# Short- and long-term ecological half-lives of radiocesium in marine populations

Kayoko Iwata, Keiko Tagami, Shigeo Uchida

National Institute of Radiological Sciences,

Office of Biospheric Assessment for Waste Disposal

# Background

- The FDNPP accident caused direct and atmospheric discharges of radionuclides (RN)—i.e. Cs-137 <Air: 8.8-15 PBq[*1-4]; Direct: ~3.5 PBq[*5]>
  - Cs-137 contamination in marine life

  [*1] Nuclear Emergency Response Headquarters, 2011 [*2] Chino et al. 2011 [*3] Morino et al. 2013 [*4] National Institute of Environmental Studies, 2013 [*5] Tsumune et al. 2012

- Radionuclides with relatively long physical half-lives
  - Cs-137 ($\approx$ 30 yrs.)
  - Possible continuance of food contamination
  - Concern about internal exposure for consumers over a long period
- ❖ Importance of a long-term contamination evaluation
  - In natural ecosystems
  - Ecological half-life
    - ✧ a valid index of food contamination & its long-term trend estimation
  - Not much data available in the actual environment

# Definition

## Ecological half-life ($T_{eco}$)

Time required for 50% decline of radionuclide in a **population** in a natural ecosystem



Wild

Fish Marine Amazon Aqua Tropical Export. 9 Nov. 2013. WALLSAVE. Web. 24 Dec. 2013.

## Biological half-life ($T_b$)

Time required for the biological elimination of 50% of radionuclide from **a living body (individual)**



Controlled
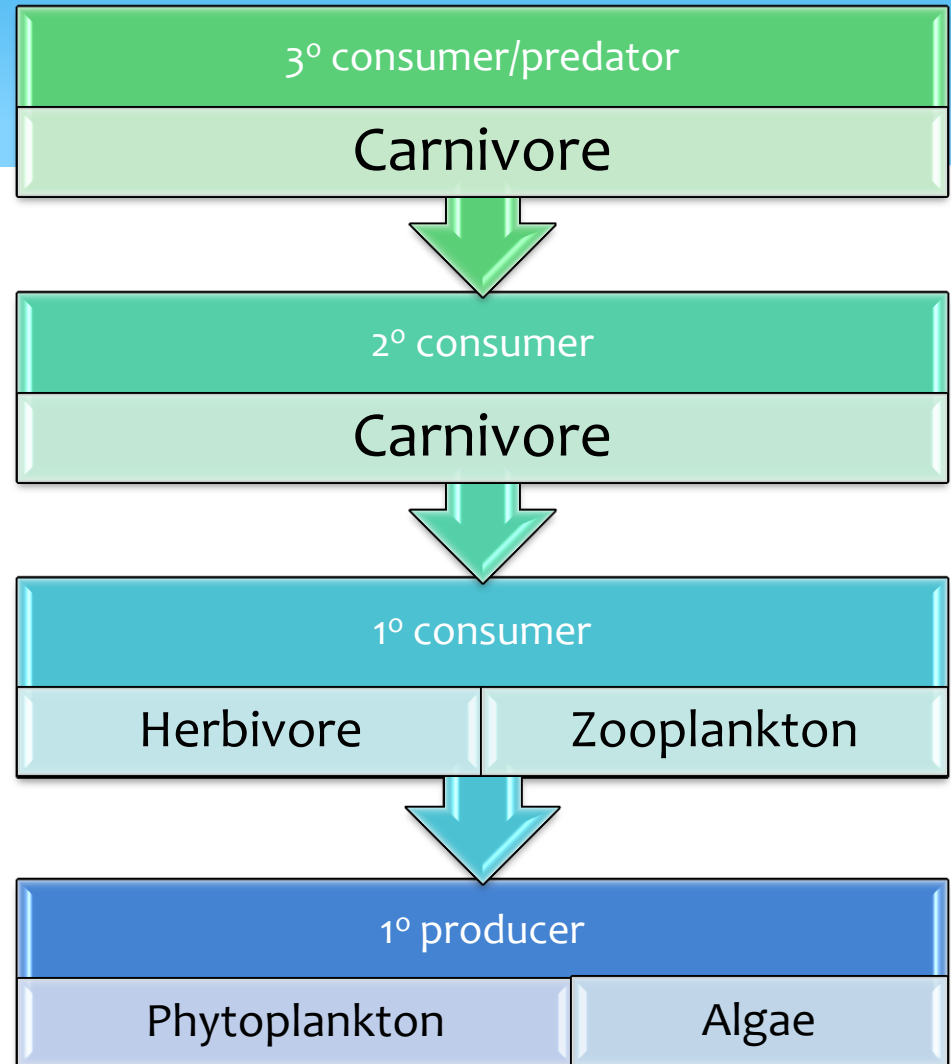
Amphiprion ocellaris. 2013. All Free Clipart. Web. 24 Dec. 2013.
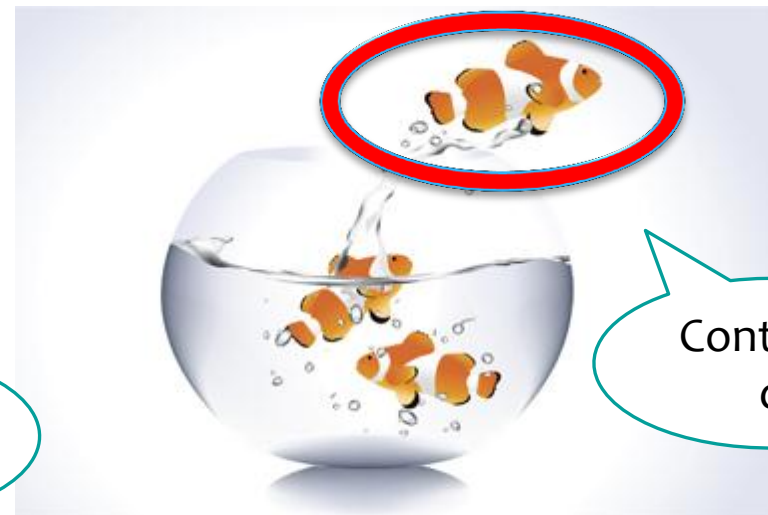
# Objectives

