Adaptation to coastal environmental changes in the polyp stage in relation to jellyfish blooms in Tokyo Bay

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Ecosystem in hyper eutrophicated bay

・ High concentrations of nutrients (Inflow from river and drain, supply from bottom layer by mixing)

・ High conc. N & P; Low conc. Si

・ Red tide event; Microflagellates prevail over diatoms

・ Production of the inedible algae enters the energy flow via detritus food chain

D O C → Bacteria → Heterotrophic nanoflagellates

→ Ciliates（Microzooplankton）

Detritus Food Chain

Appearance of **dysoxic bottom-layer waters**

・ Zooplankton consists mainly of small copepods (Microflagellate feeder)

・ Gelatinous plankton (Microzooplankton or small zooplankton feeder) dominates

・ Low ecological energy efficiency from phytoplankton (Microflagelaltes) to fish

・ Microflagellates → Small zooplankton → Gelatinous plankton

↘ Ciliates （Microzooplankton）↗

Jelly Food Chain (Medusa Stage)

・ Decrease of biodiversity

・ No predation on large gelatinous plankton; Top down controll on jellyfish population cannot be observed

Problems accompanied with mass occurrence of jellyfish

- Decrease in fishing activities by clogging and bursting trawl nets

(Accumulation of dead jellyfish on bottom)

- Aurelia aurita, Chrysaora melanaster, Nemopilema nomurai

- Coastal power plants by blocking intakes for cooling water

- Aurelia aurita, Ctenophora

- Toxins

- Cubomedusae

Surface aggregation of *Aurelia aurita* in Tokyo Bay

Polyp Stage is characterized by asexual reproduction (budding, strobilation)

Polyp with asexual budding of daughter polyp

Strobila

In coastal environment, settling substrate for polyp is increasing;

- Reclamation
- Quay
- Pier
- Bottom of a ship

Most of the settled substrate in the innermost part of Tokyo Bay is occupied by the other benthic organisms such as *Mitilus galloprovincialis*.

This observation means that *A. aurita* polyps are exposed to keen competition for space with other organisms, especially during spring and summer.

If the recruitment of planula larvae is restricted to summer, the consequent ephyra production could be low in the following spring.

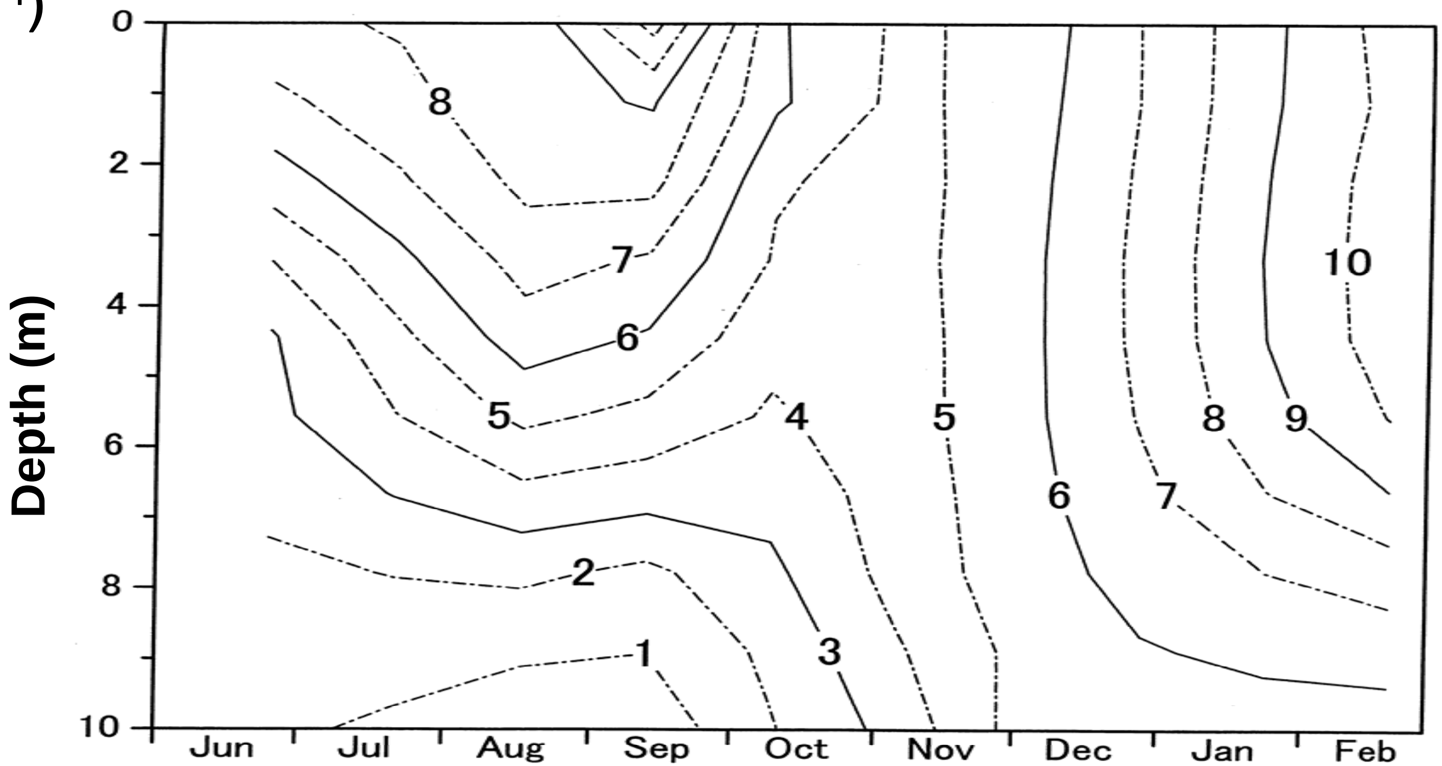
The presence of ripe medusae with planulae, even in autumn and winter, would contribute to increasing settlement and survival of polyps.

