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# Sequential monitoring at multiple sites of beached plastic debris quantity using webcam

Tomoya Kataoka[*1, *2]
Hirofumi Hinata[*1]
Shin'ichiro Kako[*3]

[*1] National Institute for Land and Infrastructure Management (NILIM)
[*2] Graduate School of Environment and Life Engineering, Toyohashi University of Technology
[*3]Center for Marine Environmental Studies, Ehime University

# Background

- Plastic debris

  e.g., polystyrene buoys, PET bottles, plastic boxes, fishing gear

- Pollution of the marine environment by plastic debris [1), 2), 3)]

  I. Threats to marine animals

  e.g., seabirds ingest plastics, mistaking them for prey.

  sea turtles become entangled in plastic debris.

  I. Coastal and/or marine pollution by toxic chemicals in plastic debris.

Marine debris is one of the most serious problems affecting the global marine environment. [1)]

To solve this problem, it is needed:

1. To identify the transportation process of plastic debris (e.g., sources, outflows, transportation routes and fluxes)
2. To estimate accumulation rates on coasts around the world
3. To show the effects of various measures (e.g., beach cleanups)

1) J. G. B. Derraik (2002), MPB, 44, 842-852. 2) Y. Mato et al.(2009),MPB,58,1437-1446. 3) E. Nakashima et al.(2011),MPB,62,762-769

# Purpose

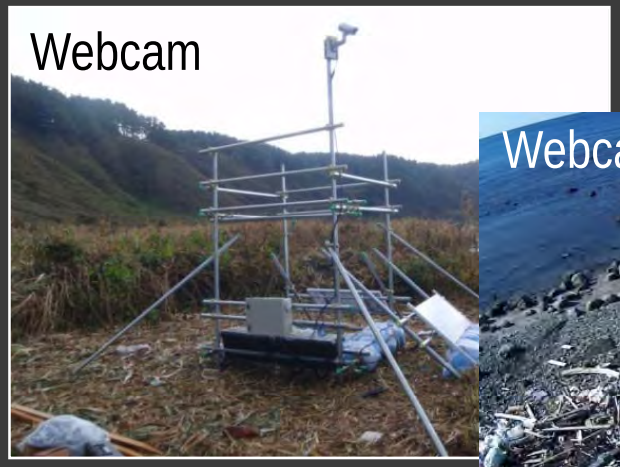
Our final goal:

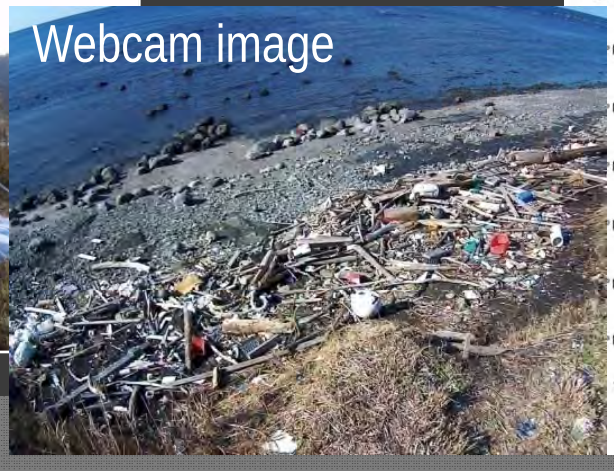
<u>To reveal the transportation process of plastic debris in East Asian seas</u>

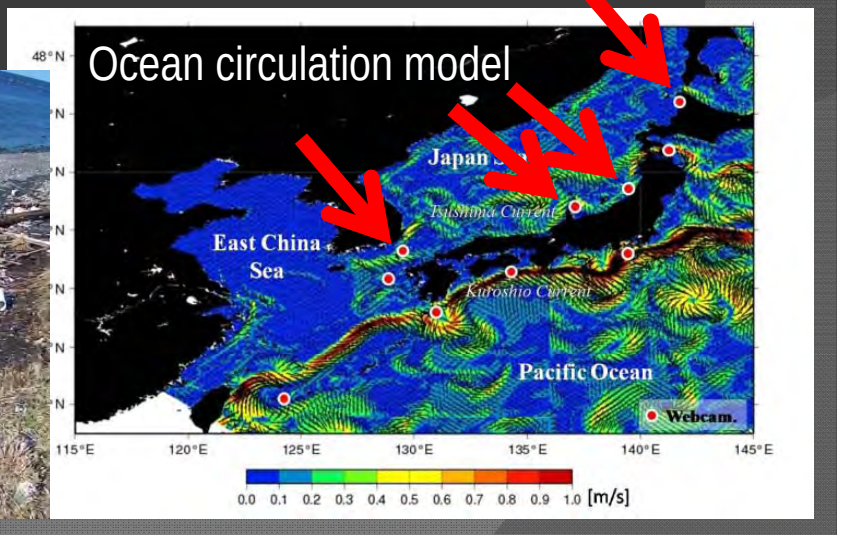
To reveal the transportation process, we must identify:

1. Quantity of beached plastic debris on multiple beaches
   ➔ Sequential monitoring using webcams installed at each site
2. Transportation sources, routes and fluxes of plastic debris
   ➔ An ocean circulation model and beached plastic debris quantity measured by webcam

