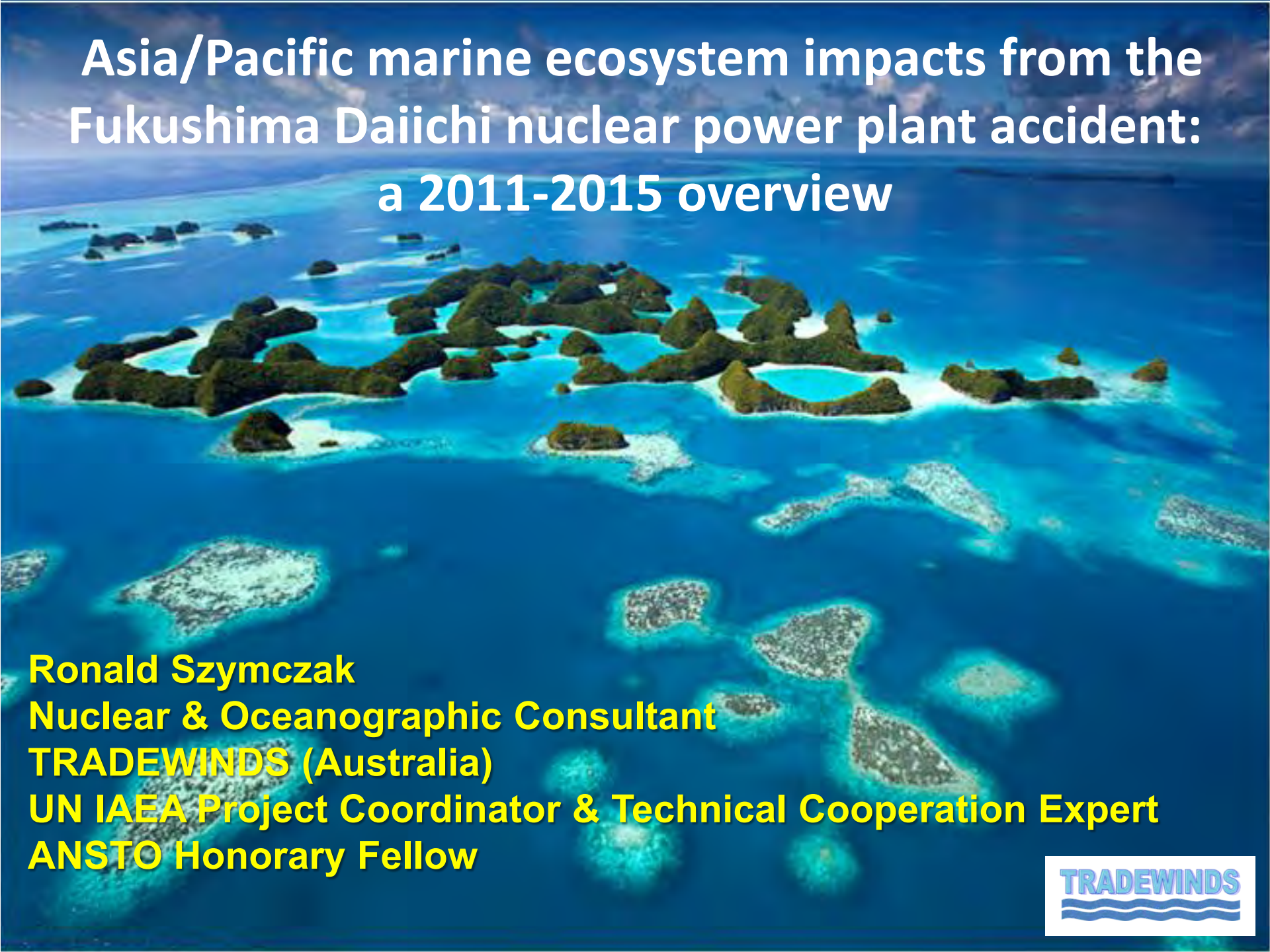
Asia/Pacific marine ecosystem impacts from the Fukushima Daiichi nuclear power plant accident: a 2011-2015 overview



