

# Marine plastic litter as a transport "vector" of toxic metals - its behavior and numerical modeling -

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## Collaborators

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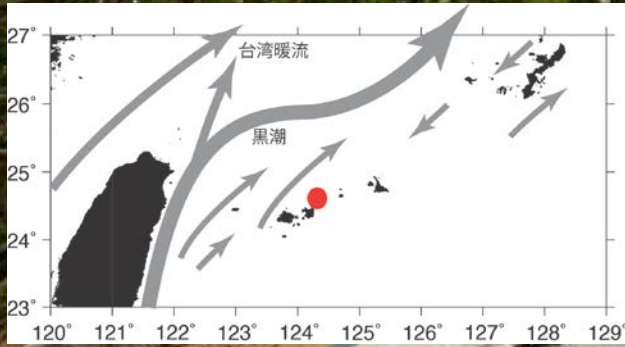
Hirofumi Hinata (Nat'l Inst. for Land & Infrastructure Management),

Satoquo Seino (Kyushu Univ.), JEAN, Shinya Magome (Sanyo Techno Marine Inc.)





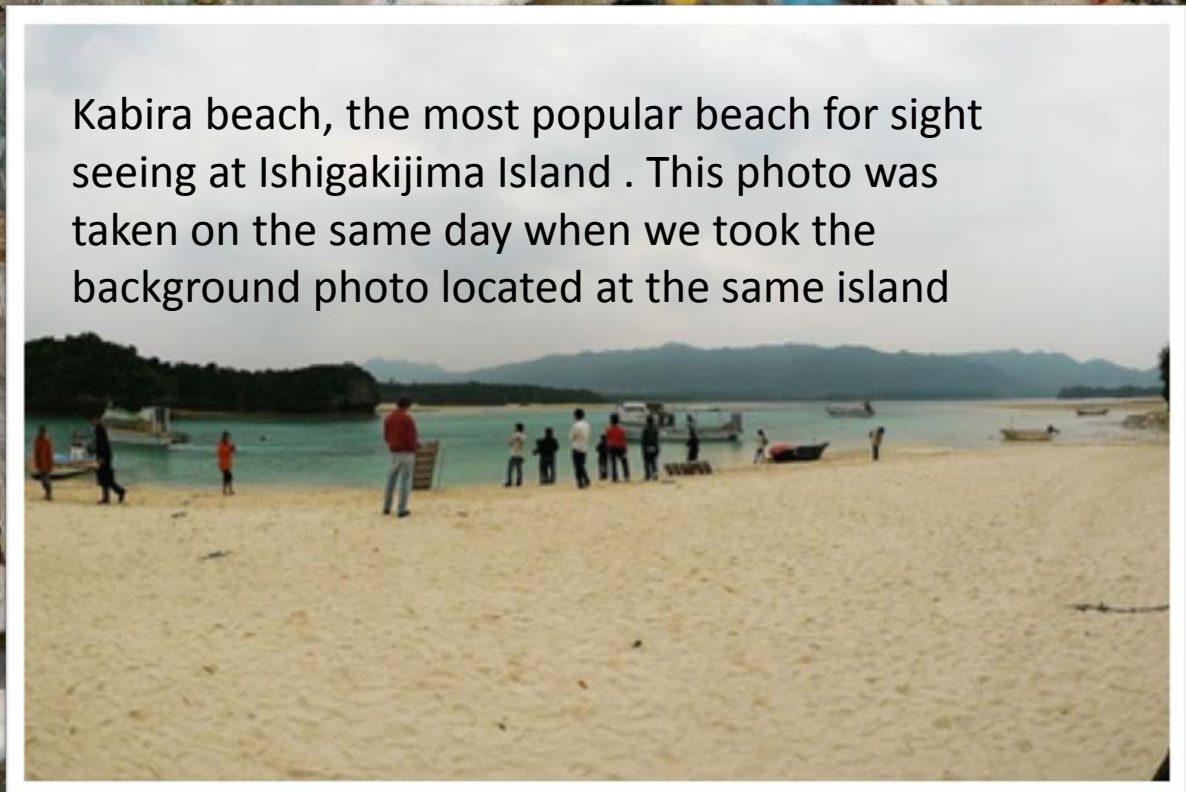
photo at Kitano beach, Ishigakijima Is.  
(March, 2011)





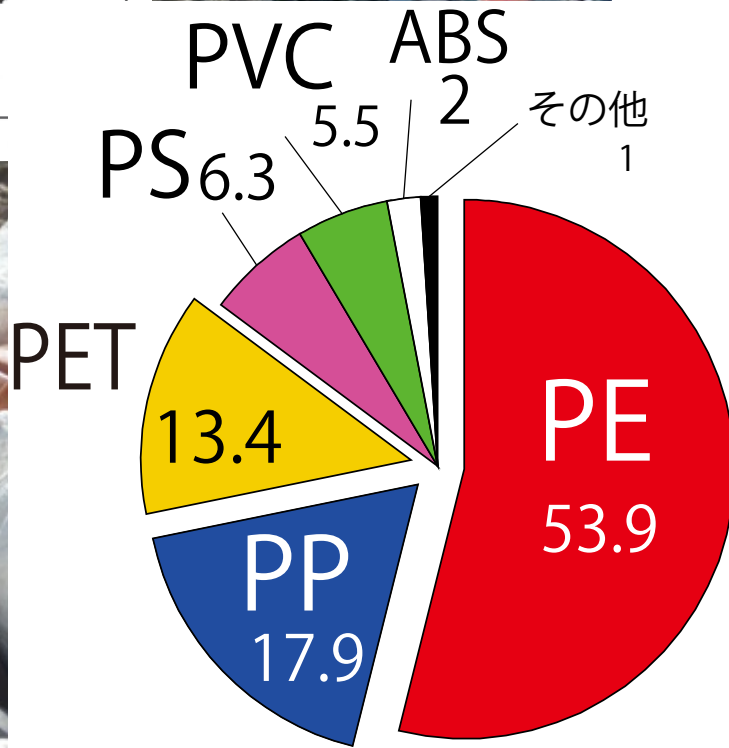
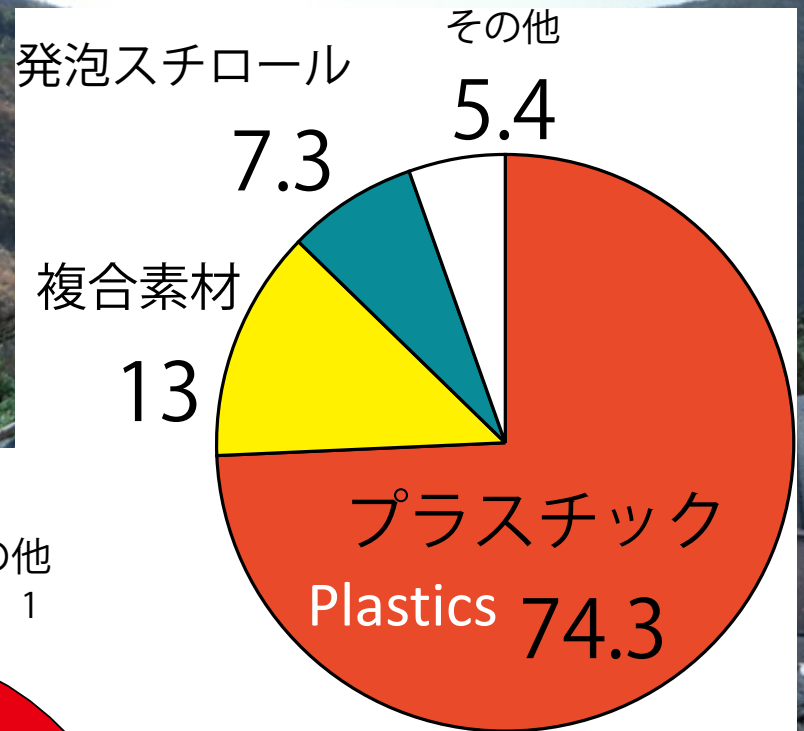
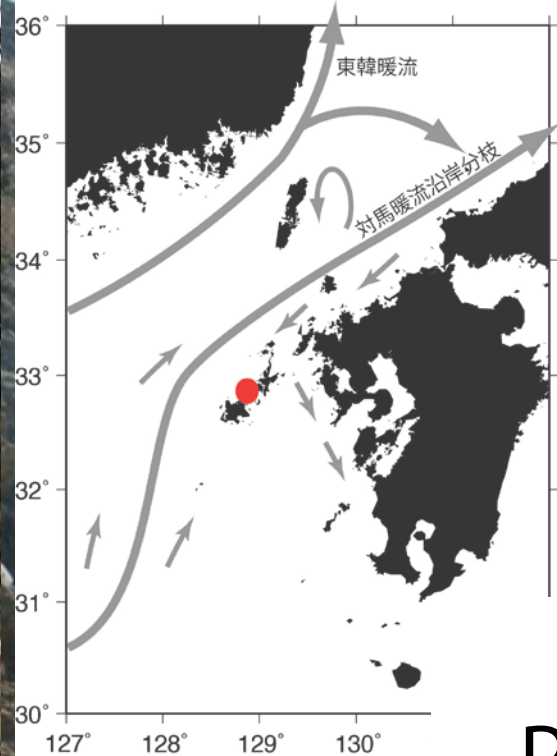
# “Polarization” of beaches