However, most of planulae are released during summer in Tokyo Bay.

Dense aggregation of *M. galloprovincialis*. No polyps are observed.

Where the released planulae are settled during summer?

- Settling substrate where no other sessile organisms are living.
- Near bottom-layer waters during summer
- Other organisms are not tolerable to hypoxia (DO ≦ 2 ml O_2 l^{-1})



Seasonal changes in the concentration of D.O. (ml O_2 l^{-1}) in the innermost part of Tokyo Bay.

Relationship between distribution of jellyfish and hypoxia

In dysoxic bottom-layer waters:

Chrysaora quinquecirrha (Keister et al. 2000; Breitburg et al. 2003)

Aequorea aequorea, Clytia gregaria (Davis 1975)

Mnemiopsis leidyi (Breitburg et al. 2003)

Over dysoxic bottom-layer waters:

Aurelia sp. (Benovic et al. 2000)

Feeding effects of jellyfish on zooplankton or fish larvae

(Breitburg et al. 1997; 1999; Decker et al. 2004)

Adaptation system of jellyfish to hypoxia

Oxyregulation (Rutherford & Thuesen 2005; Thuesen et al. 2005)

Above all studies are focused on Medusa Stage

Hypoxia tolerance on Polyp Stage

Chrysaora quinquecirrha: (Condon et al. 2001)

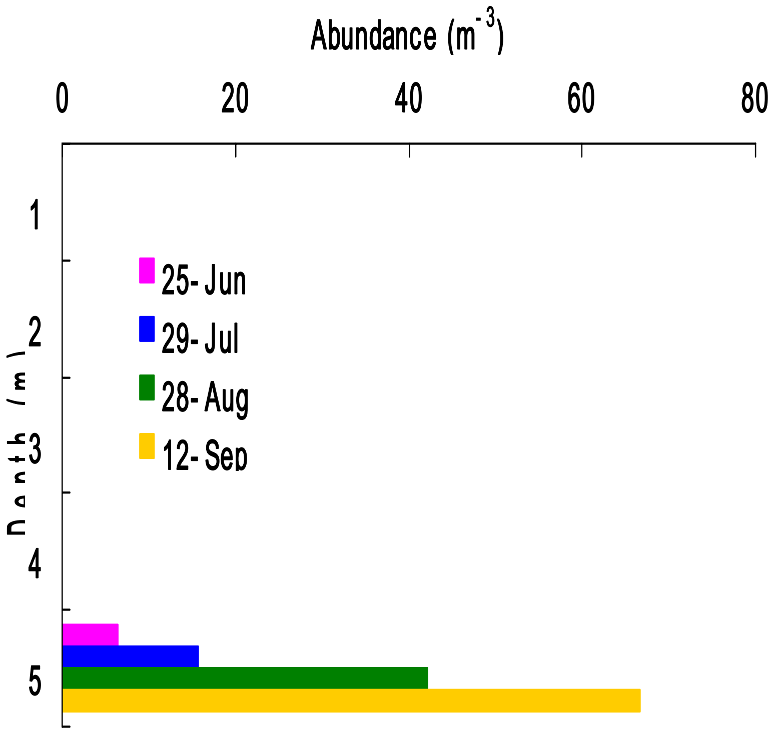
High survival and strobilation rates were observed in hypoxic water (1.5 $mgO_2\ l^{-1}$) by 25-days incubation experiments.

