Risk assessment of post-Fukushima ^{137}Cs contamination for three tuna species

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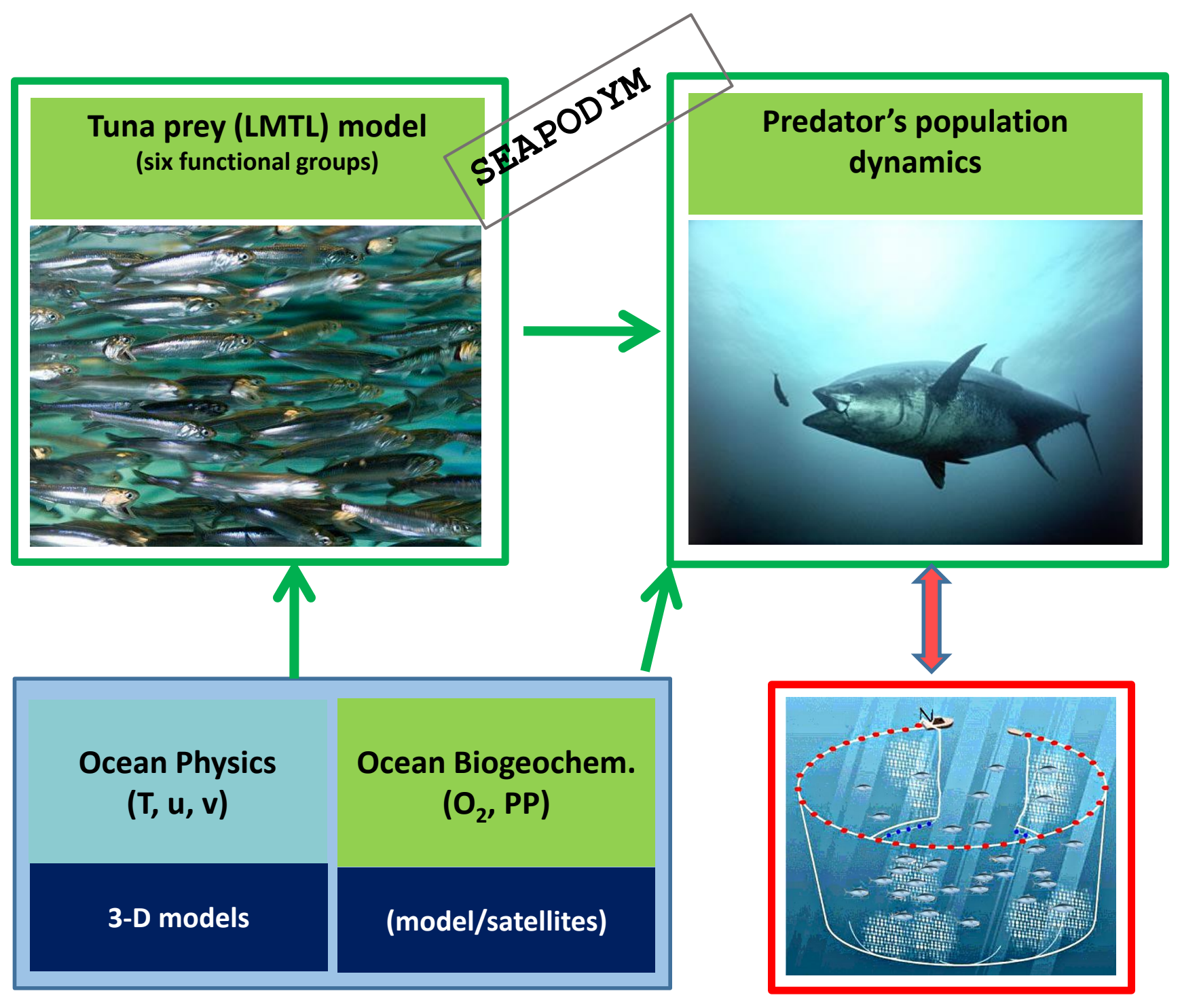
INTRODUCTION

Modelling ^{137}Cs contamination of marine food web: from zooplankton to tunas

Following the accident at the Fukushima Daiichi nuclear powerplant, radioactive elements (*mainly radioactive isotopes of iodine 131, 132, 133, Caesium 134, 137 and Tellurium 129, 132*) were released locally in the ocean and in the atmosphere.