litter-free beaches which are always cleaned up for business purpose (sight seeing, bathing..), and litter-covered beaches unsuitable for business.

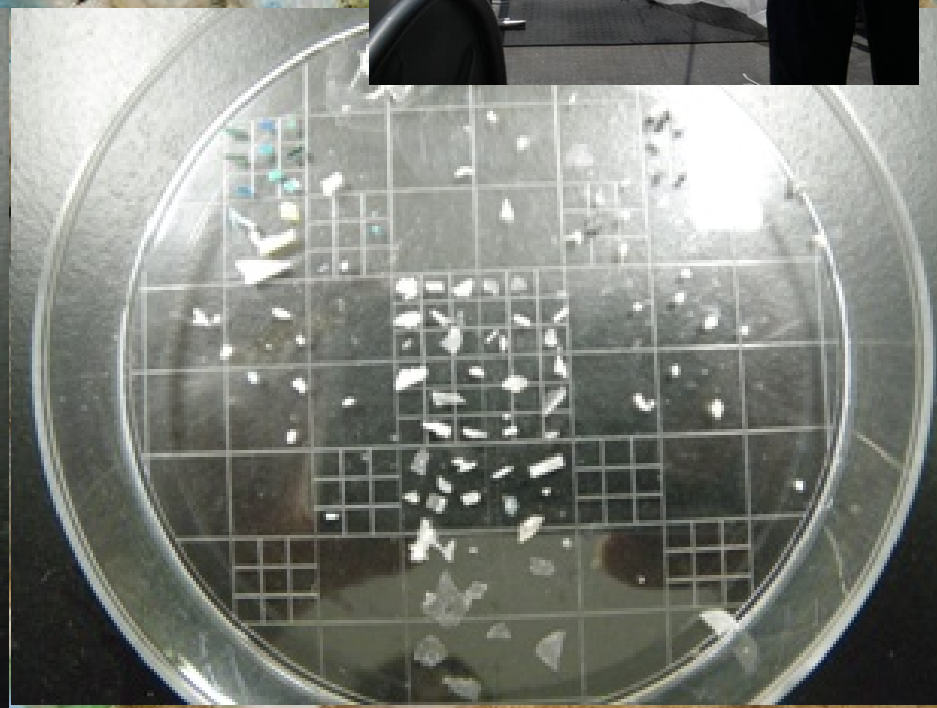




Naru Island, Goto Island chain(October, 2010)



Plastic fragments  
(microplastics)





# Balloon aerial photography for measuring quantity of beach litter washed ashore on beaches

ballooning on the beach



The Balloon hanging a digital camera was towed by hand just like a kite.



The camera angle is controlled on the ground





# Balloon aerial photography for measuring quantity of beach litter washed ashore on beaches

The area covered by beach litter is quantified by photo taken by balloon- equipped camera.

Weight of litter per unit area is measured directly by in-situ measurement

Multiplying these two values yields total weight of beach litter over the beach (Below is an example computed on Ookushi beach in October 2009.