❖To estimate $T_{eco}$ of $^{137}Cs$ in marine populations

- two-component exponential declines
- Several trophic levels

➔Any trends along food chain?

| 3° consumer/predator |
| --- |
| Carnivore |

| 2° consumer |
| --- |
| Carnivore |

| 1° consumer | |
| --- | --- |
| Herbivore | Zooplankton |

| 1° producer | |
| --- | --- |
| Phytoplankton | Algae |

# Data source

The food monitoring data publicly shared on the website of Ministry of Health, Labour and Welfare of Japan (MHLW)*

*http://www.mhlw.go.jp/shinsai_jouhou/shokuhin.html

✧ Particularly, samples caught off the south coast of Pref. Fukushima (Iwaki city)



Maps from Google Earth

# Stu... es
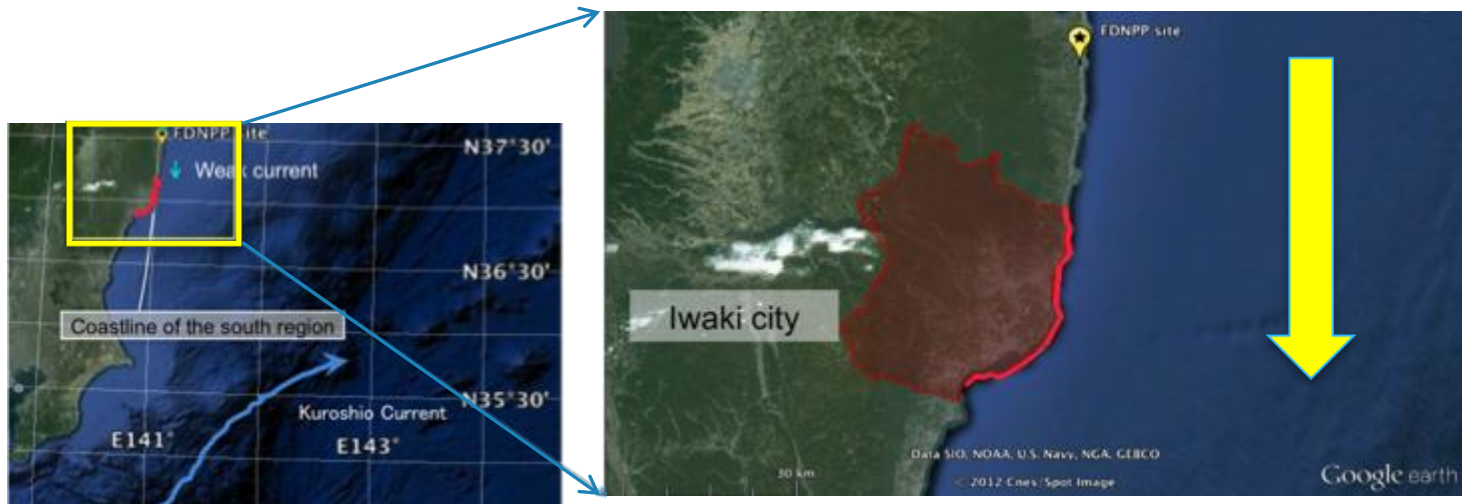
Physiculus maximowiczi. July 2003. Izuzuki Diver. Web. 24 Dec. 2013.

