MANAGEMENT FOR SUSTAINABLE USE OF INTERNATIONAL SEMI ENCLOSED SEA, SEA OF JAPAN

Takahumi YOSHIDA, Jing ZHANG, Qian LIU (Northwest Pacific Region Environmental Cooperation Center)
Akihiko MORIMOTO, Ryota SHIBANO (Ehime University)
Naoki HIROSE, Katsumi TAKAYAMA (Kyushu University)
Xinyu GUO, Naoki YOSHIE, Yucheng WANG, Taishi KUBOTA (Ehime University)
Characteristics of Sea of Japan

Rise of sea surface temperature

Mid-long term change

Marine Ecosystem

Winter cooling

Tsushima Current

Kuroshio Current

Taiwan Warm Current

Increase of nutrient input from China

Japan Meteorological Agency

(Strokal et al. 2014)
Three-scale management for Sea of Japan

Sea of Japan + East China Sea
Large-scale

Tsushima Current
Middle-scale

Local Area
Small-scale
Approach for three-scale management

Environmental change by variable factors

Variable factors
Climate change
Nutrient input
Water circulation

Ecosystem in the Sea of Japan

Response of ecosystem to environmental change

Future variation

Forecasting environmental change

Adaptation to future variation

Study in 2014–2016
Variable factors

Rise of sea surface temperature

- Current
  - Variation scenario
    - RCP8.5
    - RCP2.6

Water temperature rising in the past 100 years (JMA)

Nutrient supply

- Current
  - Variation Scenario
    - Nutrient discharge from China
      +2%/year
      -4%/year

- Future
  - Nutrient supply via the Tsushima Strait (Morimoto et al.)

Change of water circulation

- Current
  - East canal: 35 × 10^8 m^3/y
  - Central canal: 46 × 10^8 m^3/y

- Future
  - East canal: 90 × 10^8 m^3/y
  - Central canal: 95 × 10^8 m^3/y

Change of water circulation

- Current
  - East canal: 35 × 10^8 m^3/y
  - Central canal: 46 × 10^8 m^3/y

- Future
  - East canal: 90 × 10^8 m^3/y
  - Central canal: 95 × 10^8 m^3/y
Understanding of ecosystem response

**Ecosystem numerical model (low trophic)**

*Ehime University*

- **Characteristic**
  - Detailed classification of phytozooplankton

- **Objective**
  - Understanding response to change of nutrient condition

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**Ecosystem numerical model (high trophic)**

*Kyushu University*

- **Characteristic**
  - Simplification of phyto-zooplankton
  - Data assimilation by DO

- **Objective**
  - Forecasting long-term trend

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**Ehime University**

- Japanese common squid (*Todarodes pacificus*)

**Konishi et al., 2011**

- Snow crab (*Chionoecetes opilio*)

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**Characteristic**

- Transportation of egg and larvae and its survival under environmental and feed condition
- Linking to low trophic level through zooplankton

- **Objective**
  - Effective/efficient setting of MPAs
Output 1: Environmental change in Sea of Japan and East China Sea

Long-term trend of nutrient (N) concentration in Sea of Japan and East China Sea (50m depth average)

- East China Sea: +24% / 10y
- Tsushima Strait: +1.9% / 10y
- Southwest of Sea of Japan: -2.1% / 10y
- East of Sea of Japan: -3.1% / 10y

Forecast of SST rise using scenario RCP8.5

+2.4 °C / 100y
Output 2: Impact from East China Sea

Quantification of impact of East China Sea to coastal area of Sea of Japan

Composition of sourced water (0-50 m depth average)

Contribution of nutrient to primary production (0-50 m depth average)
Seasonal variation of impact of East China Sea to coastal area of Sea of Japan

Red: Kuroshio
Blue: Taiwan Warm Current
Yellow: Fresh water in ECS
Green: Fresh water in JS
Black: Deep sea water
Vertical variation of impact of East China Sea to coastal area A

Upper: Kuroshio
Red: 10m depth, Green: 50m depth and Blue: 100m depth

Lower: Taiwan Warm Current
Red: 10m depth, Green: 50m depth and Blue: 100m depth
Output 3: Ecosystem structure in Sea of Japan

Supply of nutrient from East China Sea, deep depth of Sea of Japan and rivers

- Primary producer
- Primary consumer
- Secondary consumer
- Tertiary consumer

Stable carbon isotope ratio: -24 to -18
Stable nitrogen isotope ratio: 2 to 14
Output 4: Reproduction Simulation of Japanese Common Squid and Snow Crab

- **Red line:** Result of simulation model
- **Blue line:** Change of abundance (Kidokoro et al., 2014)

**Map Details:**
- **Red square:** Target area
- **Number:** Total number of particles in target area
- **Pink:** Larvae
- **Color:** Depth of particles: $10^4 	imes 10^7$
- **Red line:** Result of simulation model
- **Blue line:** Change of abundance (Kidokoro et al., 2014)
- **White:** Larvae
- **Red:** Death by low water temp.
- **Blue:** Death by high water temp.
- **Color:** Water temp
- **Arrow:** Current direction

**Graph Details:**
- **Total number of particles** vs. **Resource of autumn (ton)**
- **$R$: 0.77**

**Graph 2:**
- **Particles** vs. **Year**
- **2000, 2005, 2010**

**Map:**
- **1998/02/01 → 1998/02/01**
- **11984**
- **35130**

**Legend:**
- **Existence of eddy in offshore of Sanin region**
Three-scale management for Sea of Japan

East China Sea
Sea of Japan

Tsushima Current

Local areas

International cooperation

MPA Network
Joint monitoring

Current/Future condition of Tsushima Current
Quantification of impact to coastal area

National measures

Local measures

Effective/efficient setting of MPAs
Land-Coastal-Offshore area
Integrated Management

Output 1: Long-term trend/Future forecasting
Output 2: Impact from East China Sea
Output 3: Ecosystem in Sea of Japan
Output 4: Reproduction of typical species
Future study
Forecasting and adaptation

• Forecasting future environment in East China Sea and Sea of Japan with variation scenarios
• Understanding response of ecosystem to environmental change
• Proposals based on ecosystem response
• Adaptation