123.5 m<sup>2</sup>

×

5.8±2.0 kg/m<sup>2</sup>

= **716** ±259 kg

(Plastics account for 74% of the above weight,

i.e., **530** ±201 kg,





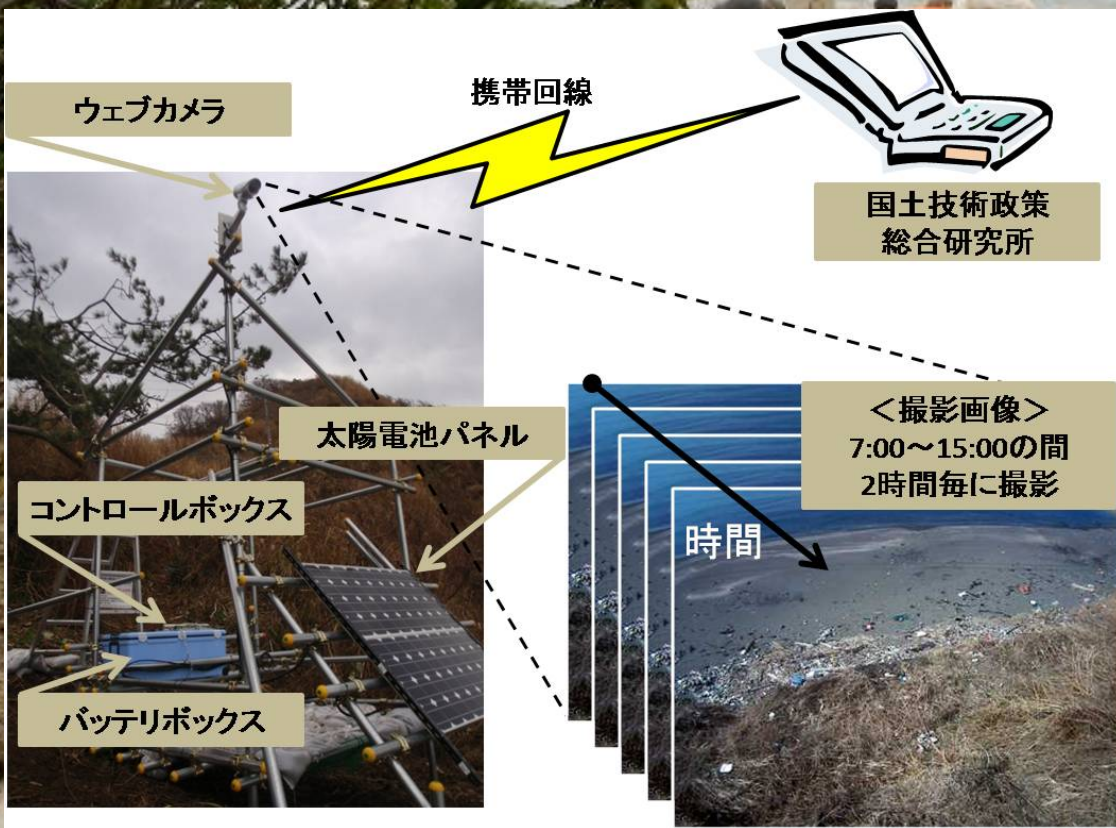
# Measuring beach litter using webcams

Please watch the movies  
in the Japanese version





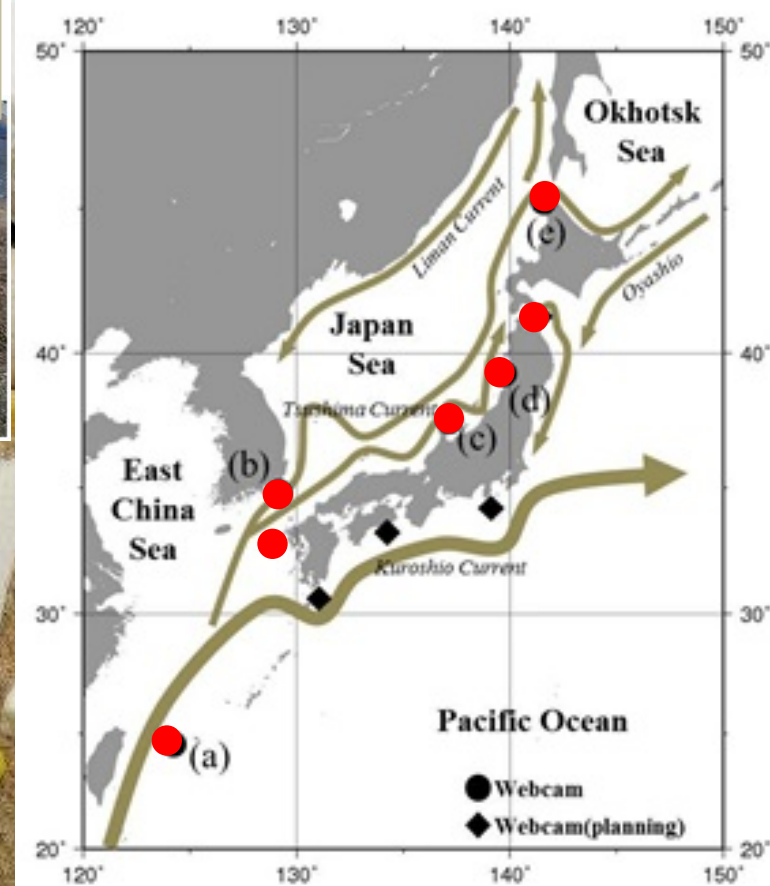
# Measuring beach litter using webcams



Kako et al, (2010, MPB)

Google

海ゴミウェブカメラ  
約 1090,000 件 (0.11 秒)



We have already set webcams on 10 beaches along the East China Sea and Japan Sea coasts. These images are opened to the public on our website



# Measuring beach litter using webcams

Photo taken at Tobishima, Yamagata at 1310 JST,  
18<sup>th</sup> November, 2011





# Measuring beach litter using webcams

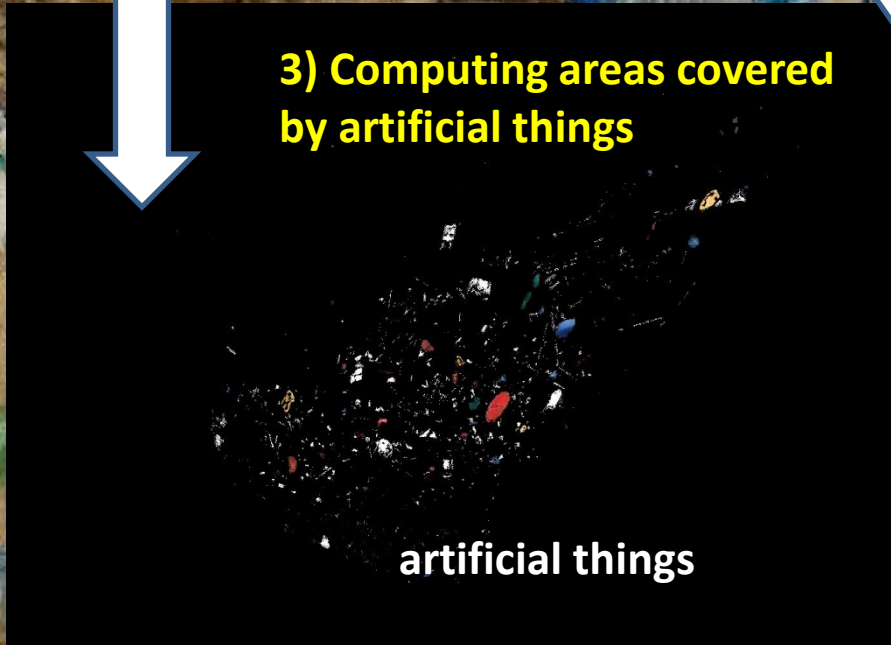
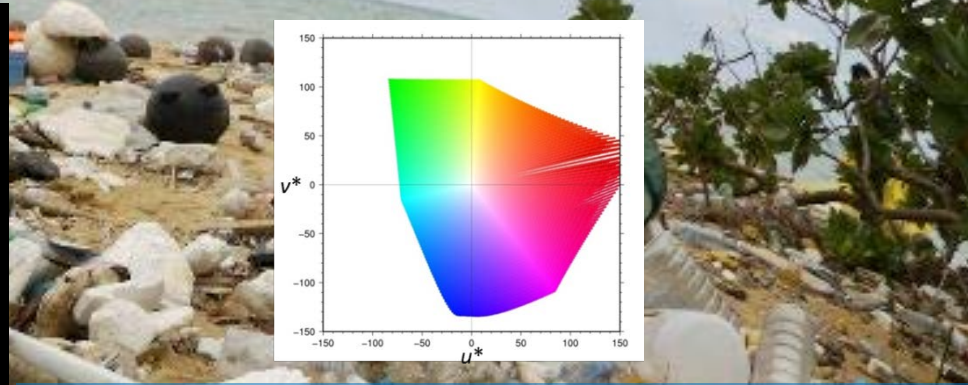
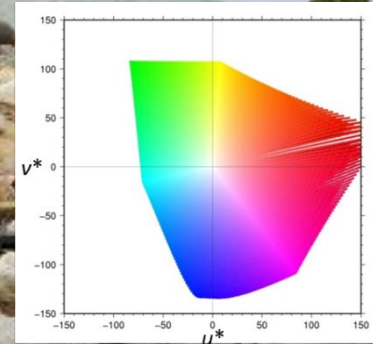
1) To compute areas precisely, RGB images are converted into photos to which our sight line is perpendicular.