...eb. 24 Dec. 2013.

| Species | Size (cm) | Main Diet | Trophic level |
|---|---|---|---|
| Abalone | oval: 5-20 by 3-17 | seaweed; kelp | 1° consumer |
| Sakhalin surf clam | > 10 | phytoplankton; detritus | 1° consumer |
| Marbled flounder | ~ 45 | polychaetes | 2° consumer |
| Brown hakeling | ~ 30 | polychaetes; crustacean; molluscs | 2° consumer |
| Gurnard | > 30 | crustacean; small fish | 3° consumer |
| Whitespotted conger | M: ~40; F: ~90 | polychaetes; crustacean; small fish; dead materials | 3° consumer/scavenger |

# Estimation of $T_{eco}$
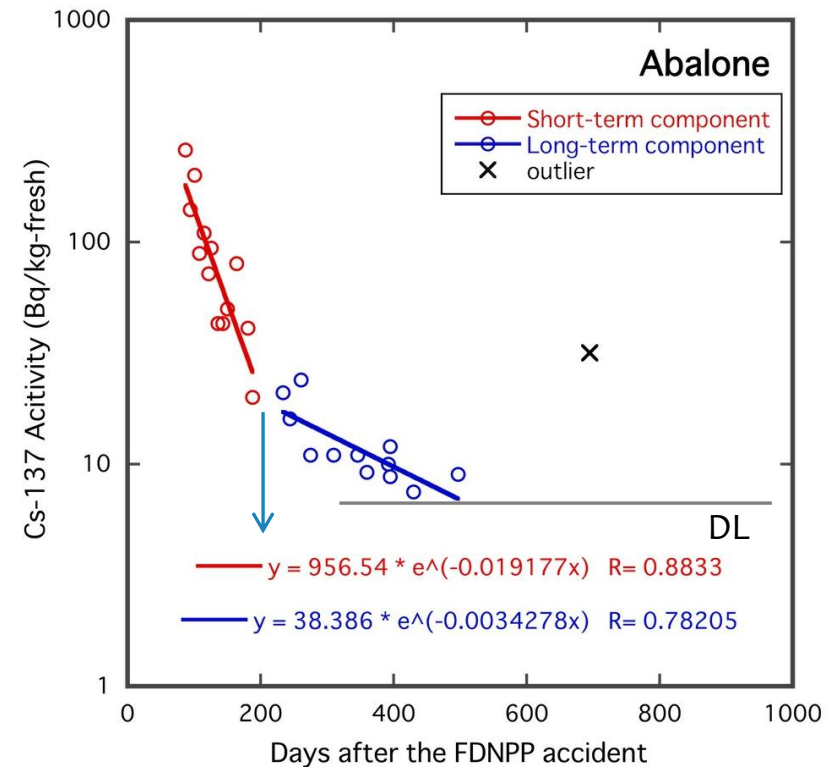## ~two-component exponential decline~

## Short- & long-term components

➔ the phenomena have been shown in the previous studies[1][2]

1) Plot all the valid data values

2) Draw the best fit to 2 (fast & slow) exponential declines

3) Estimate $T_{eco}$ by $\ln 2 \, \lambda_{eco}^{-1}$:

   ❖ $\lambda_{eco}$ = loss rate of RN activity in a population in the wild



Abalone

— Short-term component
— Long-term component
✕ outlier

$y = 956.54 * e^{\wedge}(-0.019177x)$  R= 0.8833

$y = 38.386 * e^{\wedge}(-0.0034278x)$  R= 0.78205

Cs-137 Acitivity (Bq/kg-fresh)

Days after the FDNPP accident

DL

(1) Jonsson, B.; Forseth, T.; Ugedal. O. Chernobyl radioactivity persists in fish. *Nature*. **1999**, 400 (417).
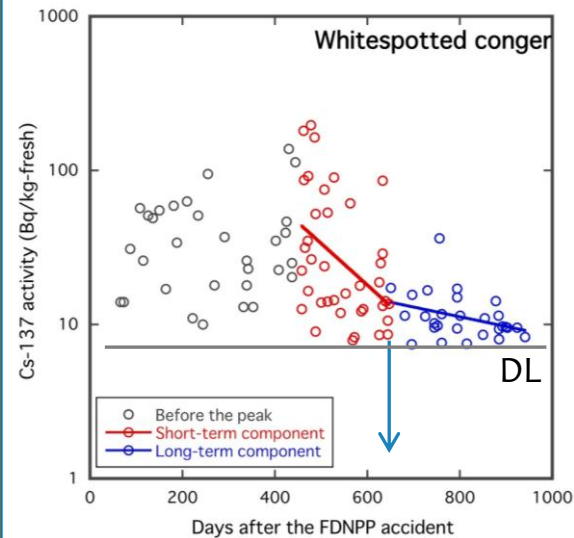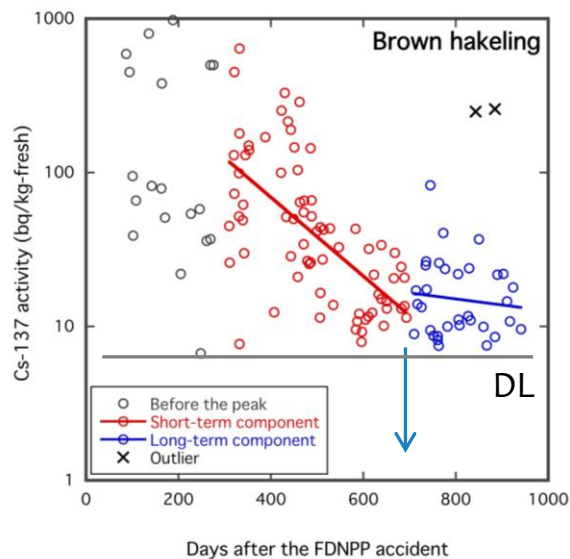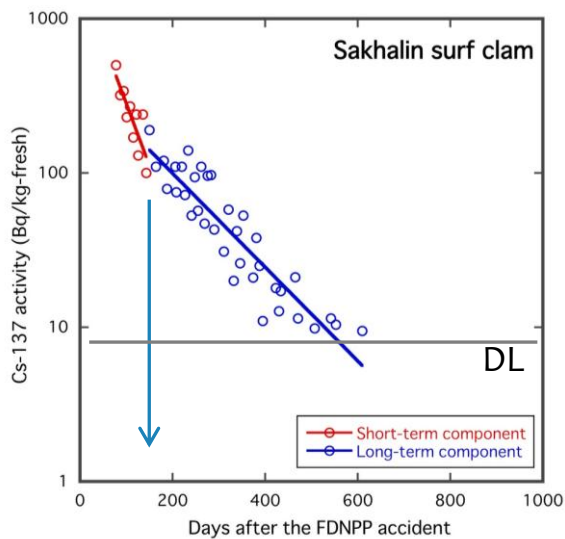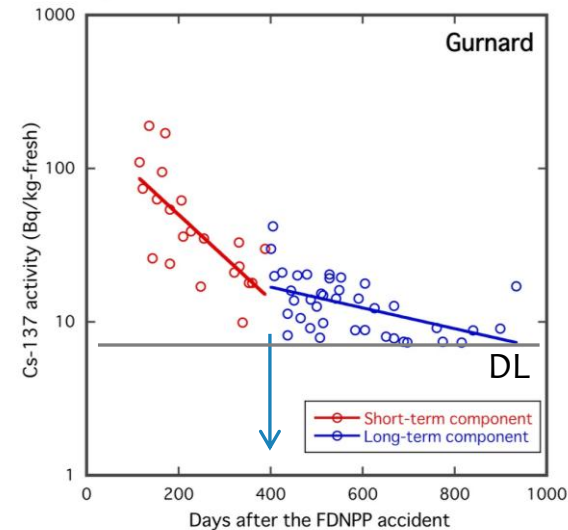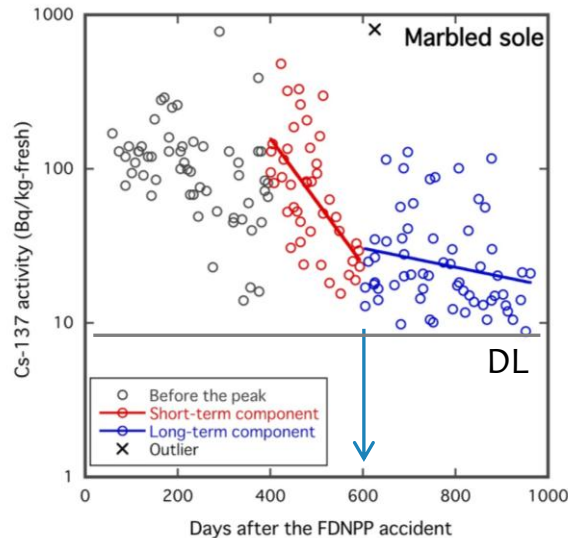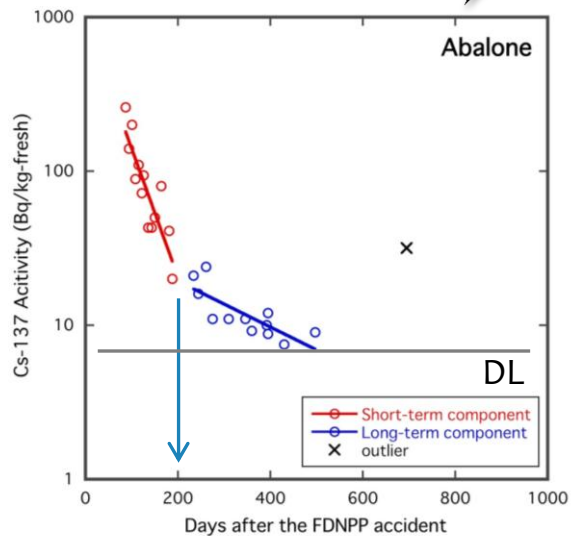(2) Smith, J.T.; Comans, R. N. J.; Beresford, N. A.; Write, S. M.; Howard, B. J.; Camplin, W. C. Pollution: Chernobyl's legacy in food and water. *Nature*. **2000**, 405 (141)