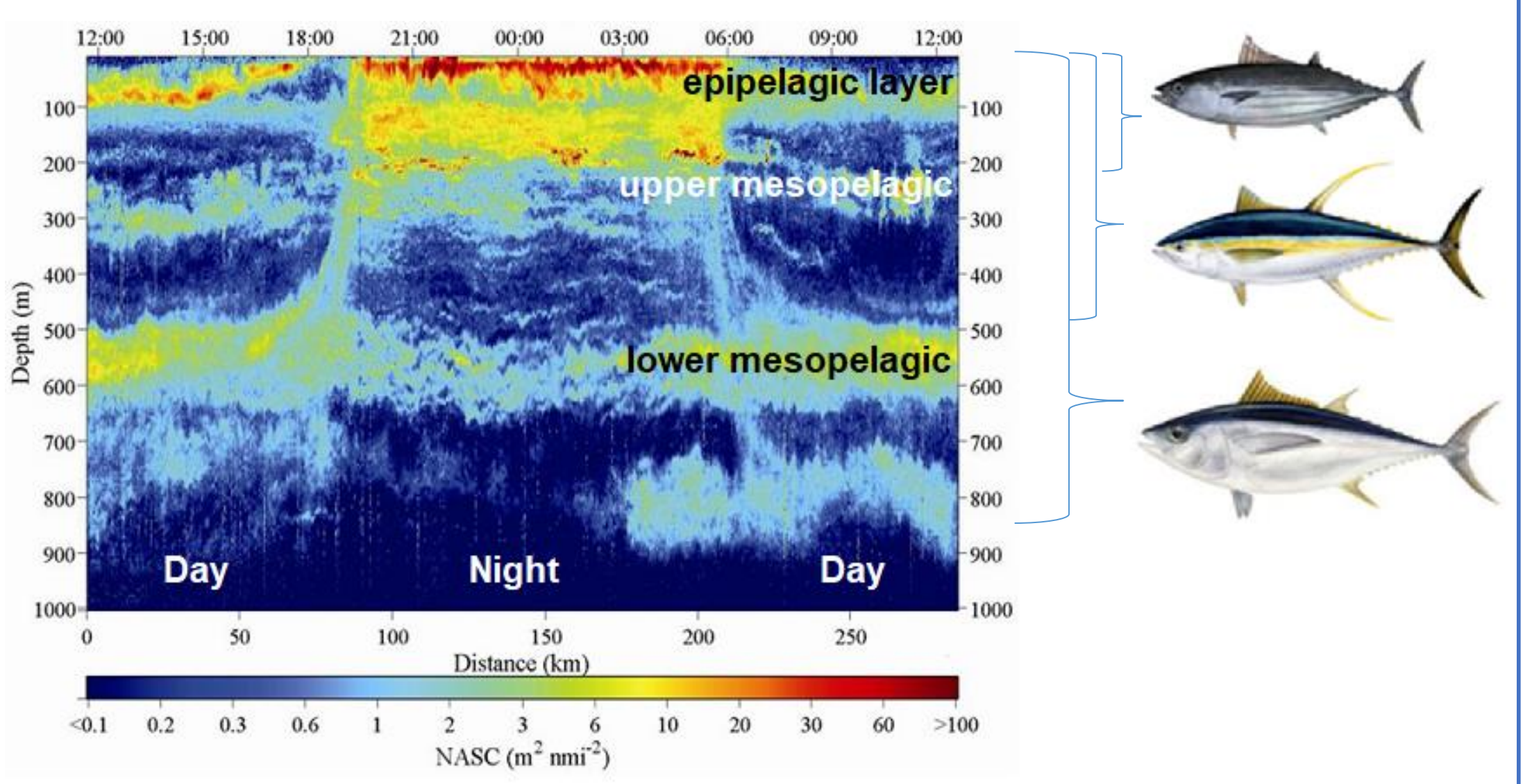
Tuna prey (LMTL) model
(six functional groups)
SEAPODYM
Predator's population dynamics
Ocean Physics (T, u, v)
3-D models
Ocean Biogeochem. (O_2, PP)
(model/satellites)