2) Artificial things (say, plastics) in the RGB images are automatically separated from natural things (driftwoods, background beaches) by an image processing technique.

3) Computing areas covered by artificial things

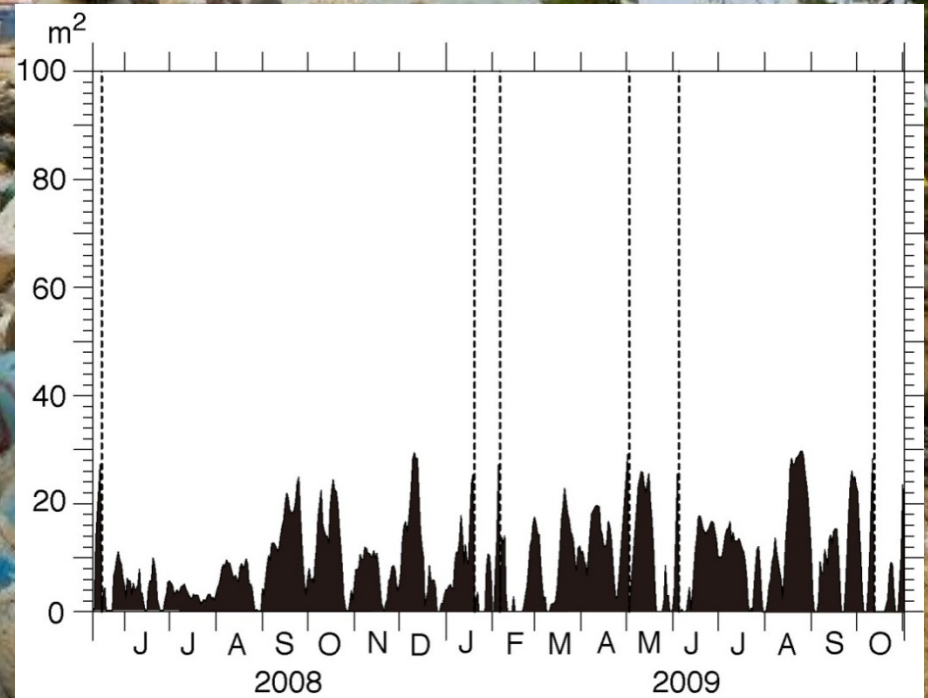
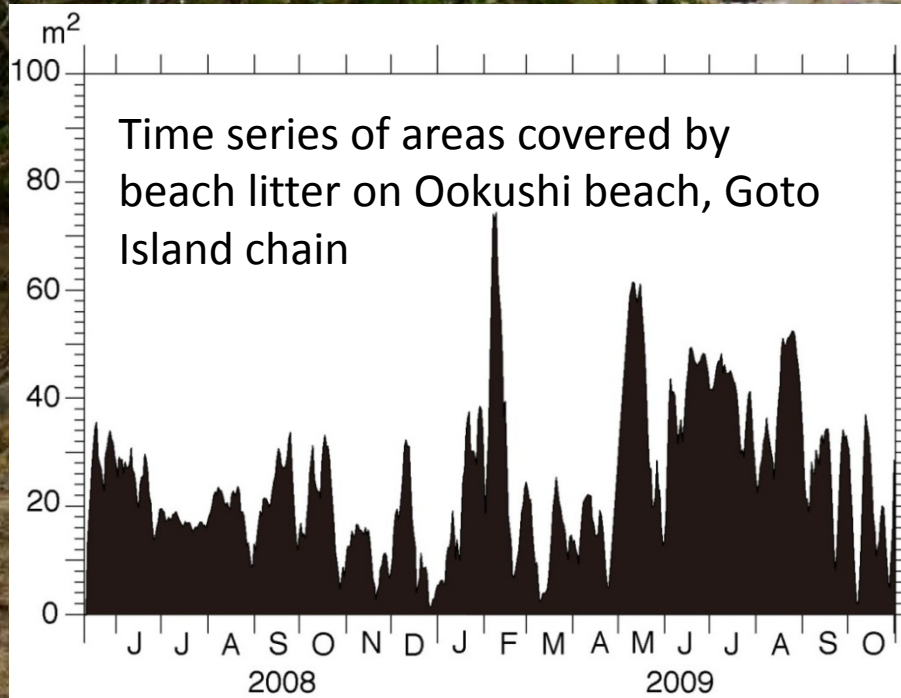
artificial things

natural things





# Simulating beach litter reduced by appropriate beach clearances



$$f(t_0 + \Delta t) = f(t_0) + \int_{t_0}^{t_0 + \Delta t} \left(\frac{df}{dt}\right) dt$$

Time derivatives of areas observed by webcams are used as they are.

Beach clearances are represented by substituting 0 here. We now assume that beach clearance is conducted when the area reaches 30 m².