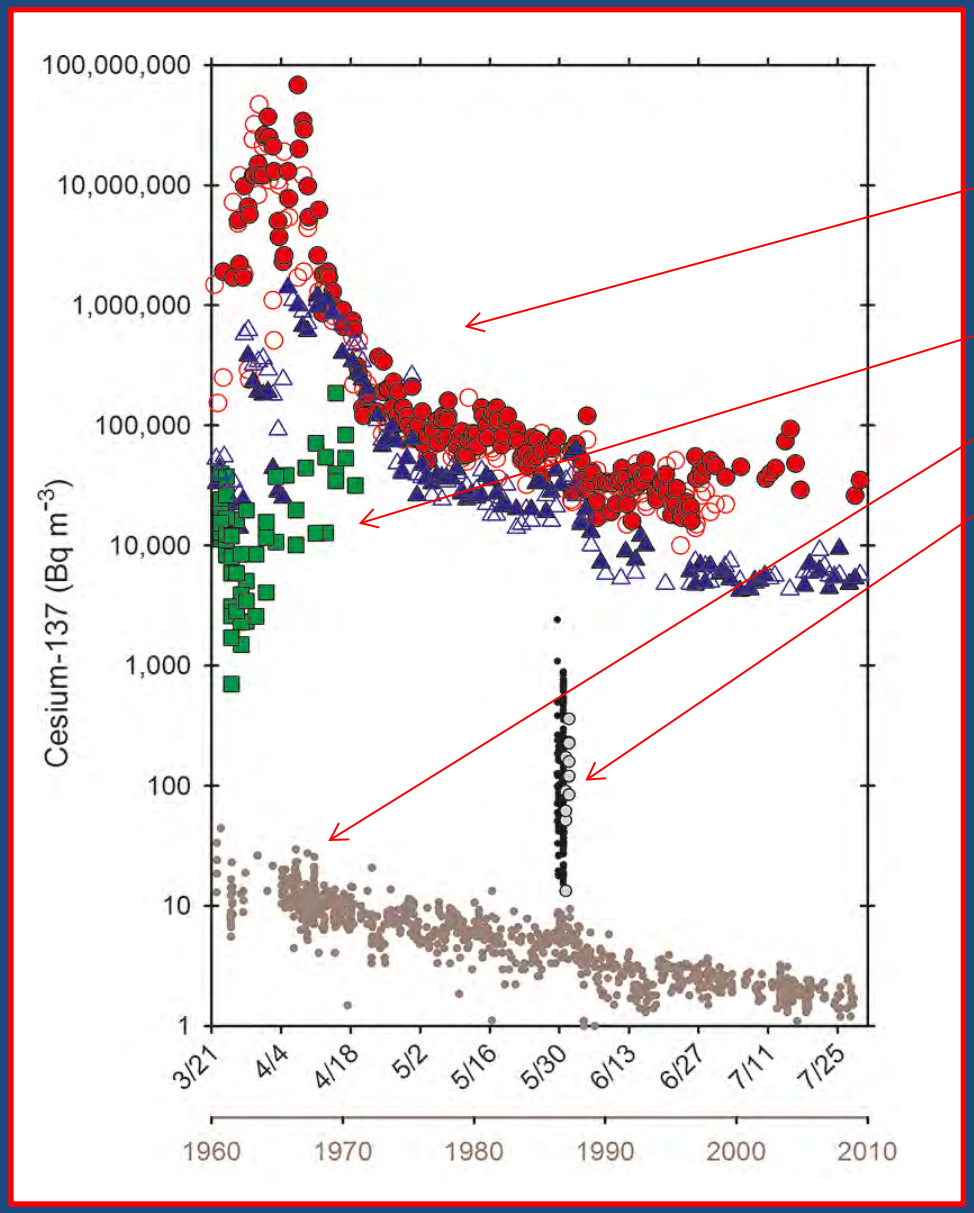
Ronald Szymczak
Nuclear & Oceanographic Consultant
TRADEWINDS (Australia)
UN IAEA Project Coordinator & Technical Cooperation Expert
ANSTO Honorary Fellow