- ○ **How to evaluate the impact of radioactive contamination on the oceanic food web?**
- ✓ Model the long-term dispersal of ^{137}Cs in sea water;
- ✓ Couple existing SEAPODYM-LTML model and Thomann radioecological equation;
- ✓ Use observed ^{137}Cs activity concentrations to calibrate and validate the model;
- ✓ Predict the risk of contamination for the exploited top predators based on SEAPODYM modeling of tuna population dynamics.

MODELLING TUNA HABITATS

Quantitative modelling approach

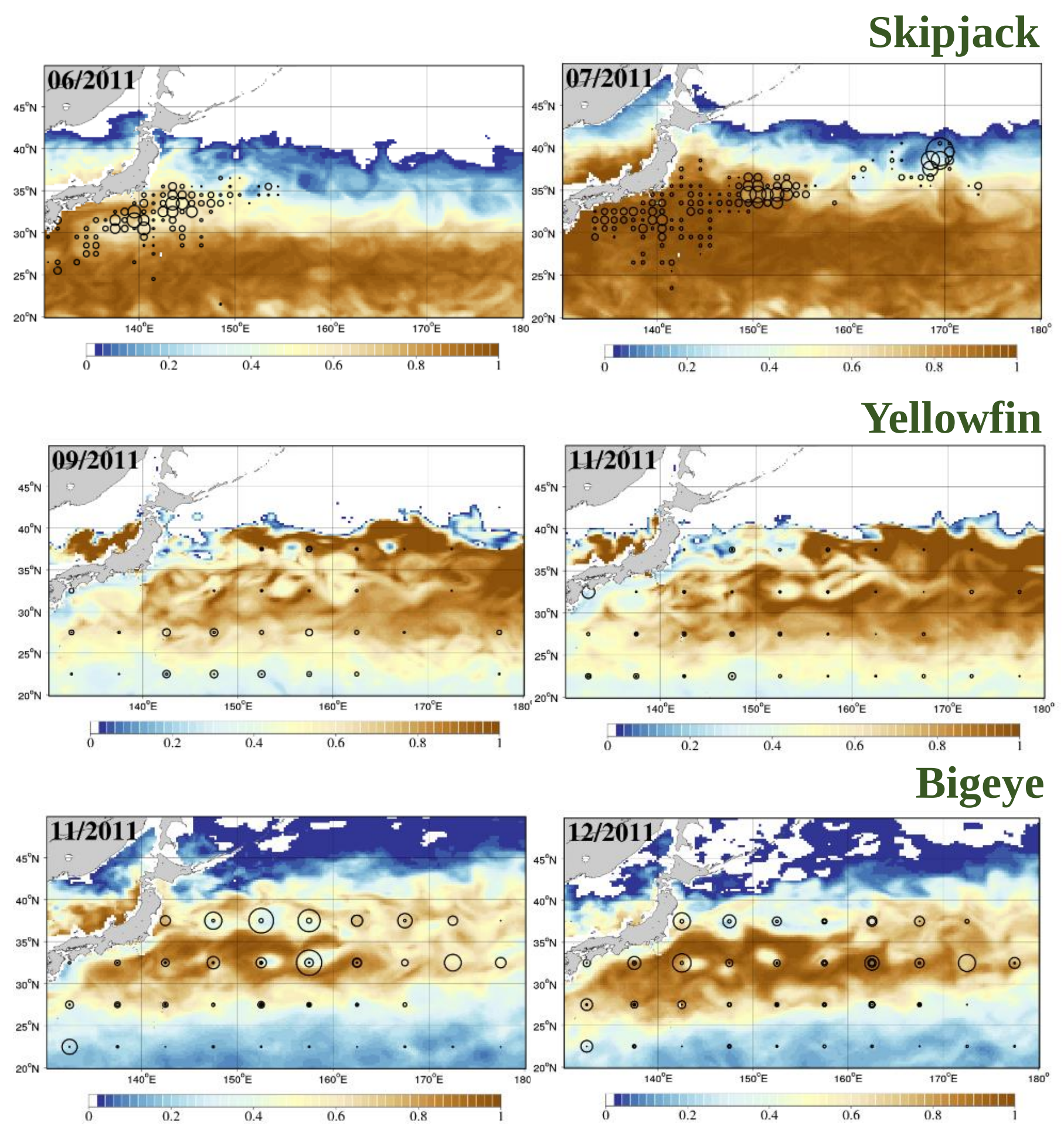
The quality of tuna habitat(*) is defined by the amount of accessible forage, called micronekton. The accessibility depends on preferred temperature and tolerance to dissolved oxygen in pelagic layer occupied by micronekton.