# Results

# Results

| Species | $T_{eco}$: short | $T_{eco}$: long | Before the peak (days) | Trophic level |
|---|---|---|---|---|
| Abalone | 36 | 202 | N.A. | 1º consumer |
| Sakhalin surf clam | 37 | 99 | N.A. | 1º consumer |
| Marbled flounder | 74 | 489 | 400 | 2º consumer |
| Brown hakeling | 118 | 767 | 310 | 2º consumer |
| Gurnard | 109 | 445 | N.A. | 3º consumer |
| Whitespotted conger | 111 | 479 | 450 | 3º consumer/scavenger |

# Trophic Levels

* Shellfish: univalve/ bivalve →food selection matters?
  - Filter feeder may have lower assimilation rate and/or higher metabolism than other herbivores
  - Monitoring data reached under DL relatively fast→ difficulty in estimating long-term $T_{eco}$ accurately
* Fish:
  - Short-term $T_{eco}$ were relatively similar & longer than that of shellfish
  - Long-term $T_{eco}$ showed more moderate decline than those of shellfish

# Conclusion

* Time-lag before the Cs-137 concentration peak in some populations
* Short-term $T_{eco}$ became longer in populations at higher trophic levels (fish>shellfish)
* Long-term $T_{eco}$ varied among fish populations
  * The ecology of marine populations is complicated
  * Data under DL in the latter monitoring period can cause overestimation
➜ To find out the trend of Cs-137 decline in marine biota
  ✧ Necessity to analyze as many populations as possible
  ✧ Further understanding of each niche

# Thank you for your attention