Present study:

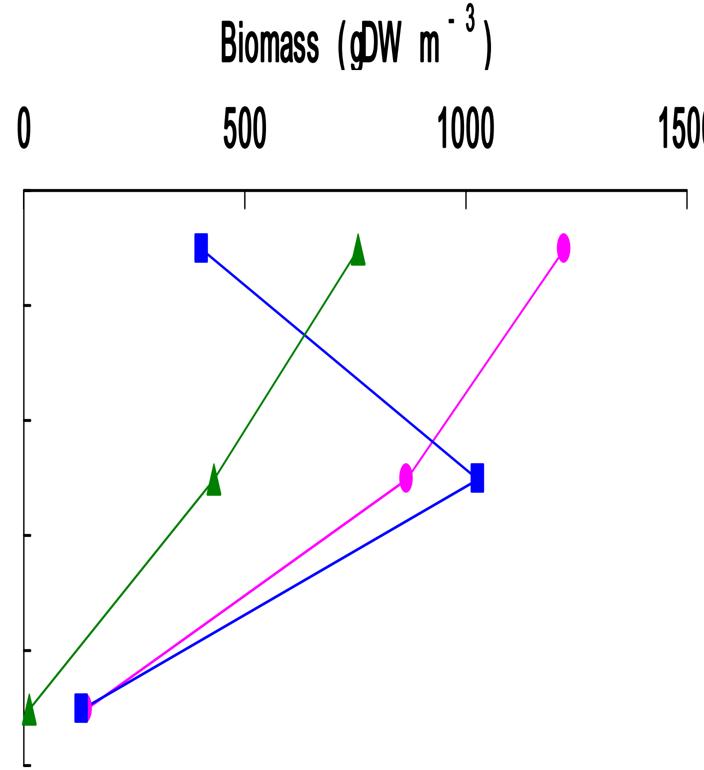
1. In situ vertical distribution of *A. aurita* polyps.
2. Effect of DO concentration on *A. aurita* planula settlement
3. Production of *A. aurita* polyps in the different D.O. concentration waters
4. Respiration rate of *A. aurita* polyps in the different D.O. concentration waters