(*) All habitat parameters are informed from fisheries (catch and length) and tagging data with help of methods of quantitative modelling.

Tuna preferred habitats in the North Pacific. Average monthly habitat indices of three tunas vary between 0 (worst habitat) 1 (the most suitable habitat).

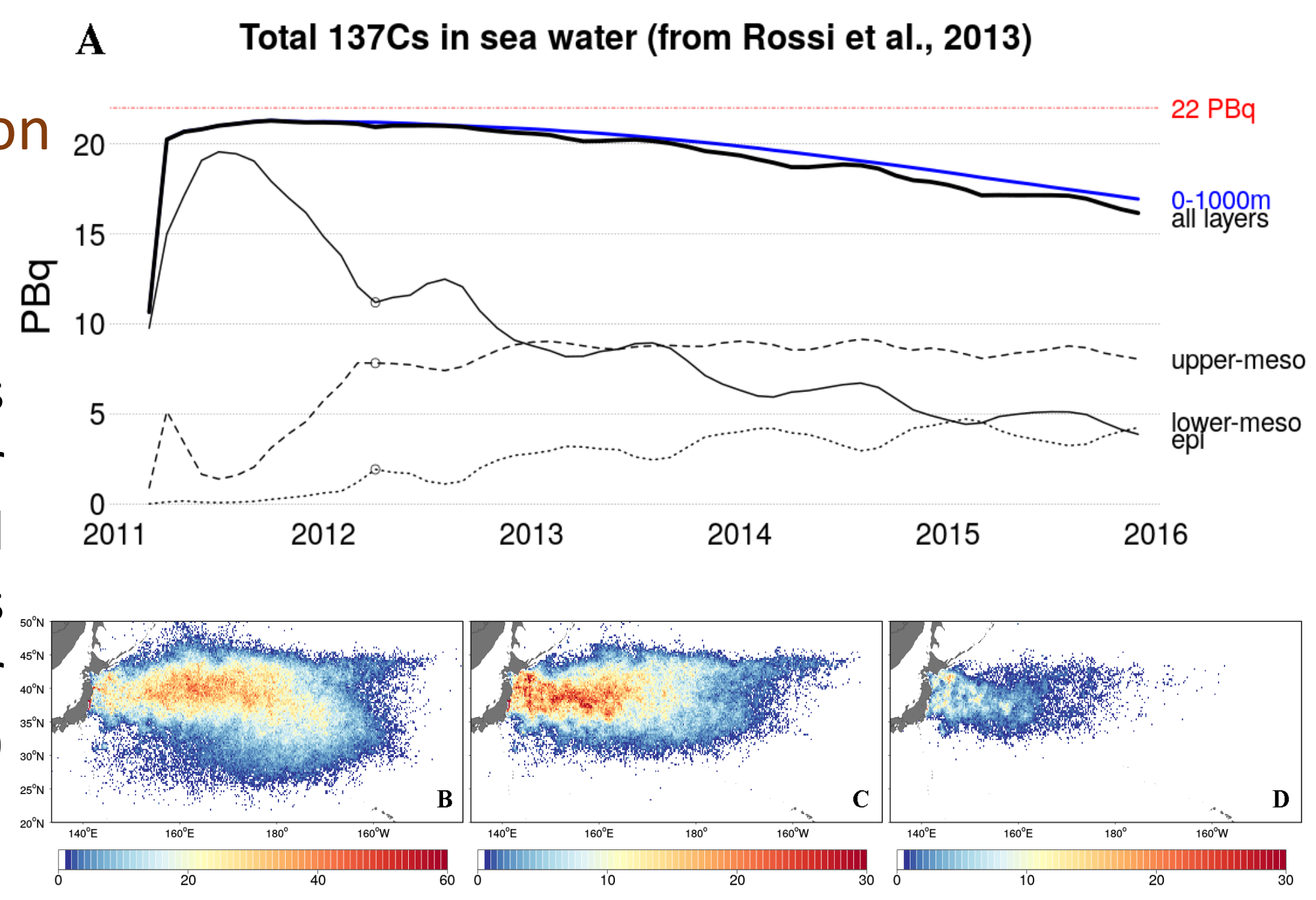
Fishing activity is seasonal in the region contaminated by radioactive isotopes after Fukushima accident. The maximal catches are observed through May-September for skipjack, September-December for bigeye and yellowfin (secondary target by longline gear). The catches are shown by circles, with the radius proportional to the catch within 1° (for skipjack) and 5° (yellowfin and bigeye) area.