Today's topic



# Our monitoring sites


(a)Tsushima


(b)Wajima

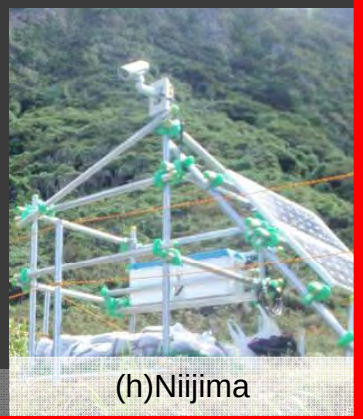

(c)Tobishima）

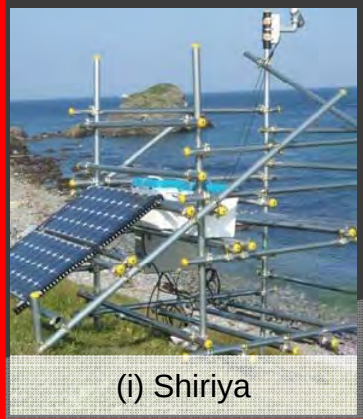

(d) Wakkanai


(e) Ishigaki

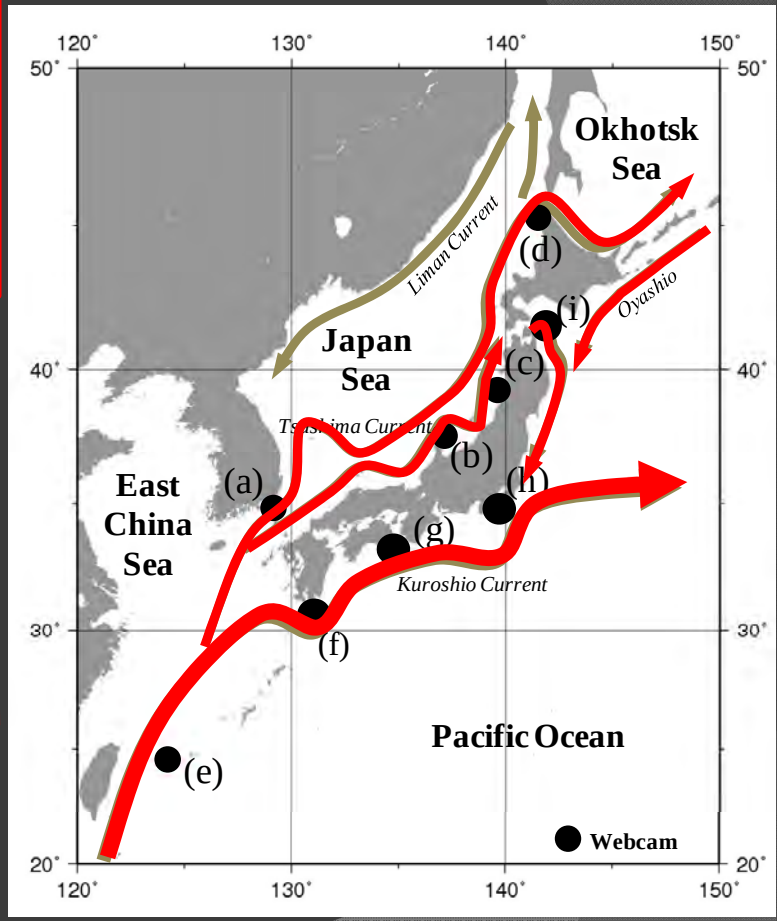

(f)Tanegashima


(g)Muroto


(h)Niijima


(i) Shiriya

## Nine monitoring sites

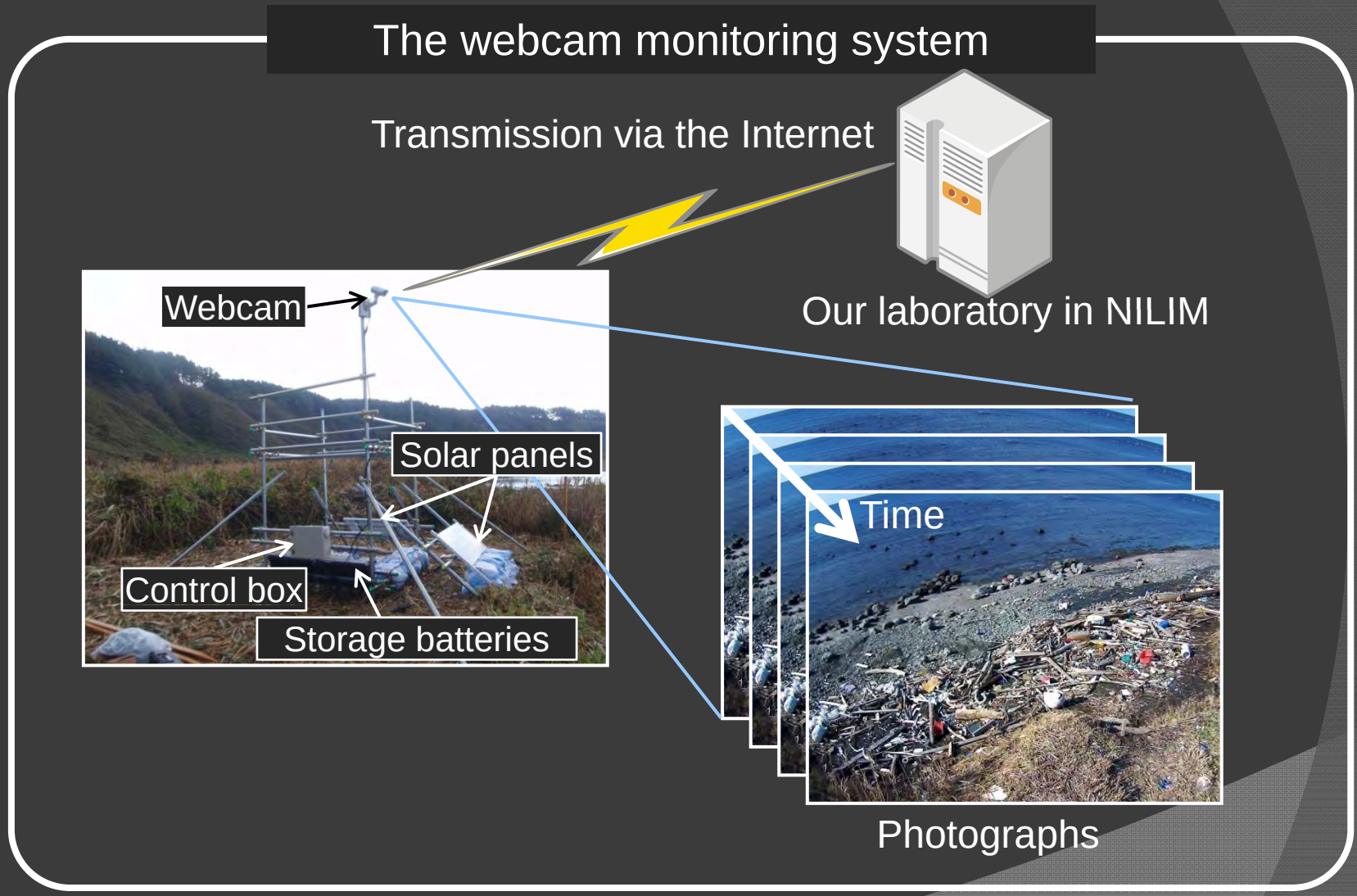



Tsushima current: 4 sites

Kuroshio current: 4 sites

Oyashio: 1 site

# Webcam monitoring system




Operating time ➔ every two hours from 7:00 to 15:00 (i.e., five time every day)
Taking photographs ➔ five photographs every operating time
Daily number of photographs ➔ 25 photographs (i.e., 5 (times) × 5 (photos)=25)

# Webcam images at all sites

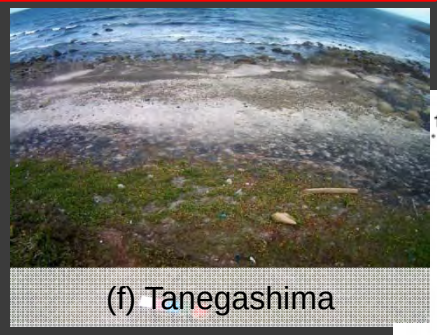

(a) Tsushima


(b) Wajima


(c) Tobishima


(d) Wakkanai


