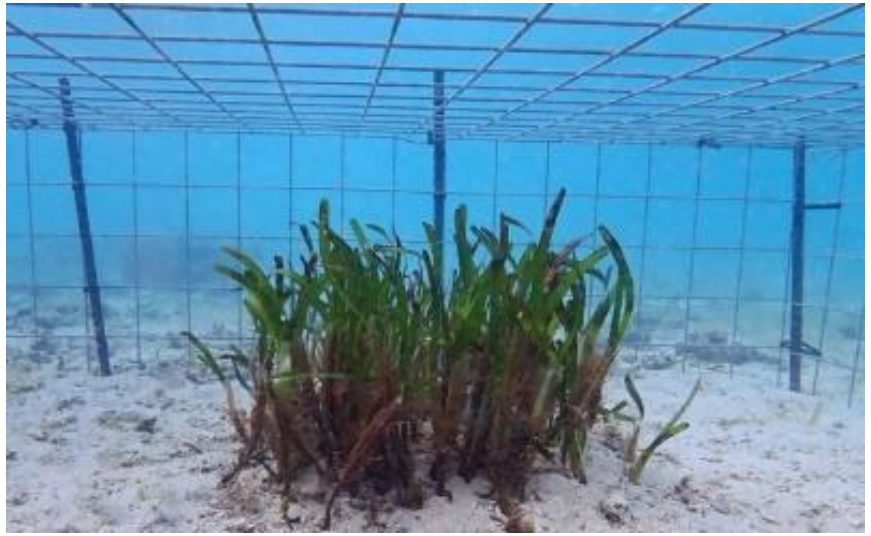


Protection of Seagrass meadows by Turtle Exclusion Cage



- Promote the installation of turtle exclusion cages, to protect seagrass from overgrazing by green turtles
- Once installed, seagrass inside the cages begins to regrow within several months.
- The area that can be covered with cages is limited due to economic costs

Artificial restoration of Seagrass meadows



Transplantation of *Thalassia hemprichii* shoots

Sees of *Enhalus acoroides*

Artificial seedlings of *Thalassia hemprichii*

- Transplant naturally growing seagrass shoots into degraded meadows
- Develop techniques for seedling production in aquacultural tanks
- Restore seagrass meadows by planting produced seedlings
- Regularly monitor the survival rate, growth rate, propagation rate, and reproductive output of the transplanted seedlings

Sociological studies to explore policies acceptable to local communities

1. Organize participatory workshops to identify the social, economic, and cultural values of green turtles and seagrass meadows held by stakeholders inside & outside the local community
2. Organize public forums to explore what coexistence policies are acceptable to local communities
   - Population management, including the potential consumption of green turtles
   - Housing excess green turtles in captive facilities
   - Expanding the area of exclusion cages
3. Investigate the acceptance of each policy among local residents, as well as stakeholders outside the local community

A participatory workshop in local community

A public forum in local community

Conclusions

- Overabundant green turtles are causing seagrass decline and desertification in Okinawa
- As a result, ecosystem services, including fisheries, are decreasing
- Green turtles themselves are suffering from poor nutritional condition
- Exclusion cages can protect seagrass, but their use is limited by cost and scale
- It is necessary to develop techniques for the artificial restoration of seagrass meadows
- Environmental policies must be designed, tailored to the economic and cultural contexts of each local community