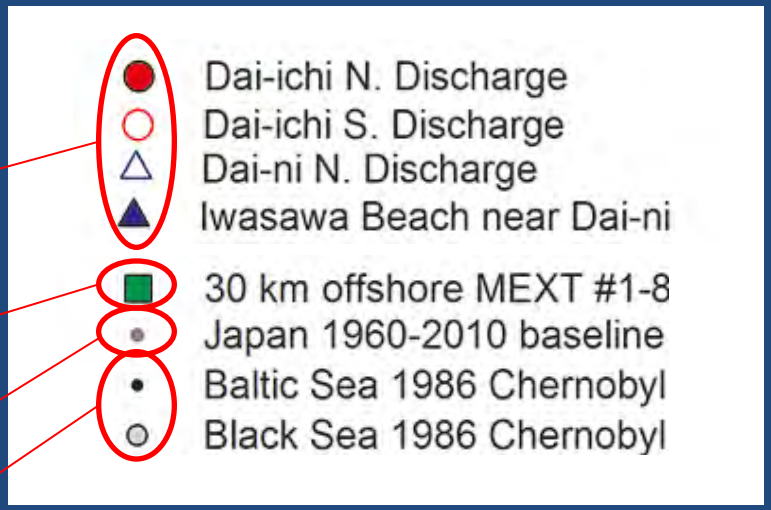
TRADEWINDS

Acknowledgements - models, databases & sources

- **Radiological Impact Assessment for Coastal Aquatic Ecosystems v1.15 Westlakes Scientific Consulting ERC, Liverpool University - UK**
- **AQUARISK v3.2 - A computer code for aquatic ecological risk assessment Australian Nuclear Science & Technology Organisation (ANSTO)**
- **ERICA-Tool Radiological ERA**
- **FREDERICA Radiation Effects database**
- **IAEA/RCA ASPAMARD database**
- **MEXT & TEPCO – Japan**
- **Dr Ken Buesseler (WHOI) – USA**
- **Dr Scott Fowler - France (ex-IAEA Monaco) & Dr Jan Pentreath - UK (ICRP)**

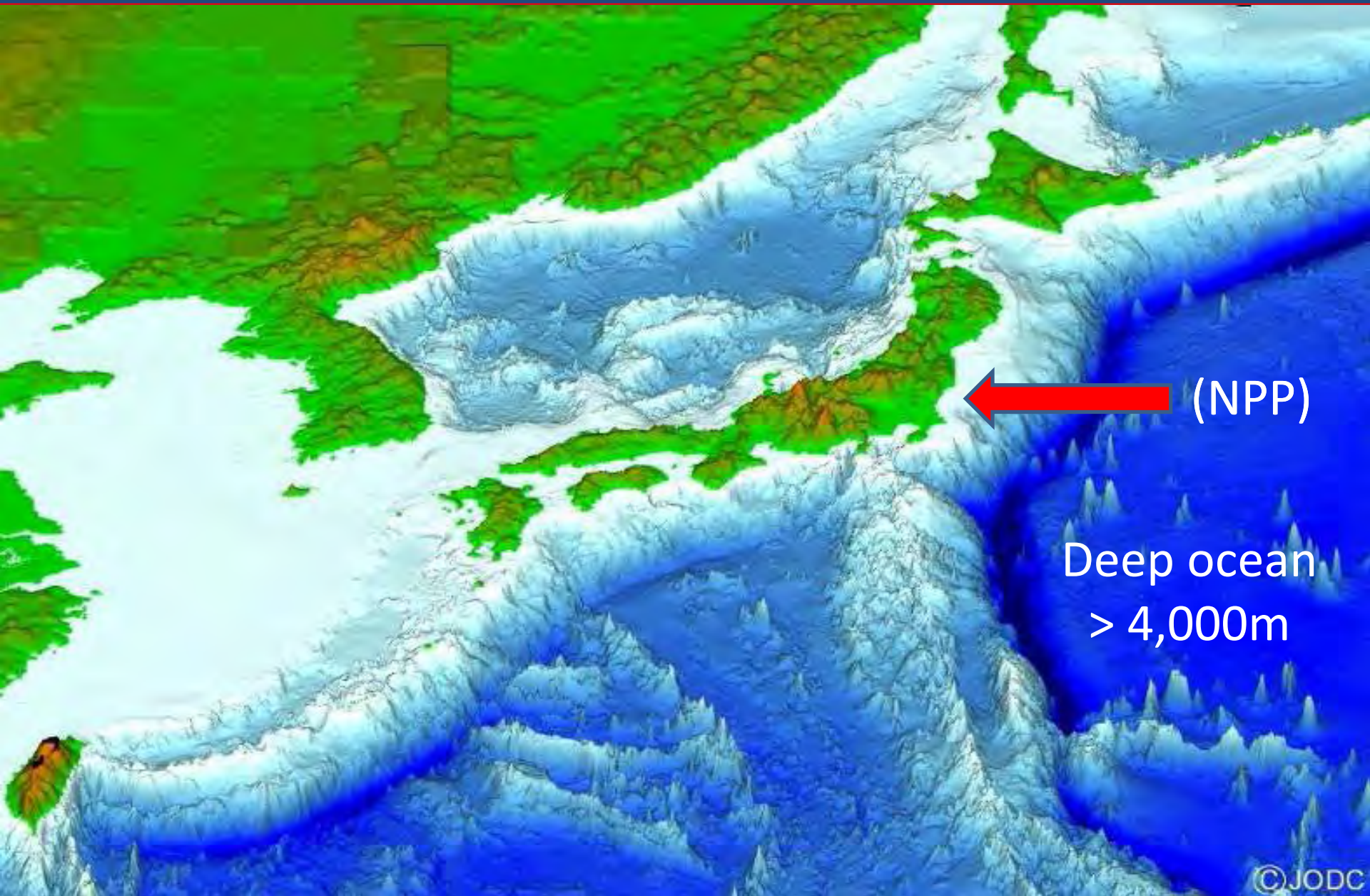
137-Cs in Fukushima, etc seawater (Buesseler et al., 2011)