(e) Ishigaki

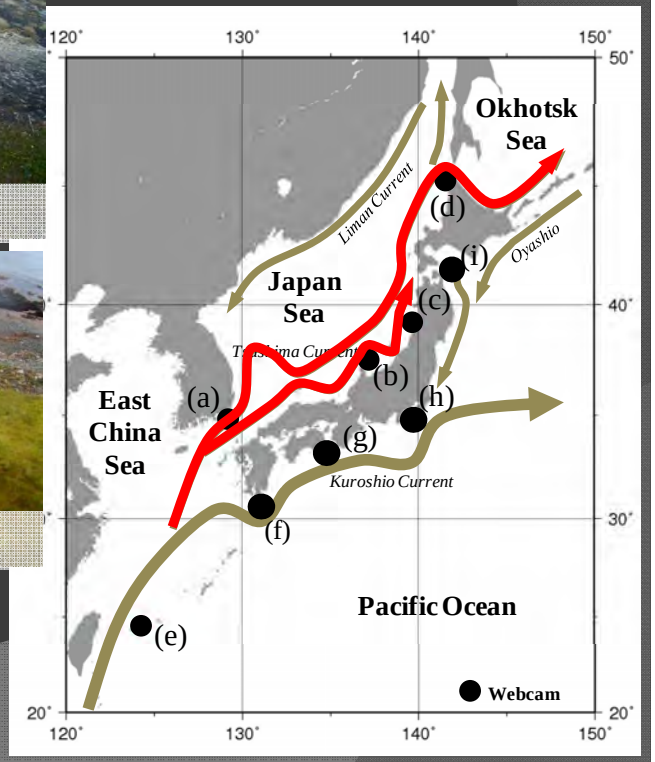

(f) Tanegashima


(g) Muroto


(h) Nijima


(i) Shiriyazaki

【Today's topic】
Tsushima Current:
4 sites




Webcam Home Page
http://www.ysk.nilim.go.jp/kakubu/engan/enganiki/umigomi/index.html

# Animation of webcam images

# Technique for detecting plastic debris pixels[1)]

**1. Generation of color references**

Color references for detecting pixels of plastic debris are generated using CIELUV color space.

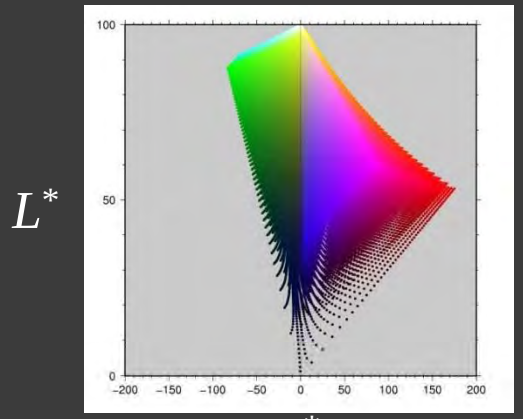
CIELUV color space:

- This space is one of three-dimensional color spaces
- Colors are expressed by ($L^*$, $u^*$, $v^*$).

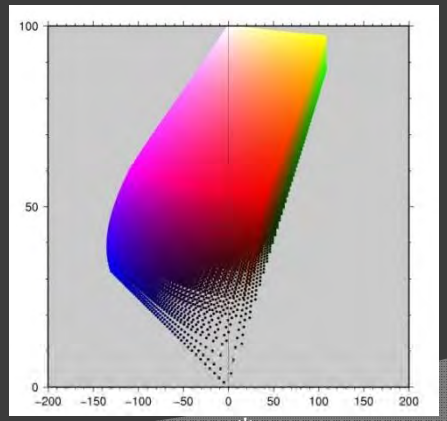
**2. Detection of plastic debris pixels using the color references**

Plastic debris pixels are detected using color references and a composite method.