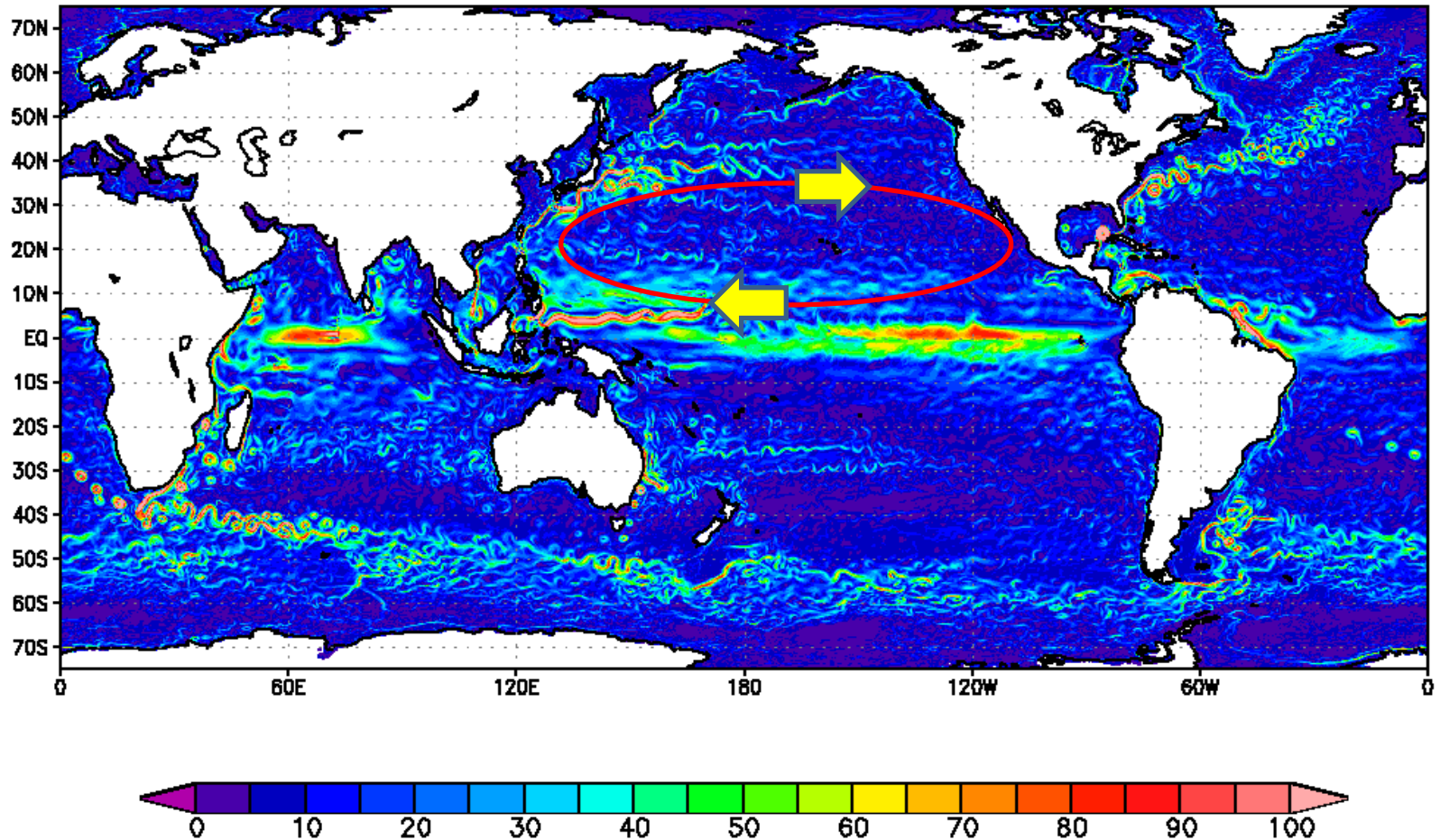
**We can reduce the amount of beach litter by 40% after an appropriate interval between beach clearances**



# Speed of ocean currents computed on the Earth Simulator

The subtropical gyre is a huge eddy composed of Kuroshio, North Pacific Current, California Current, North Equatorial Current, and returns to the Kuroshio.

Monthly Mean of Surface Current Velocity [cm/sec] (JAN/50YR)





Finding the origin(s) of beach litter by a particle tracking experiments using simulated ocean currents reversed in sign

Please watch the movies in the Japanese version

left) Ocean currents simulated on the computer

lower right) Modeled particles returning back to their origins in the ocean currents field reversed in sign

In strict terms, the above procedures are called “two-way particles tracking method” and “inverse problem using a Lagrangian multiplier”

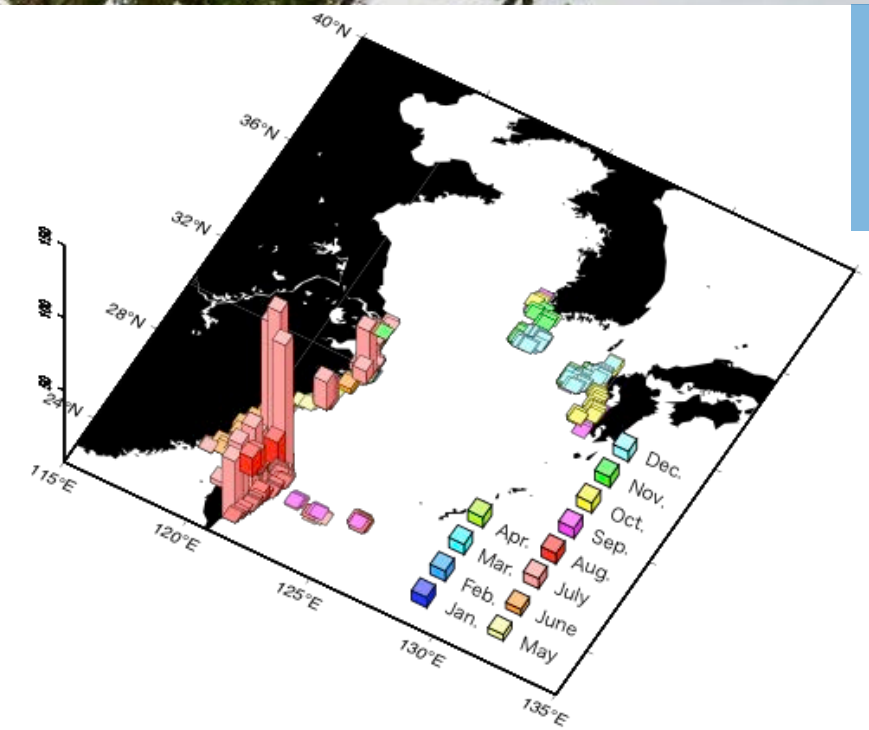
Isobe et al., (2009, J. Atmos. Ocean. Tech., American Meteorological Society)  
Kako et al. (2010, J. Oceanography)

Please watch the movies in the Japanese version



← Litter origins, release months, and release quantities deduced as an inverse problem