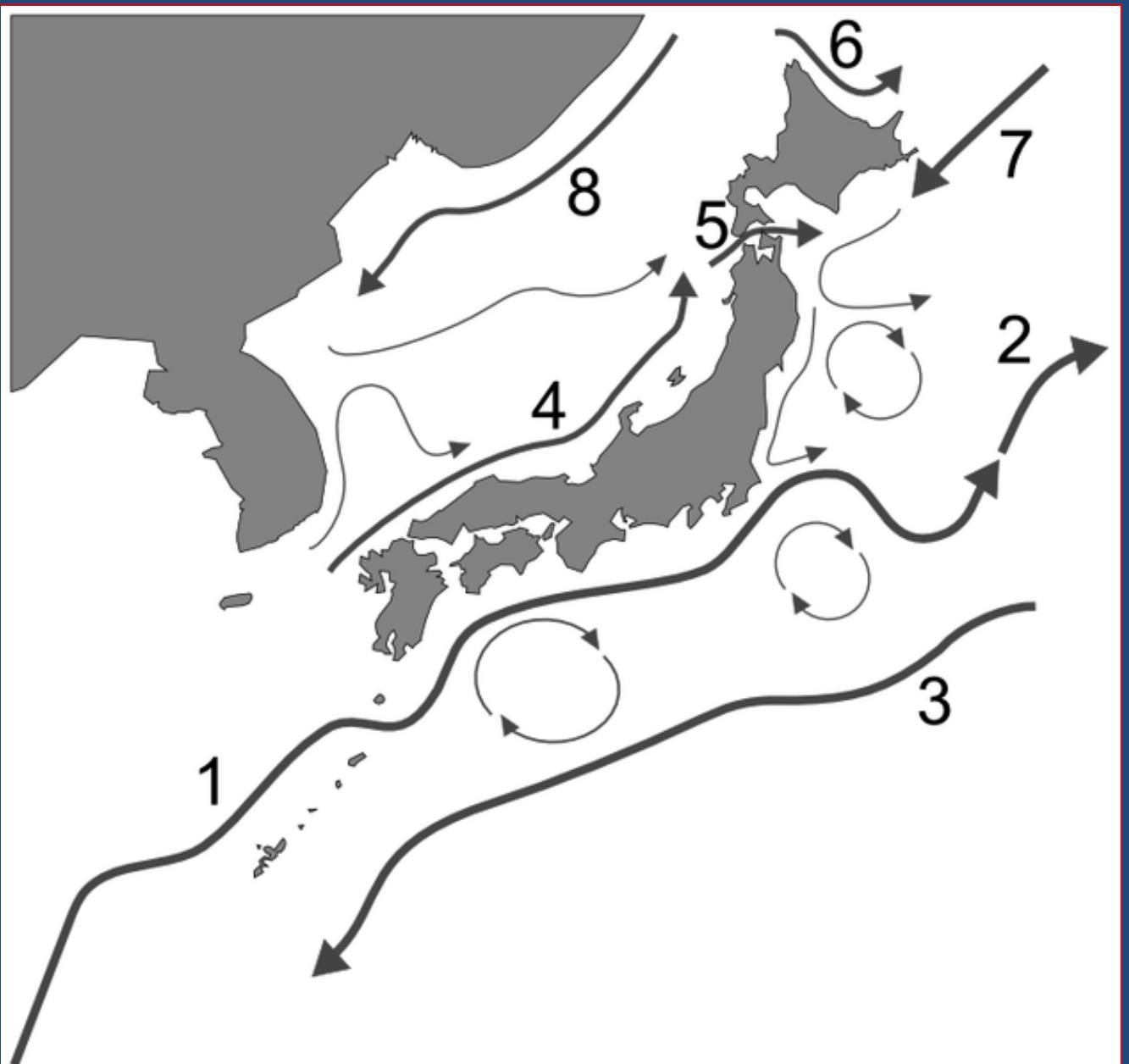


Surface ocean concentrations from March 21 to July 31, 2011 of 137Cs (Bq m^{-3}) for two sites near the Fukushima Dai-ichi nuclear power plant (red circles, north [filled] and south [open] discharge channels, Dai-ni NPPs (10 km to the south of Dai-ichi, blue filled triangles), Iwasawa Beach near Dai-ni (16 km south of Dai-ichi, blue open triangles), and 30km off-shore (green squares), stations 1-8 in original MEXT data.