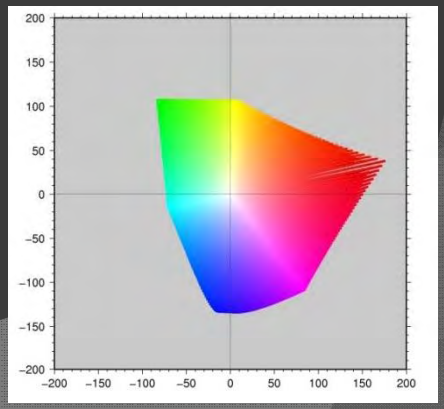
$L^*$-$u^*$ coordinate




$L^*$-$v^*$ coordinate



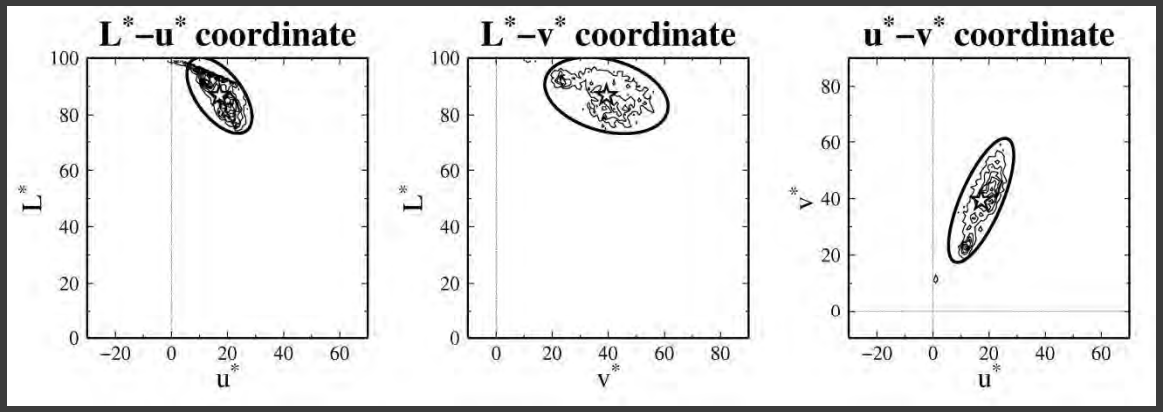

$u^*$-$v^*$ coordinate

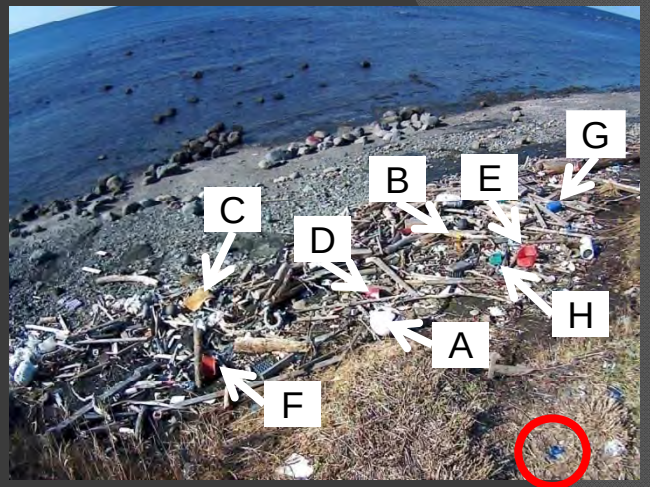



1) T. Kataoka et al.(2012), MPB, 64, 1829-1836

# Generation of color references

Color distribution of plastic debris “C” in the CIELUV color space.

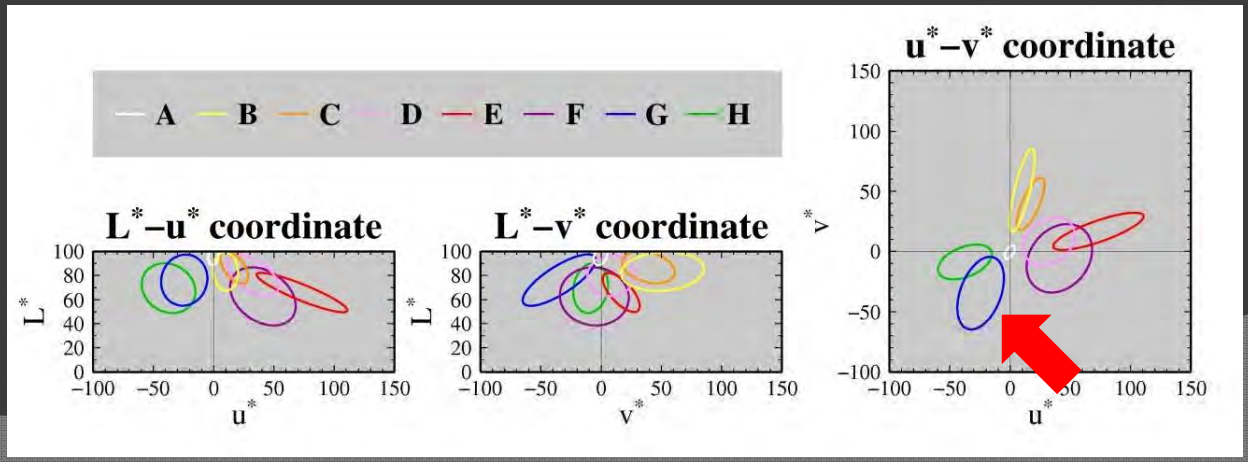



Three ellipses form the ellipsoid body in the CIELUV color space

Ellipsoid body in the CIELUV color space ➔ Color references

Color references, which are generated from webcam images at Tobishima.




| Typical color | Ellipsoid body | Periods[a] | Number of selected pixels |
|---|---|---|---|
| white | A | p1, p2, p3, p4, p5 | 41755 |
| yellow | B | p2, p3, p4, p5 | 23491 |
| | C | p1 | 8712 |
| red | D | p1, p3, p4, p5 | 19100 |
| | E | p1 | 5000 |
| | F | p1, p2, p3, p4, p5 | 24000 |
| green | G | p1, p2, p3, p4, p5 | 62000 |
| blue | H | p1, p3, p4, p5 | 33200 |