1. Vertical distribution

Polyps of *A. aurita*



M. galloprovincialis



Survey area

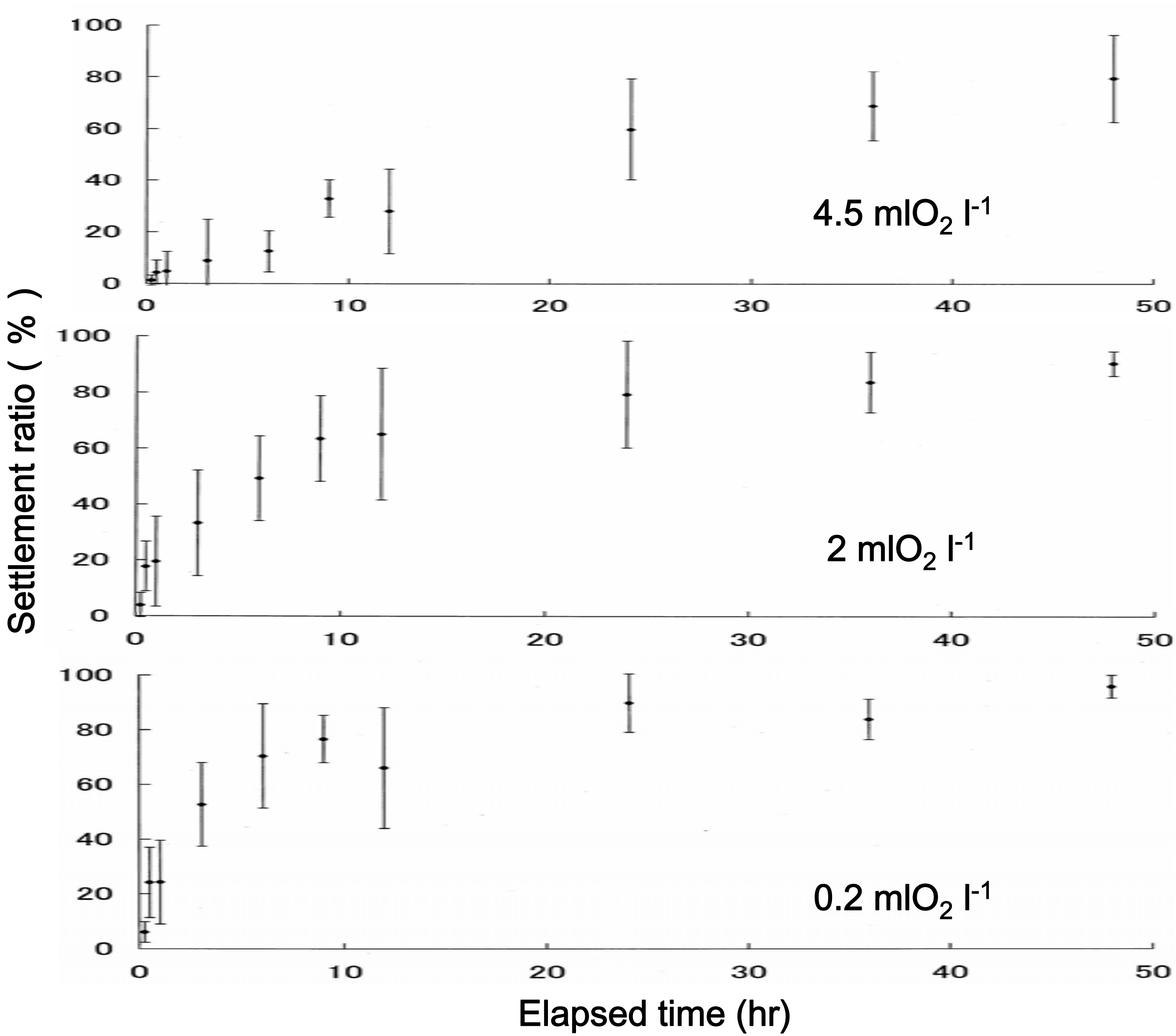
Museum of Maritime Science

(In Odaiba, innermost part of Tokyo Bay)

The polyp aggregations in the dysoxic bottom-layer waters during summer (Peak season of planula release) are found.