Seafloor bathymetry nearby Fukushima Japan

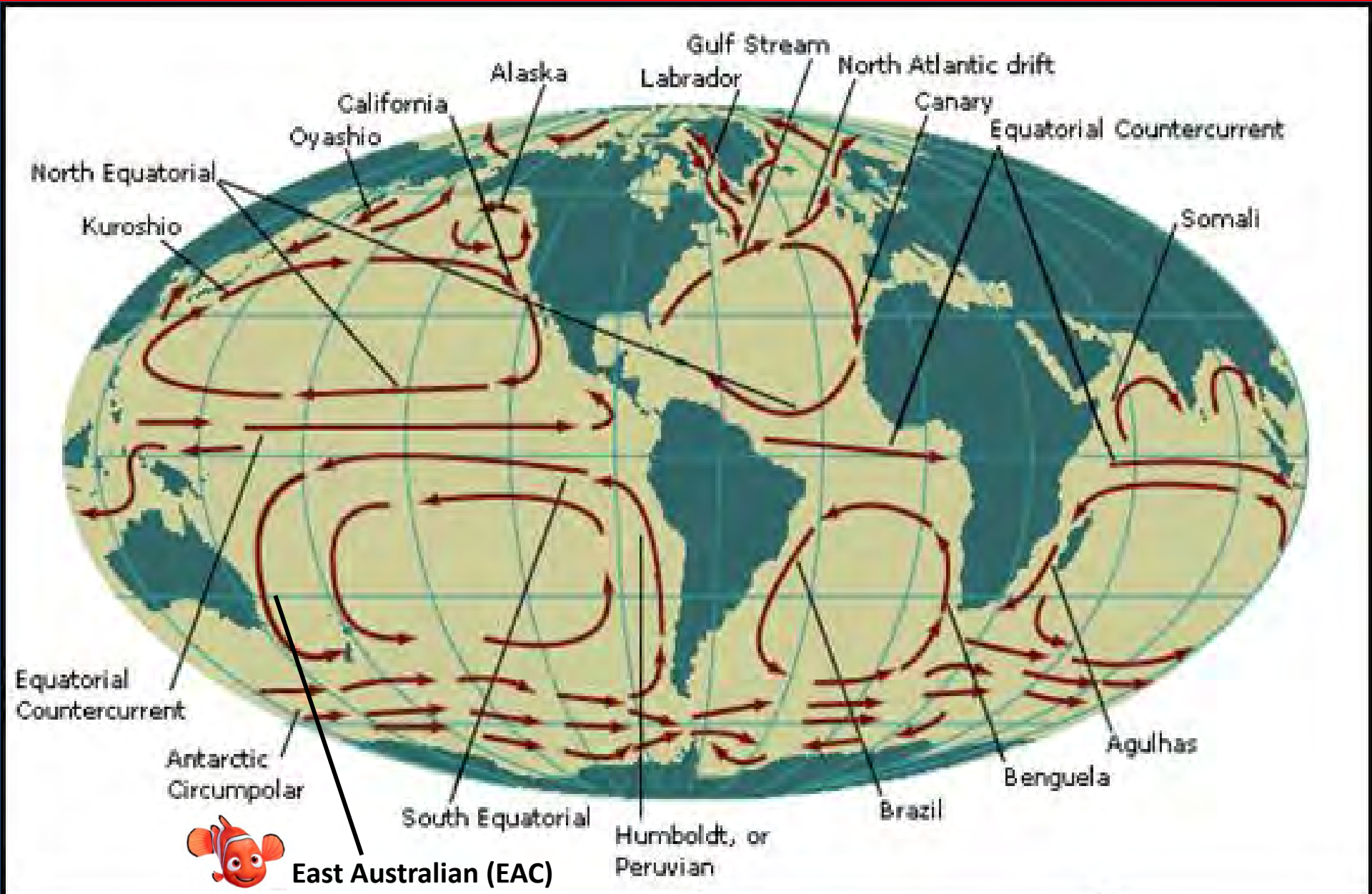


The complex coastal & ocean currents around Japan



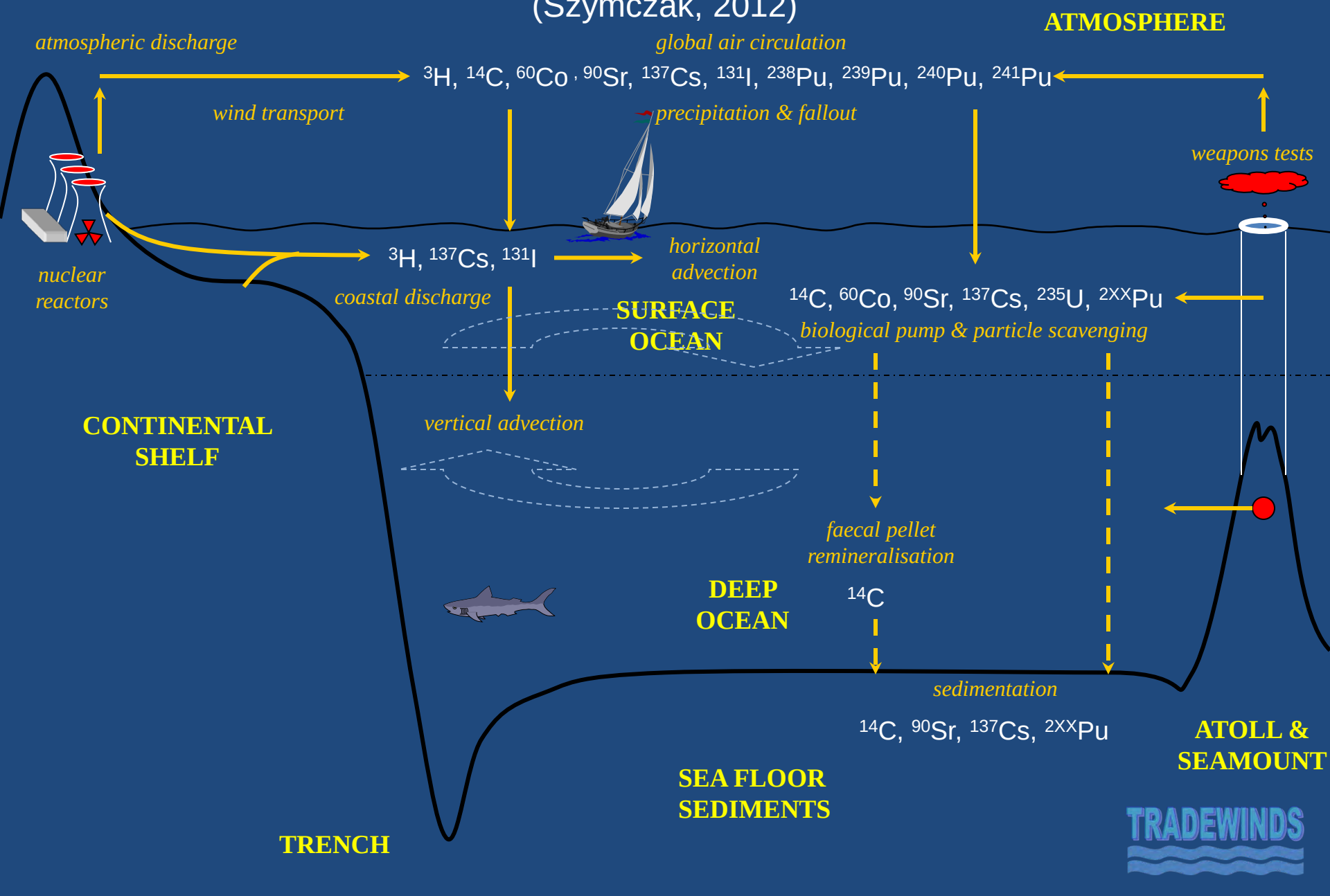
1. Kuroshio
2. Kuroshio extension
3. Kuroshio counter current
4. Tsushima Current
5. Tsugaru Current
6. Sōya Current
7. Oyashio Current
8. Liman Current