Numerical modeling of motion of litter released from origins deduced above. ↓



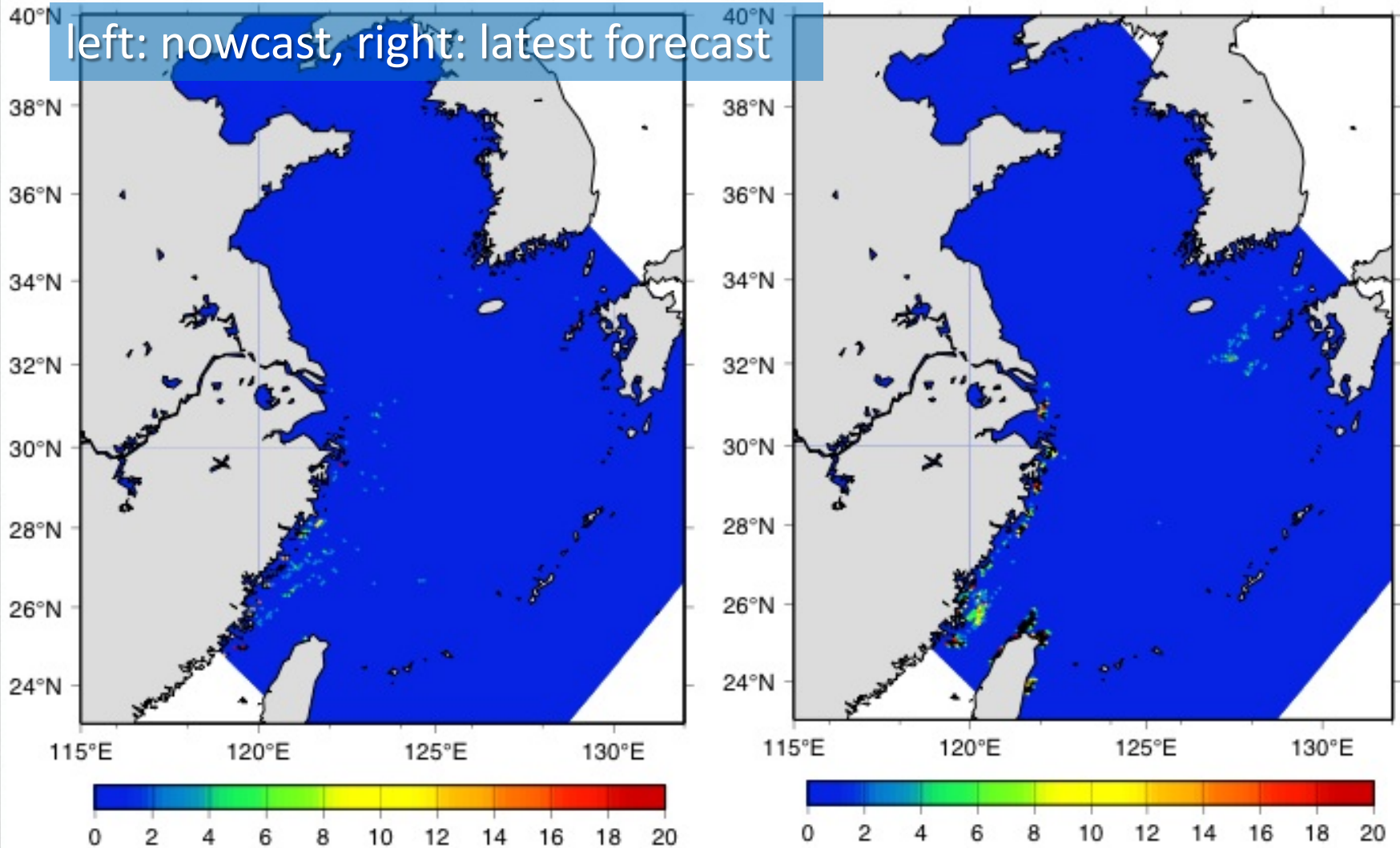
Please watch the movies  
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We are able to hindcast/forecast of beach litter using numerical models with satellite-observed and forecasted wind data up to one month after

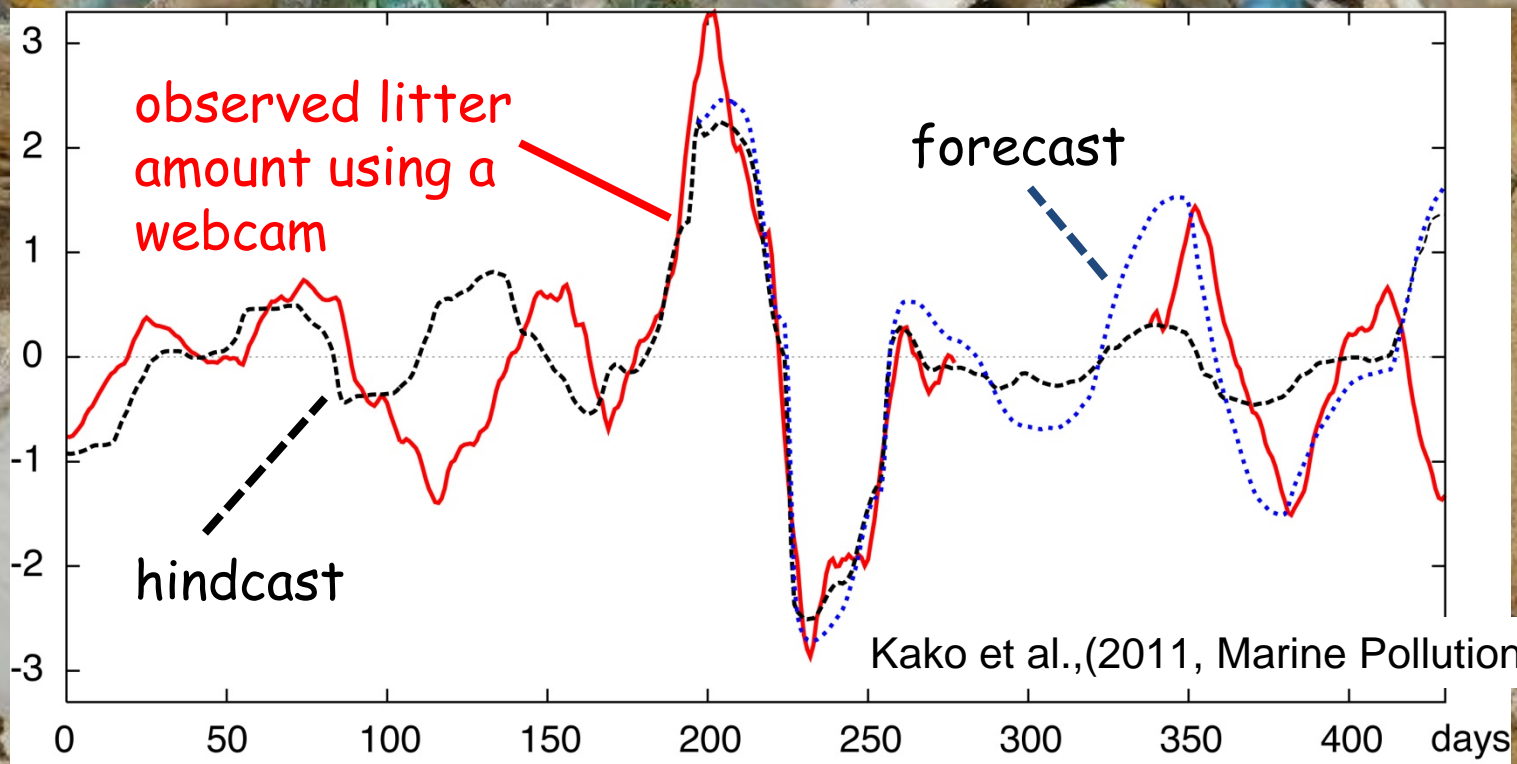
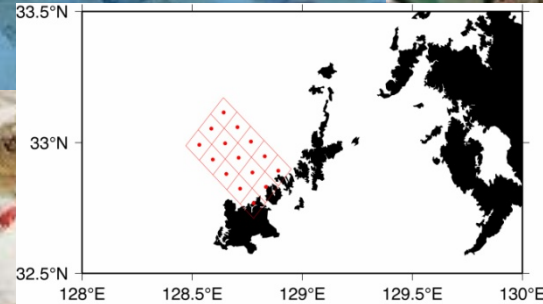
(a)5月02日の漂流ゴミ分布図  
(Ascat を用いた現況図)