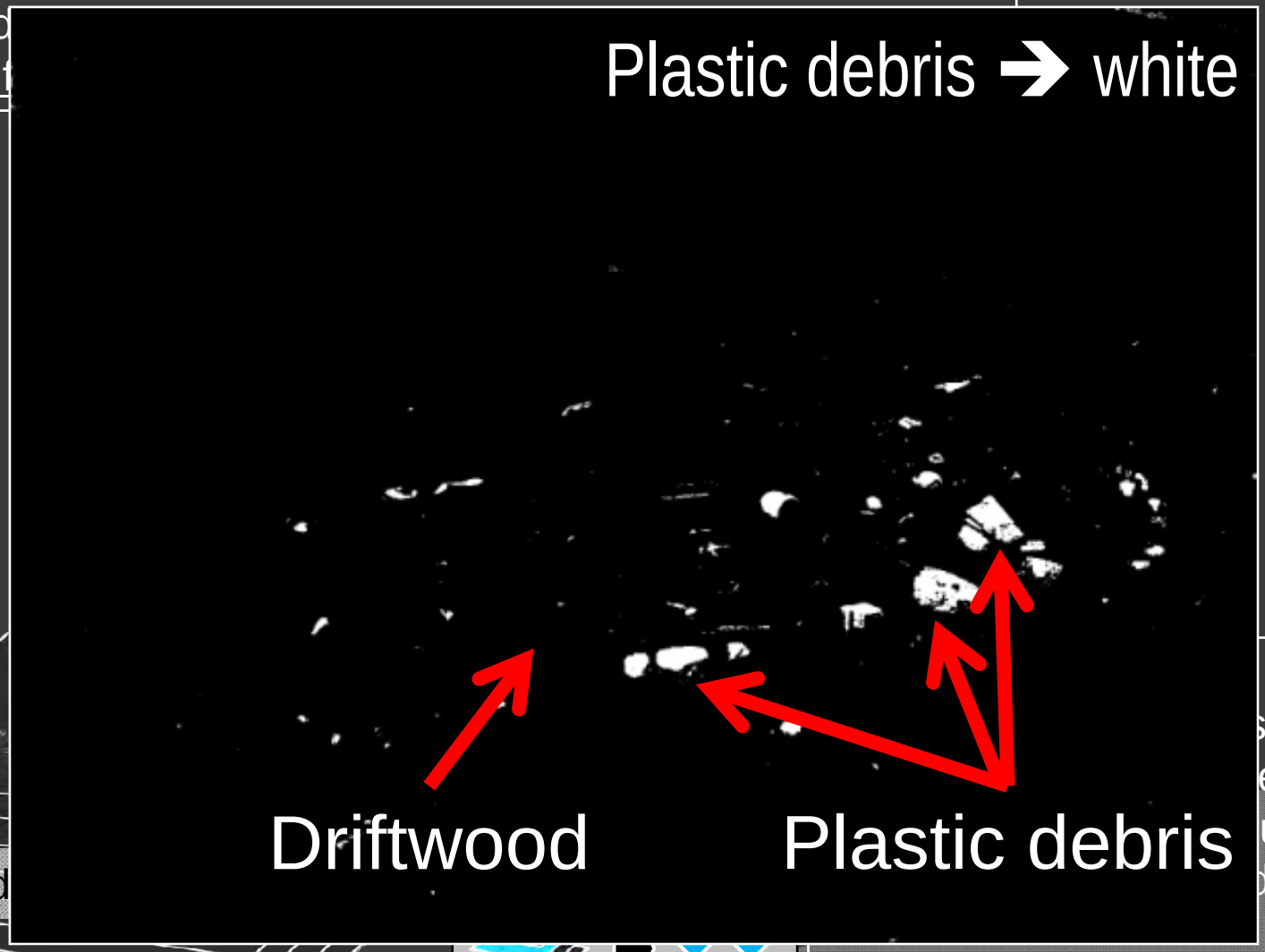
[a]Periods: p1, November 21-27, 2010; p2, December 14-21, 2010; p3, February 16-22, 2011; p4, April 1-7, 2011; p5, May 18-24, 2011

# Detection of plastic debris pixels using the color references

【Detection of plastic debris using a single photograph】

Plastic d

e.g., Drif




For 3 d

e ellipsoid

using

days.

Not plastic debris

➔Plastic debris pixels

# Computation of the beached plastic debris quantity

## Beached plastic debris quantity ➔ **Covered area**

Projective transformation[1)]

$$X = \frac{b_1 x + b_2 y + b_3}{b_4 x + b_5 y + 1}$$

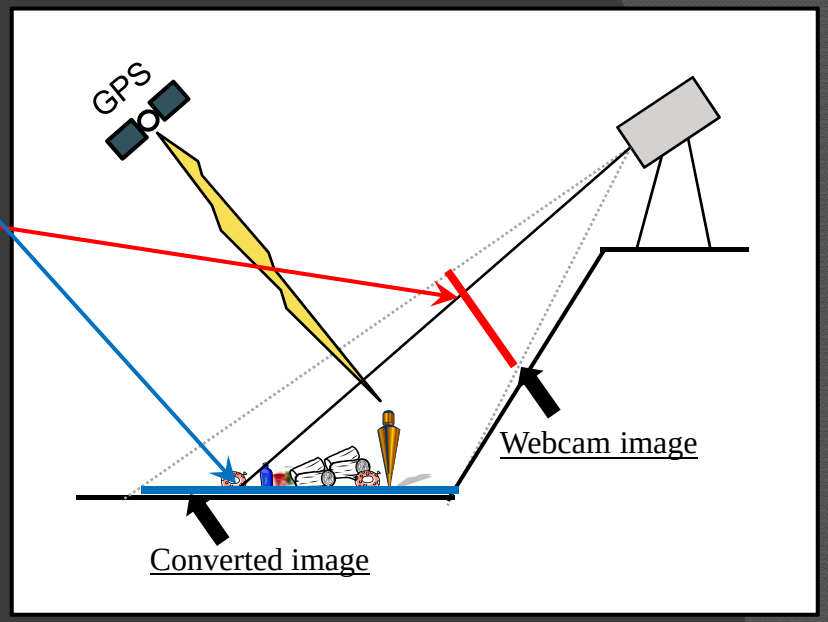
$$Y = \frac{c_1 x + c_2 y + c_3}{c_4 x + c_5 y + 1}$$