MODEL INPUT

^{137}Cs in water, 5 years after release

Dispersal model relied on the assumption of 22PBq of total released ^{137}Cs



Time series of total monthly concentrations of ^{137}Cs in sea water and aggregated over three vertical layers (A); the spatial distributions of average ^{137}Cs concentrations (Bq/m3) *one year after FDNPP accident* for the epipelagic (B), upper mesopelagic (C) and lower mesopelagic layer (D).

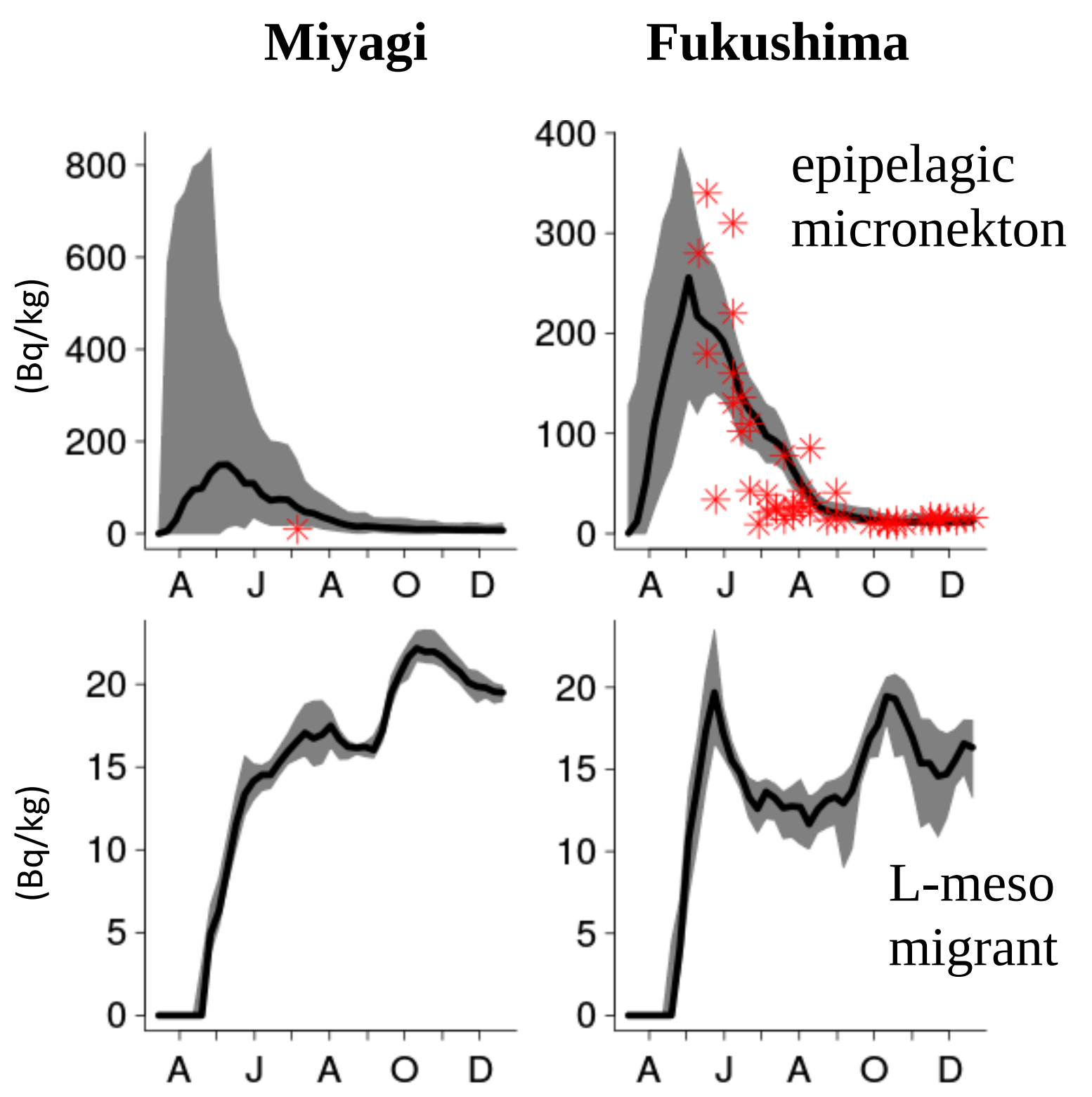
RADIO-ECOLOGICAL MODEL FOR LOW AND MID-TROPHIC LEVELS

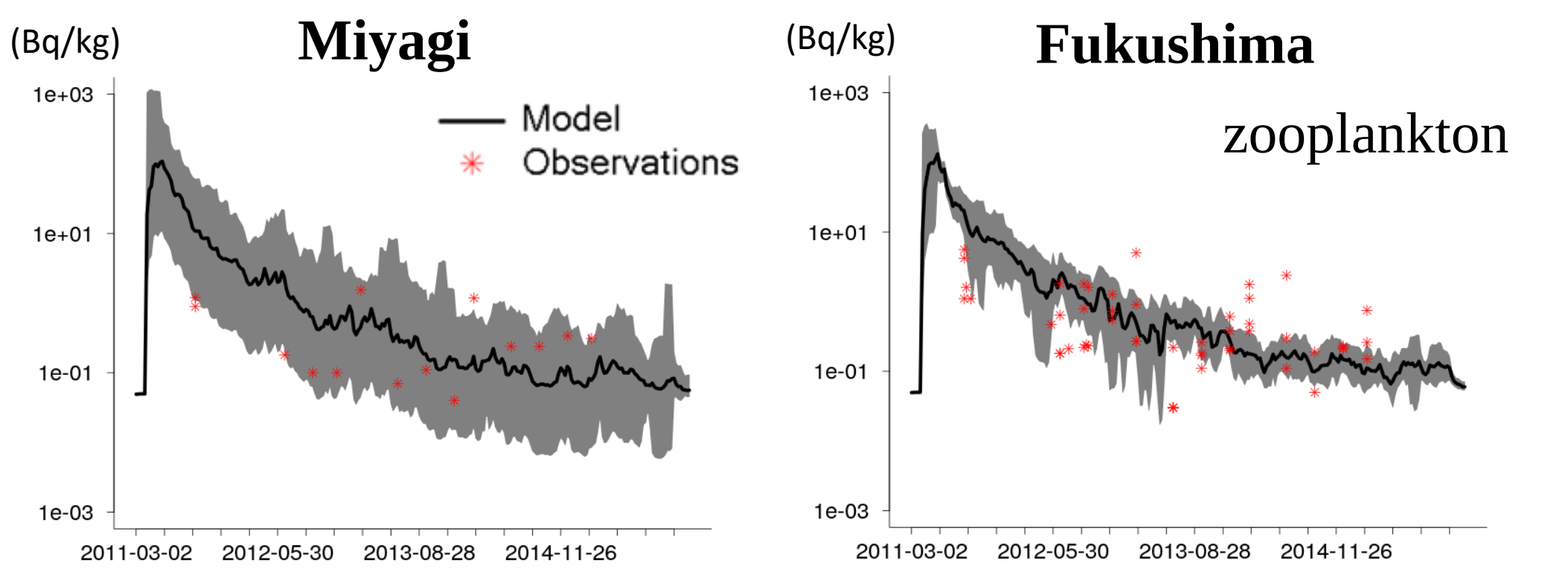
1. Coupling SEAPODYM-LMTL with Thomann radio-ecological equation

The mathematical model predicts the ^{137}Cs activity concentration in zooplankton and micronekton species and spatial distributions of their biomass. The model calibration and validation relied on published sources and observations in epipelagic species collected and provided by Japanese scientists.

2. Predicted ^{137}Cs activity in zooplankton and micronekton biomass

Within 200km off the coast of Japan, the radionuclide activity concentrations were predicted to reach maximum within a month after the accident in zooplankton, in May-June in epipelagic micronektonic species. Contamination was delayed in the deep-water species.