(b)6月10日の漂流ゴミ分布図  
(気象庁の予報風 を用いた予報図)





Accuracy of the hindcast/forecast is  
“acceptable level” except for the period  
during typhoons





**“Polarization” of beaches**  
litter-free beaches which are always cleaned up for business  
purpose (sight seeing, bathing..) and litter-covered beaches  
unsuitable for business.



Kabira beach, the most popular beach for sight  
seeing at Ishigakijima Island . This photo was  
taken on the same day when we took the  
background photo located at the same island.





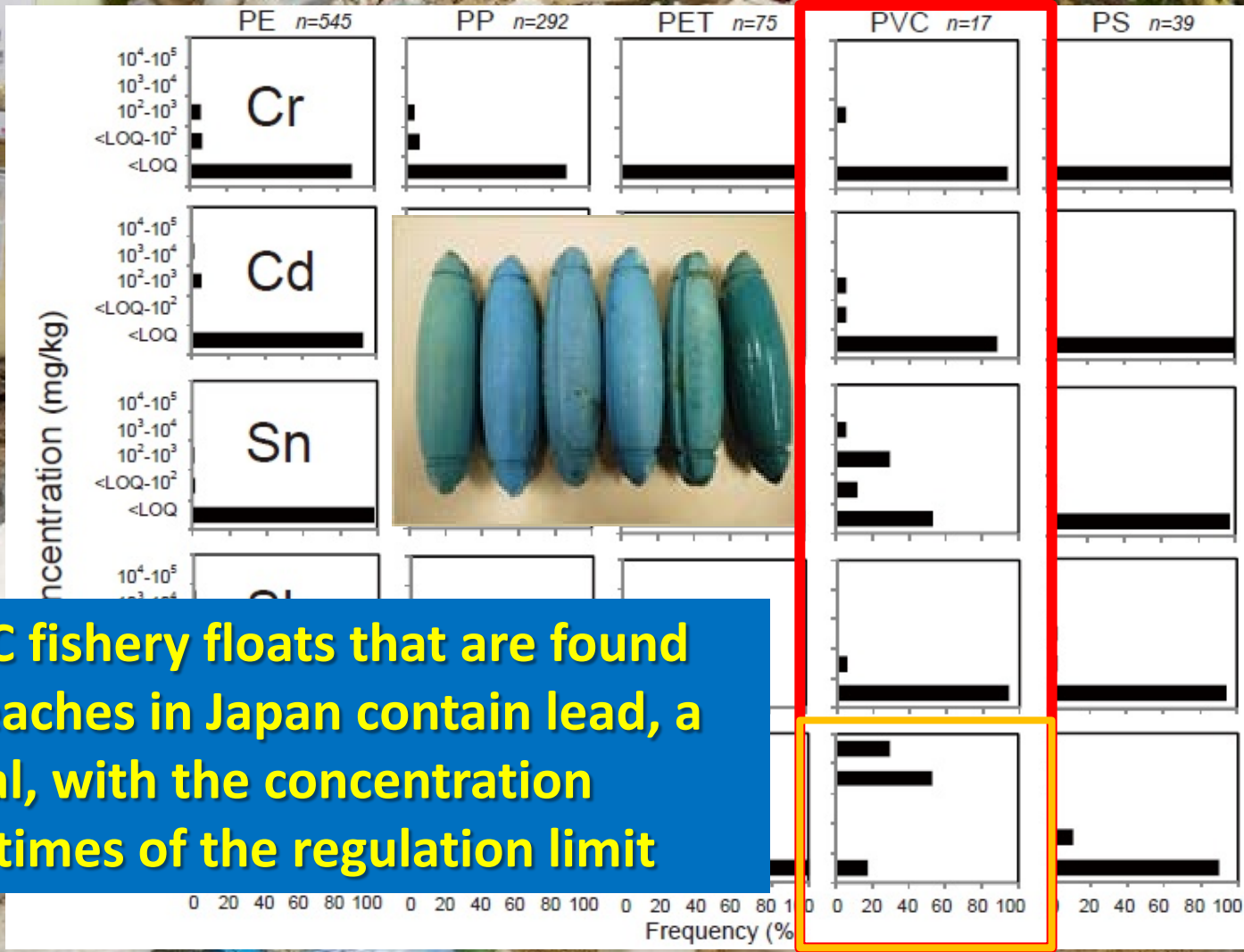
PVC floats used for fishery  
(probably from China)





# Do plastics play a role of a "transport vector"?

We measure toxic metals included in plastic litter using a XRF analyzer.



For instance, PVC fishery floats that are found frequently on beaches in Japan contain lead, a toxic heavy metal, with the concentration higher than 100 times of the regulation limit



Do plastics play a role of a "transport vector"?