$(X, Y)$: Geographic coordinate

$(x, y)$: Photographic coordinate

$b_i, c_i (i = 1,2 \cdots 5)$ Coefficients

1) S. Magome et al.(2007),JO,63,761-773



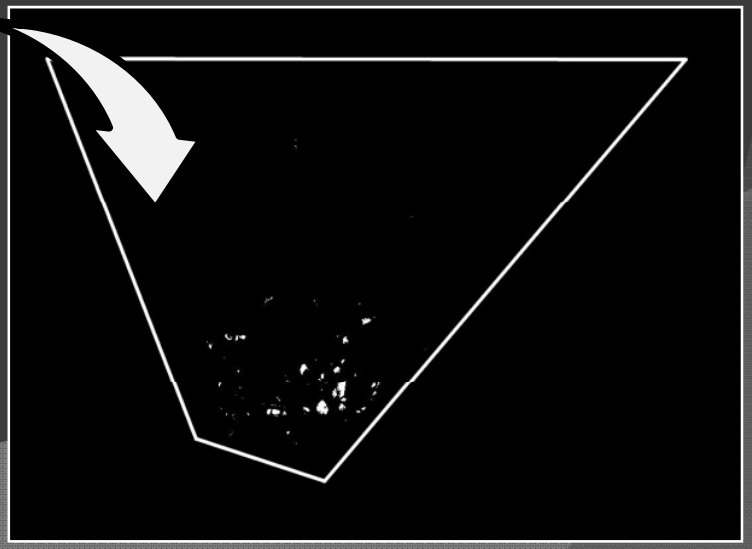

Covered area $A$

$A = N \times a$

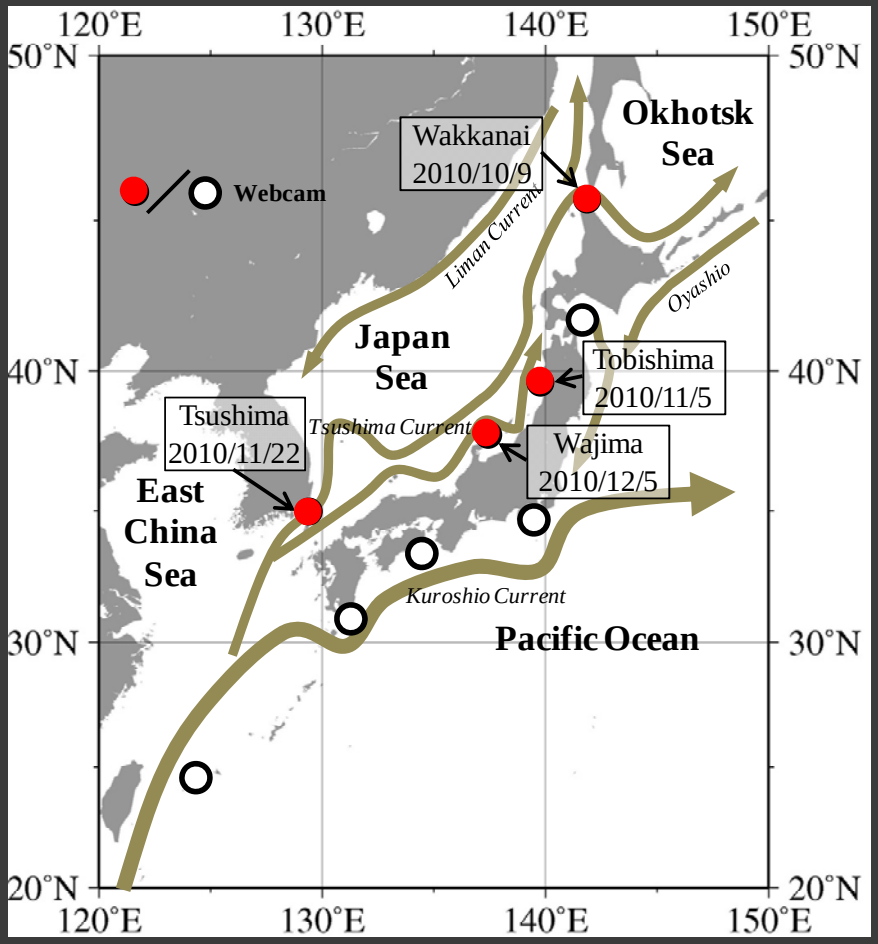
$N$ : Number of plastic pixels

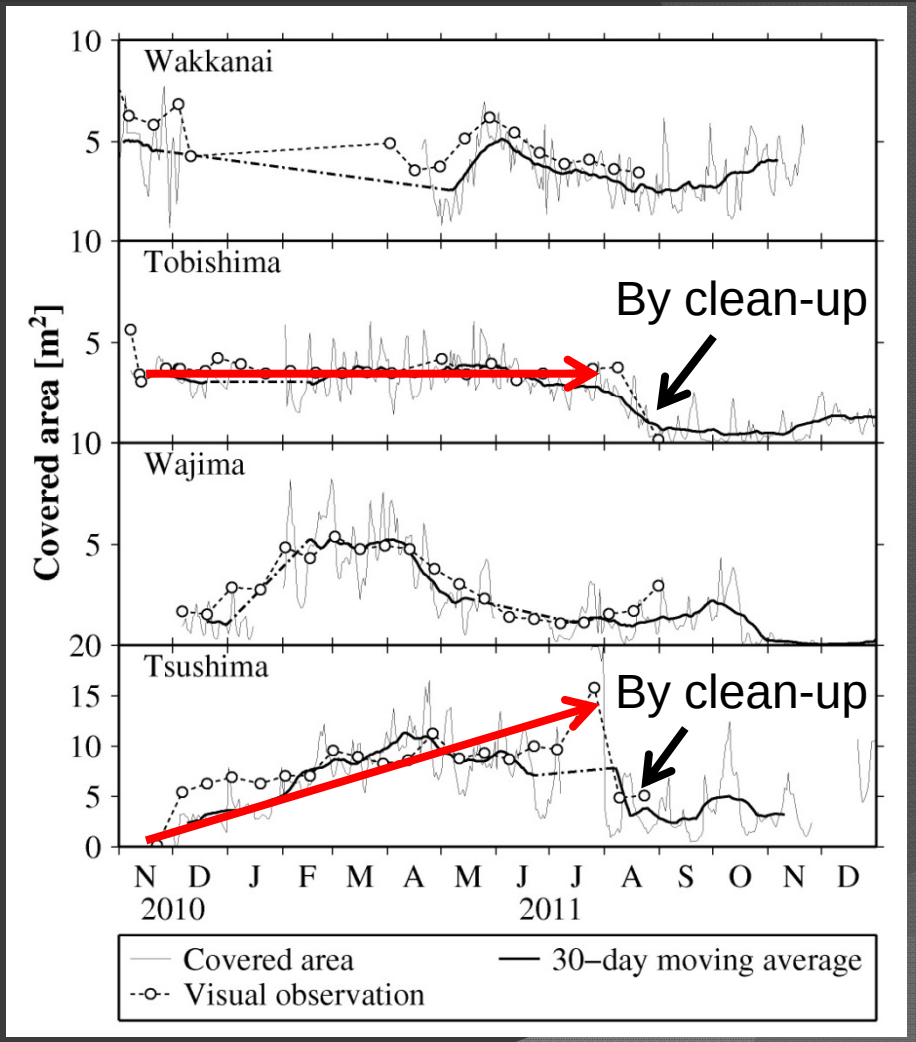
$a$ : Area of a single pixel