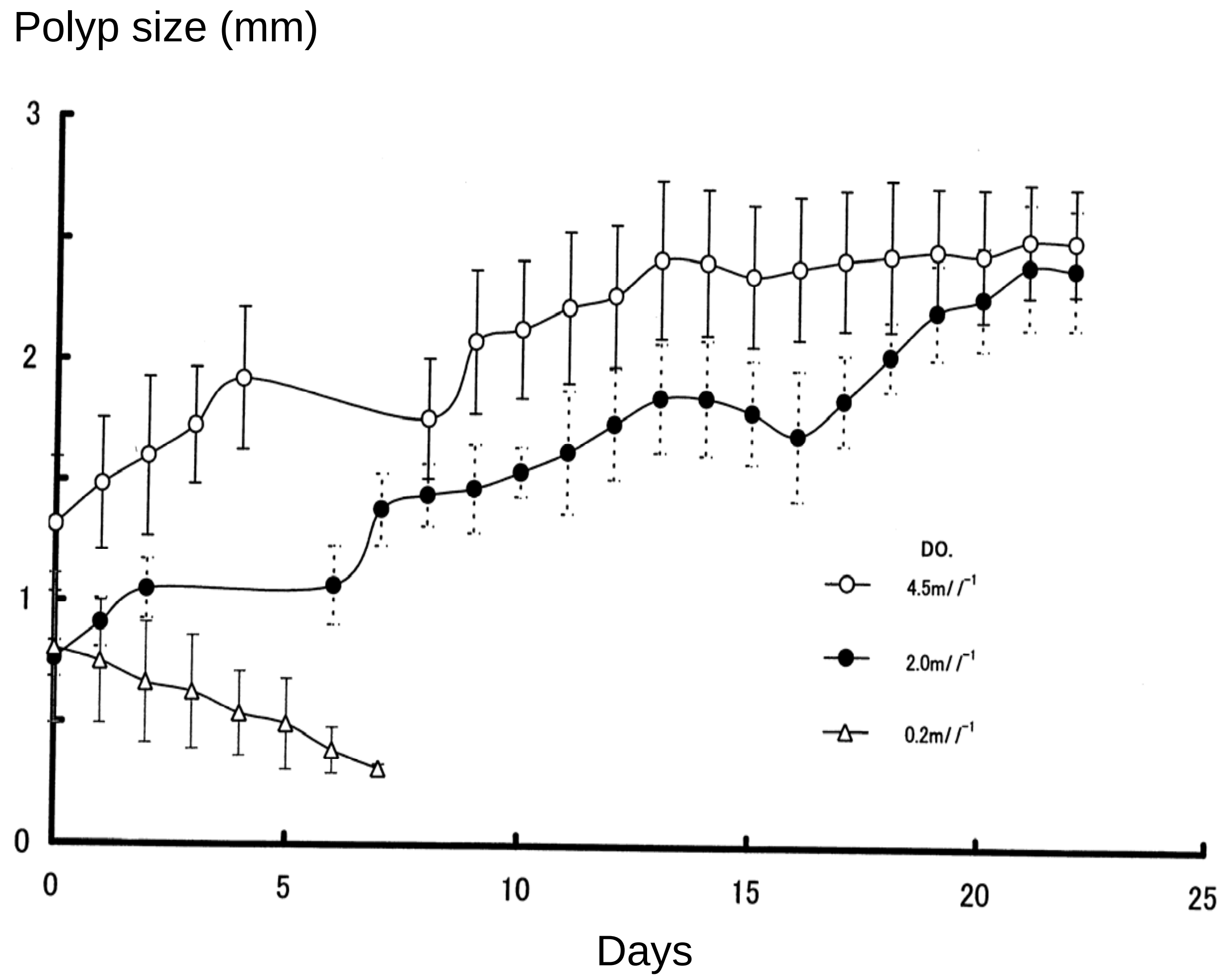
This layer is characterized by low recruitment and growth of other benthic organisms such as *M. galloprovincialis*, resulting an abundant settlement and high survival during the polyp stage.