# Does lead contained in PVC floats leach into beach? (please visit Nakashima-san's poser with respect to leaching experiments)

15 samples collected on various beaches in Japan



a single float in a bottle

Elix Water  
820 ml

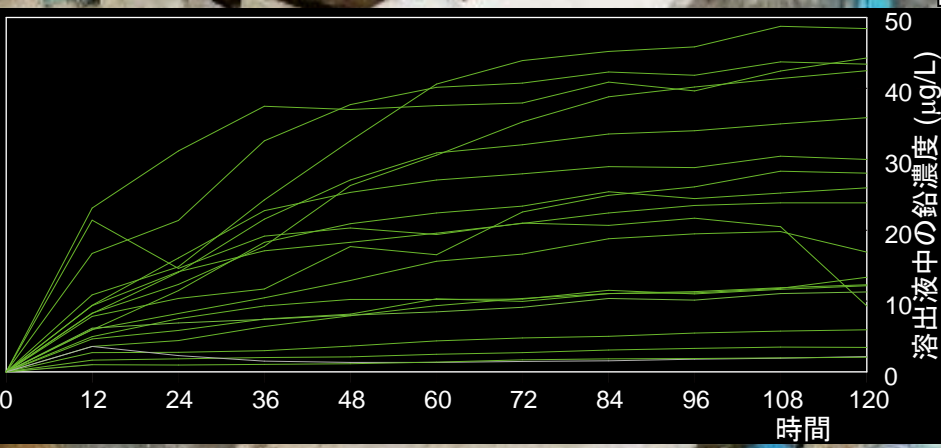
Please watch the movies in the Japanese version

We assume leaching process due to rain water on beaches

23.5-26.6C  
oscillating the bottle during 120 hours

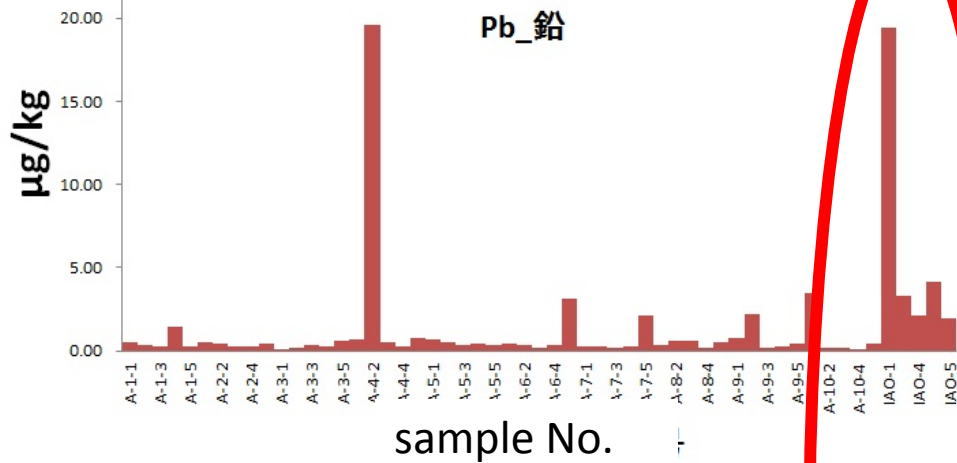
collecting sample water of 10 ml every 12 hours

quantifying leaching lead using ICP-MS



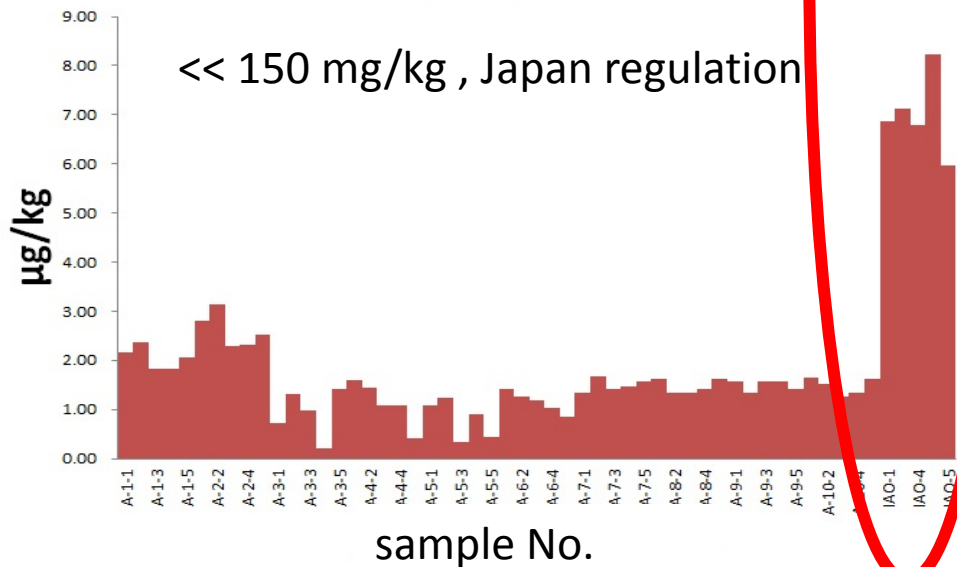


<< 150 mg/kg , Japan regulation

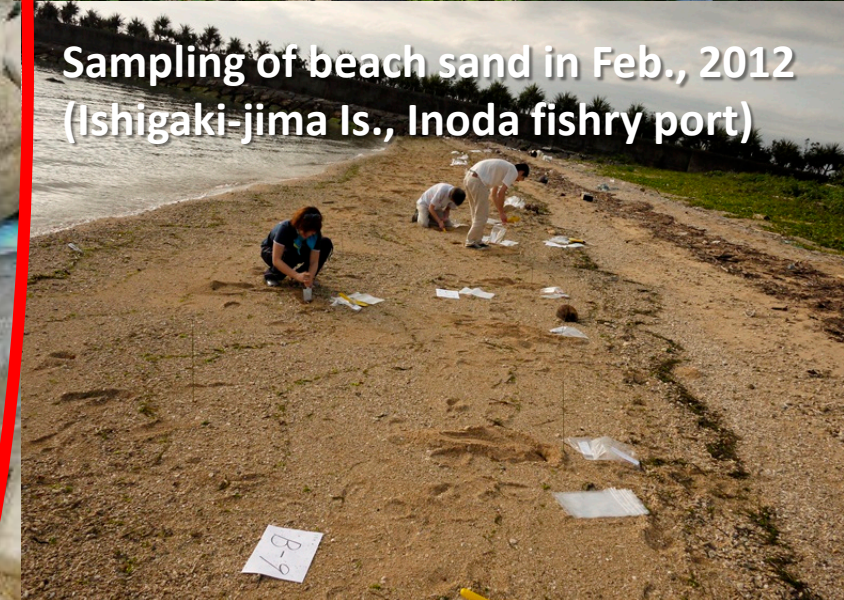


cd\_カドミウム


<< 150 mg/kg , Japan regulation



Sampling of beach sand in Feb., 2012  
(Ishigaki-jima Is., Inoda fishry port)







Plastic litter certainly plays a role of a "transport vector" of toxic metals. Hence, we have to clean-up beaches not only for keeping its value of sight seeing, but also for reducing their environmental risk. According to our estimate, it should be however noted that leaching flux of toxic metals is not serious at the present time (~600 mg/year of lead leaches over the entire Ookushi beach). Rather, it should be recognized as a "future risk" that will be realized if we ignore plastic litter on beaches.

Please watch the movies  
in the Japanese version



Ocean currents carrying plastic litter is a part of a huge eddy, and so we can define neither "upstream" nor "downstream" of these currents. This means that receptors of beach litter simultaneously become origins of litter. Thereby, plastic wastes should be reduced simultaneously around countries surrounding the huge eddy.

Monthly Mean of Surface Current Velocity [cm/sec] (JAN/50YR)