Error of computed area: within5.0%



# Time series of plastic debris quantity

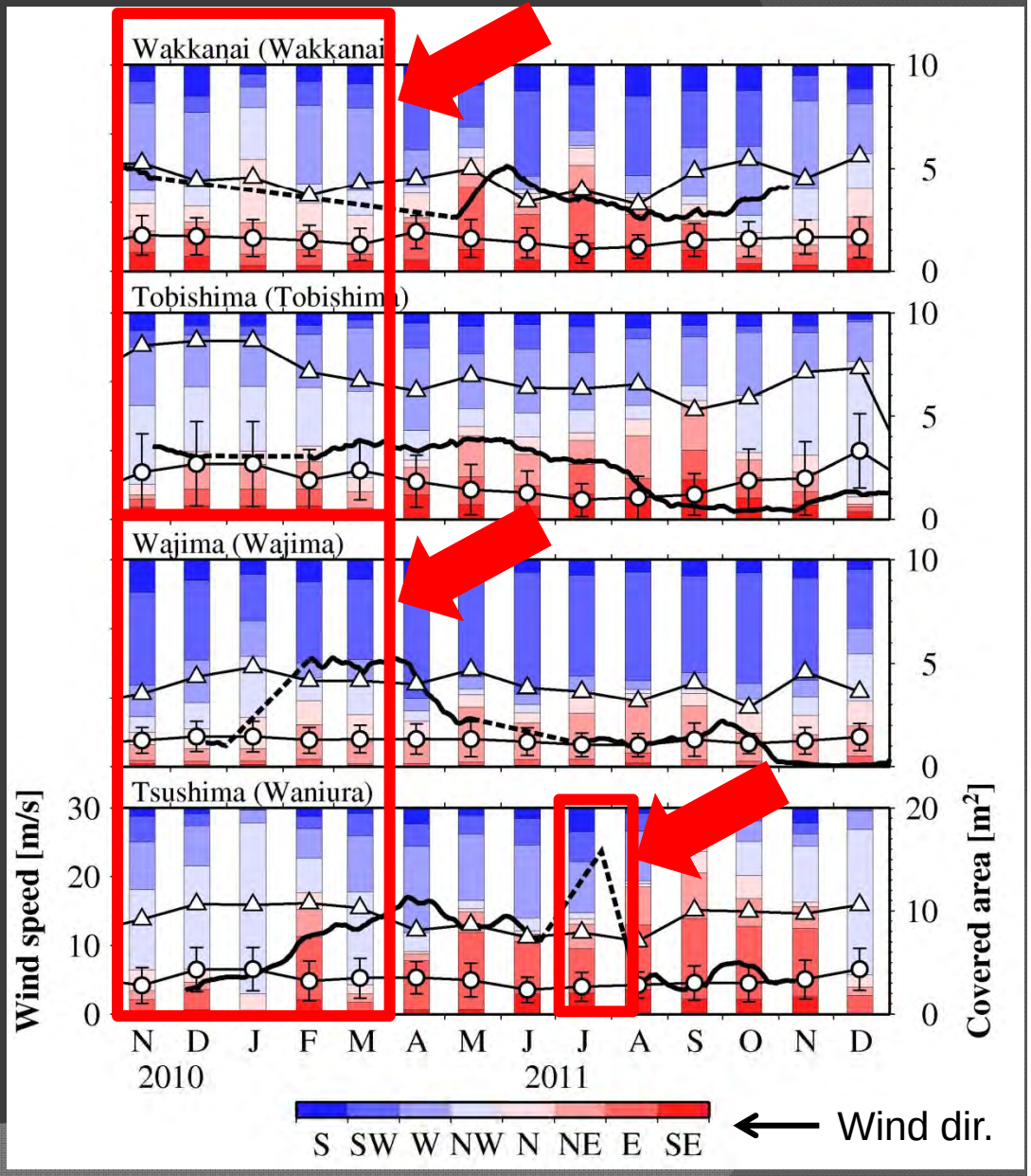



Time series of daily covered areas ➔ Short-term fluctuations depended on changes in the weather conditions (e.g., amount of sunlight, wind).
Removing the short-term fluctuations ➔ Time series of 30-day moving averages (bold line).