Major Global Ocean Surface Currents (GOE, 2002)



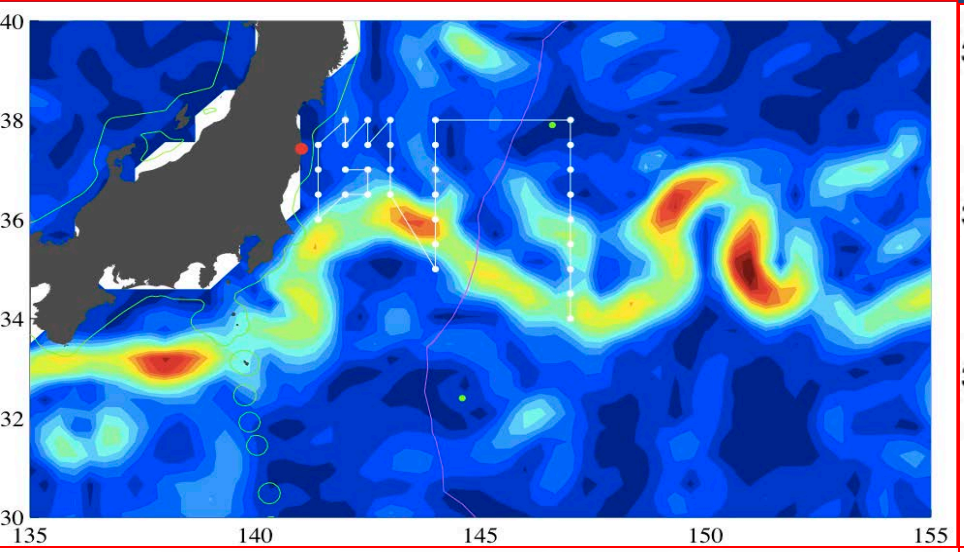
Ocean cycling of artificial radionuclides

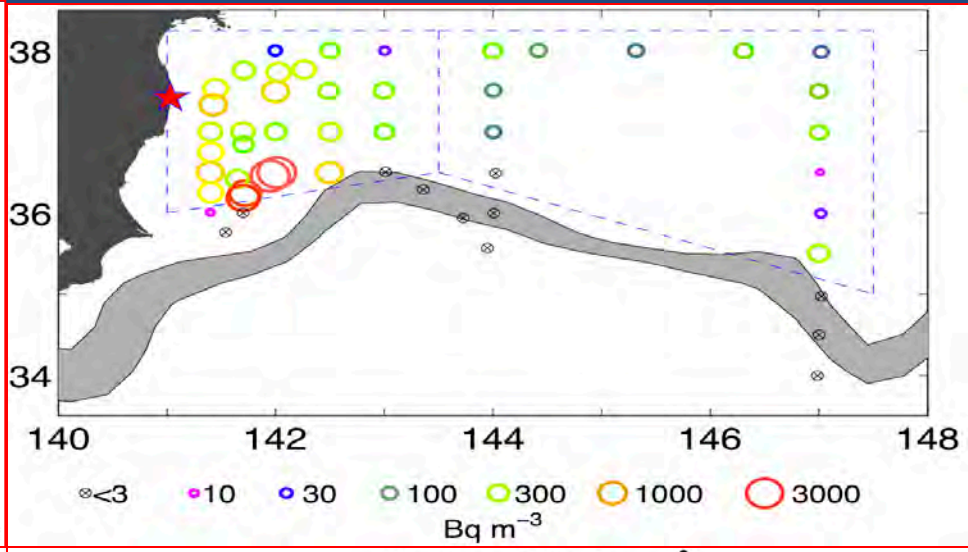
(Szymczak, 2012)