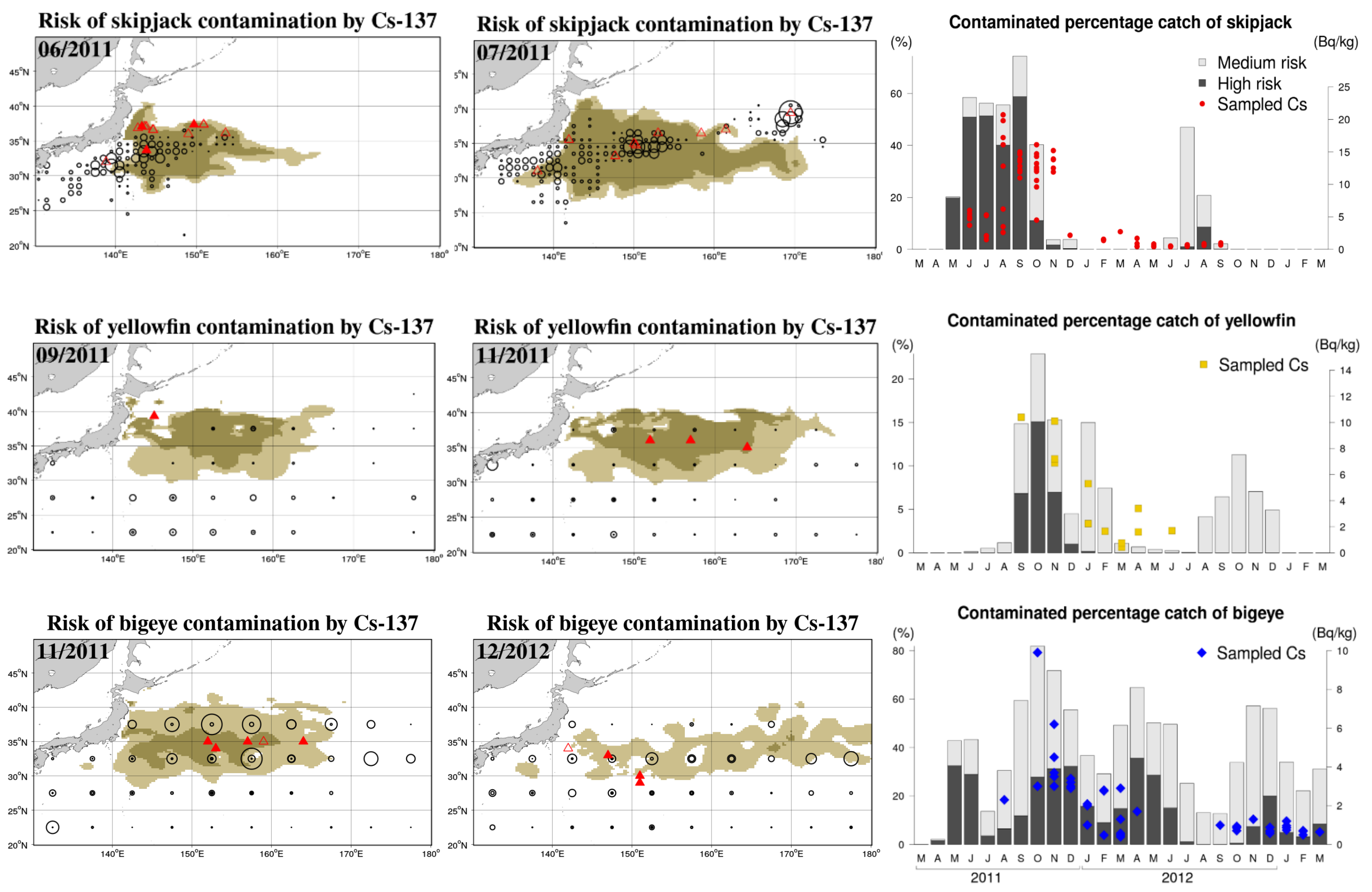


TUNA CONTAMINATION RISK

1. From top predator habitats to risk maps

Tuna movements are driven by habitat suitability. Knowing the parameters of preferred habitats, the micronekton biomass and the radionuclide activity concentrations in micronekton, we can predict the risk of contamination for tunas through consumption of contaminated prey organisms.

The feeding migrations of skipjack coincided with the peak of ^{137}Cs activity concentration in epipelagic micronekton. Up to 60% of regional skipjack catch occurred in the area of high risk for this species. Yellowfin and bigeye feeding on mesopelagic prey, their preferred habitats farther offshore, were less impacted. However, bigeye tunas were longer exposed to contaminants via feeding on deep-water prey with significant levels of ^{137}Cs activity through 2012.



The contamination risk is characterized by 3 levels: low (no color), medium (light color) and high (dark color).

Observations on total Cs activity are made by Japanese Fisheries Agency. The red triangles show the positions of caught tuna with above detection limit (filled triangle) and below (empty triangle) Cs activity.

CONCLUSIONS

- Ecosystem model incorporating the dynamics of radioactive caesium isotopes, provides reliable estimations of contaminants in low and mid-trophic level organisms;
- Computed contamination risk indicators for three exploited tuna species (skipjack, bigeye and yellowfin) corroborate results found by other studies showing low levels of ^{137}Cs in tunas;
- The approach can be adopted for operational monitoring of post-accidental risks.

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