# Comparison with wind data

【Nov. 2010 – Mar. 2011】
At Wajima and Tsushima
➔ Increase
At Wakkanai and Tobishima
➔ Not increase
【May. 2011】
At Wakkanai ➔ Increase
【April. 2011】
At Wajima ➔ decrease
【July. 2011】
At Tsushima ➔ Increase



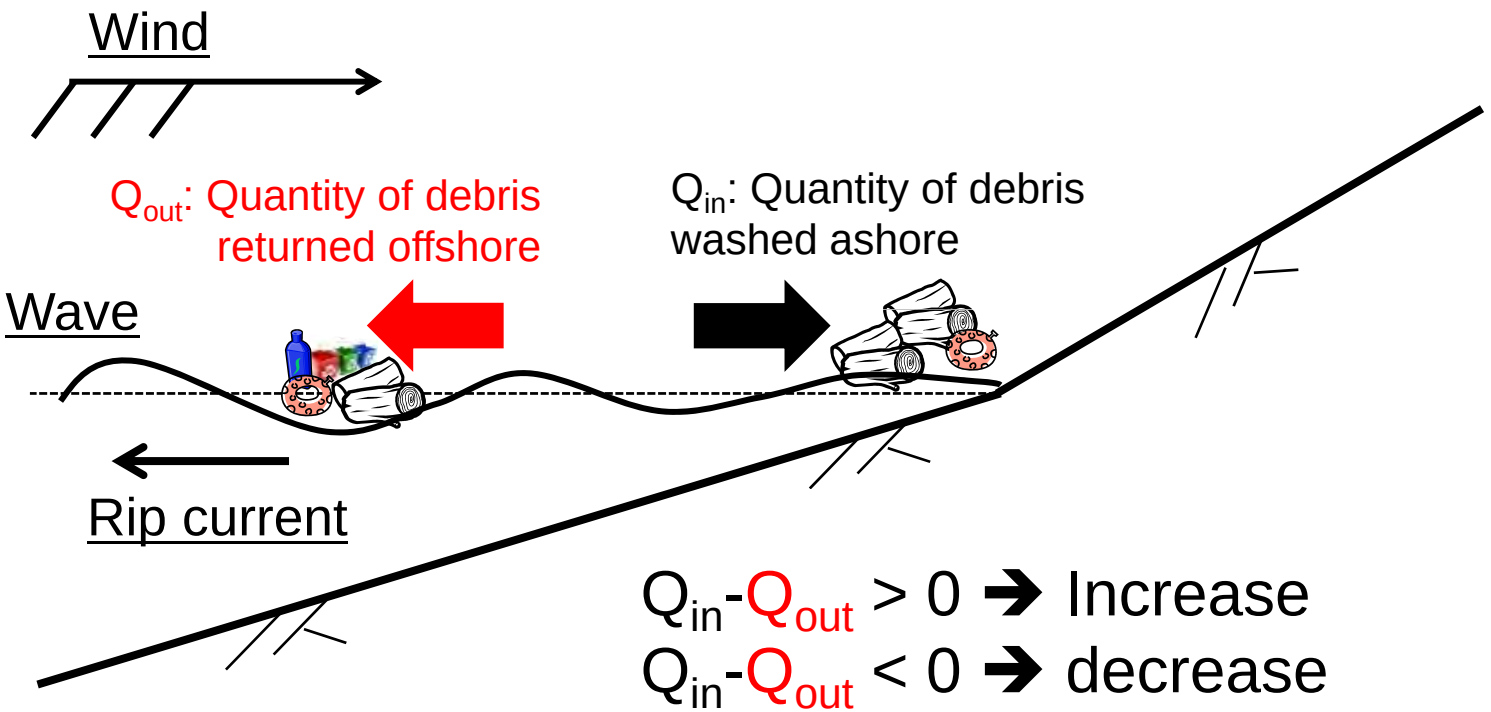

30-day moving average

Monthly max. wind speed

Monthly ave. wind speed
& Monthly standard deviation

# Mechanism of the variability

## One line model




$Q_{in}$-$Q_{out}$ > 0 ➔ Increase

$Q_{in}$-$Q_{out}$ < 0 ➔ decrease

$Q_{in}$-$Q_{out}$ = 0 ➔ not change

# Summary

As a first step to reveal the transportation process of plastic debris in East Asian seas, we computed the quantity of plastic debris using webcam images at four sites along the Tsushima Current and compared with wind data measured by Japan Meteorological Agency.

【Major conclusion】

- We have succeeded to sequentially monitor beached plastic debris quantity at multiple sites.
- plastic quantity not only vary by intensification of westerly wind but also by other factors.
  - At Wajima and Tsushima ➔ increase according to intensification westerly wind for Nov. 2010 – Mar. 2011
  - At Wakkanai and Tobishima ➔ Not vary despite intensification of westerly wind
  - At Tsushima ➔ Increase greatly despite no intensification of westerly wind

【Our future work】

- We'll investigate the mechanism of the variability of plastic quantity using a wind wave model and/or a near-shore current model.
- We'll compute the plastic quantity at other monitoring sites.
- We'll reveal the transportation process of plastic debris.

# Thank you for your attention

## Acknowledgement

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