Dense aggregation of *A. aurita* polyps.

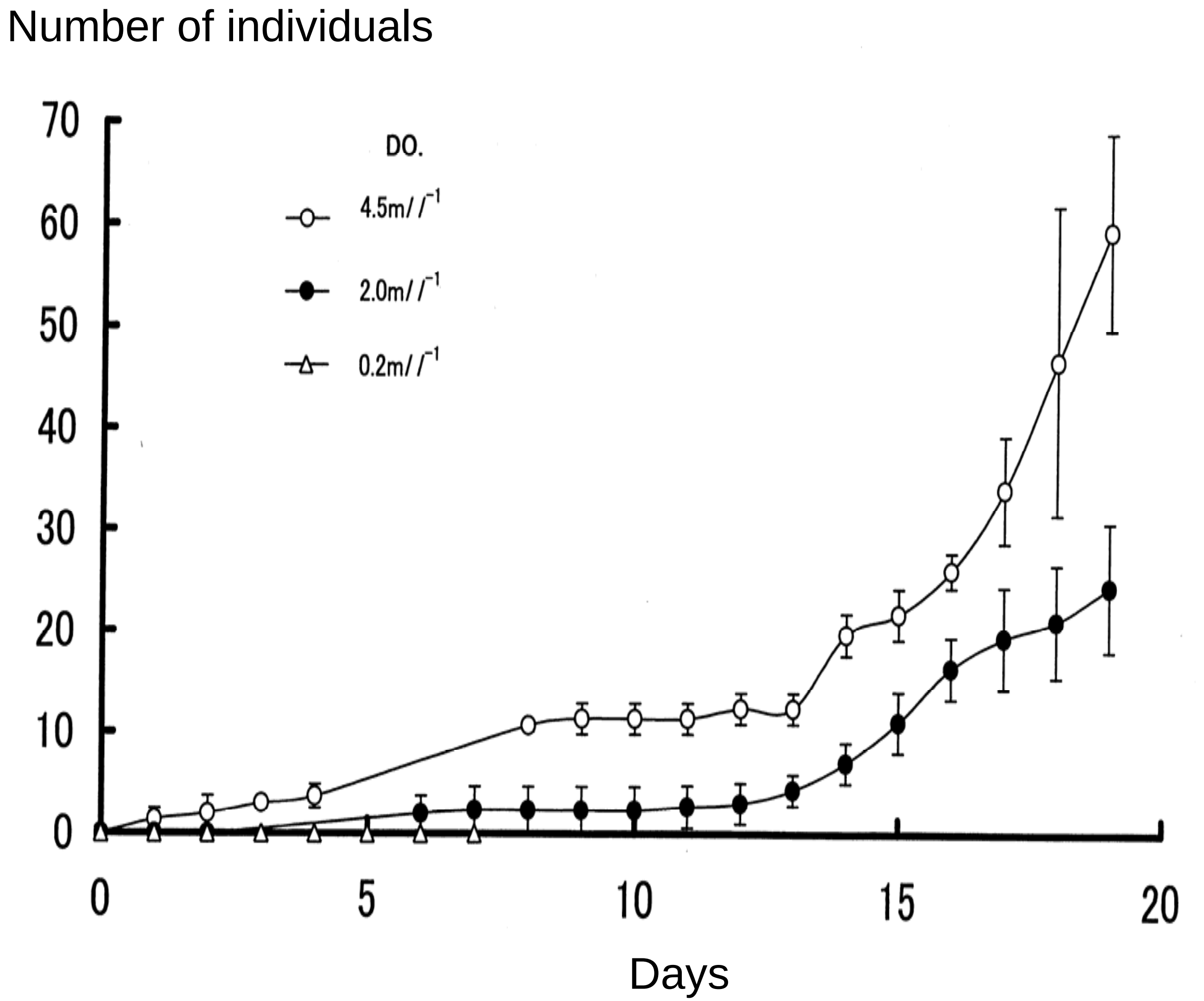


2. Effect of DO concentration on *A. aurita* planula settlement

Initial number of planula larvae: 1000 inds



3. Production of *A. aurita* polyps: Growth in the different D.O. concentration waters



3. Production of *A. aurita* polyps: Increase of daughter polyps by asexual budding in the different D.O. concentration waters

Relationship between dissolved oxygen concentration and production of ephyrae and discs in strobila

Changes of DO Concentration (ml O_2 l^{-1})	Strobilation: Period until Starting Dates	Strobilation: Ratio (%)	Strobilation: Duration	Strobilation: Number of Discs	N	Ephyrae Diameter (mm)
2.0 → 2.0	-	-	-	-	30	-
2.0 → 4.5	37.6	45.8	22.8	7.1	30	3.1
4.5 → 4.5	42.9	43.3	17.1	6.1	30	2.8

When the D.O. concentration increased, strobilation and ephyrae liberation were also observed even in the polyps cultured in hypoxic waters.

4.

Relationship between dissolved oxygen concentration and respiration rate of *Aurelia aurita* polyps

DO Concentration (ml O_2 l^{-1})	Respiration Rate ($\mu l O_2$ ind^{-1} hr^{-1}) Mean	SD	N
0.2	0.082	0.002	8
2.0	0.100	0.002	8
4.5	0.120	0.003	8

<Experimental condition>
Temperature: 22℃
Dark
Water bottle method
Incubation time: 24 hr

<Polyp condition>
Previously fed; starved during experiment
No. of polyps used per one bottle: 10 - 20 inds
Polyp internal diameter: 1.2 ± 0.3 mm
Polyp dry weight: 0.114 ± 0.004 mgDW

Summary

1. The polyp aggregations in the dysoxic bottom-layer waters were found. This layer was characterized by low recruitment and growth of other benthic organisms, resulting an abundant settlement and high survival during the polyp stage.

2. Planulae settlement was stimulated with decreasing D.O. concentrations.

3. Growth and daughter polyp production were also observed even in the hypoxic waters (2 ml O_2 l^{-1}). If the D.O. concentrations were restored, strobilation and ephyrae liberation were also observed in these polyps.

4. Respiration rates of polyps significantly decreased with decreasing D.O. concentrations.

Aurelia aurita polyps have an ability to adapt to hypoxia by decreasing their respiration, and dysoxic conditions in bottom-layer waters are favorable for their survival and production.

Guideline to prevent the mass occurrence of jellyfish

1. Recover from hyper eutrophicated bay

Decreasing the nutrient (N and P) concentration
→ Disappearance of red tide event and dysoxic bottom-layer waters

2. Reconsideration of coastal reclamation

→ Decreasing the polyp settling substrate

Study:

- **Construction of the simulation model including various parameters in relation to environmental changes; climate, river water, economic activity in the city, development of coastal region, eutrophication, and jellyfish biomass**

- **Prediction of the mass occurrence of jellyfish and control of the transition to jelly-ecosystem**


Thank you for your kind attention
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