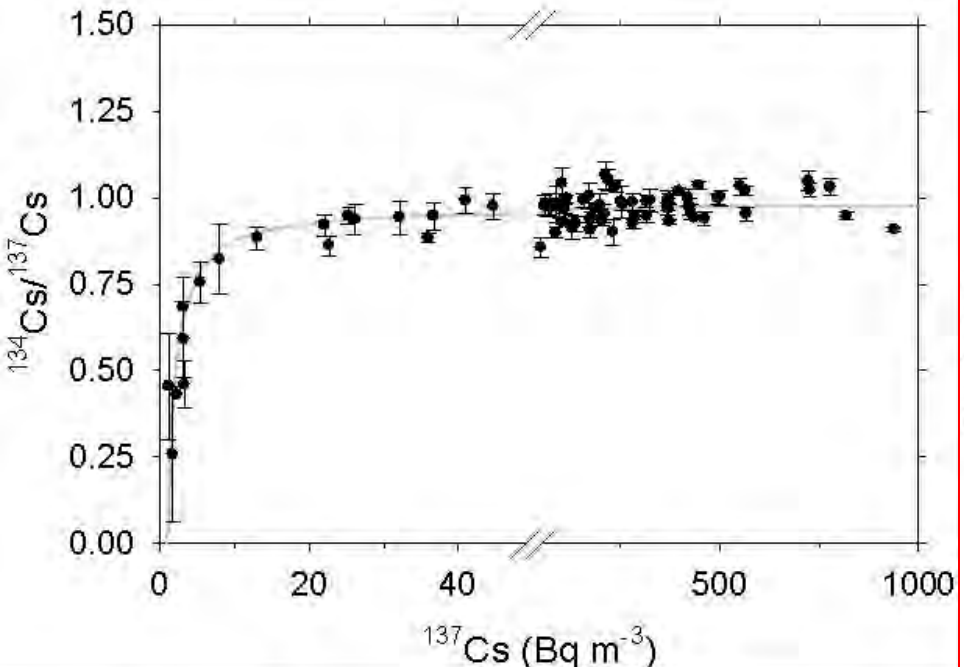


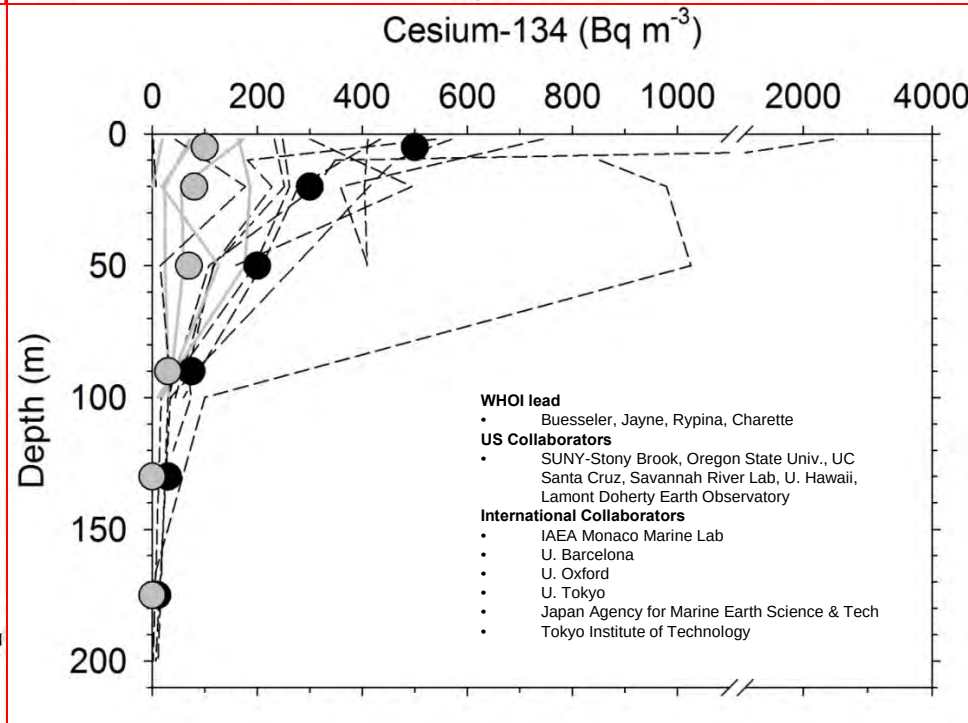
TRADEWINDS

RV Kok Cruise June 2011 (Buesseler et al., 2011)



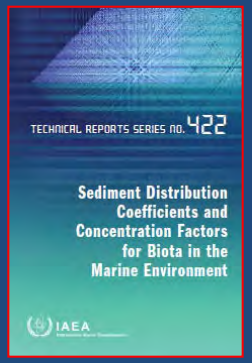


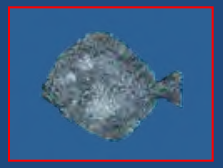




IAEA transfer factors (TF) for ICRP+ reference organisms (RAPs)

(+International Commission on Radiological Protection, 2009)

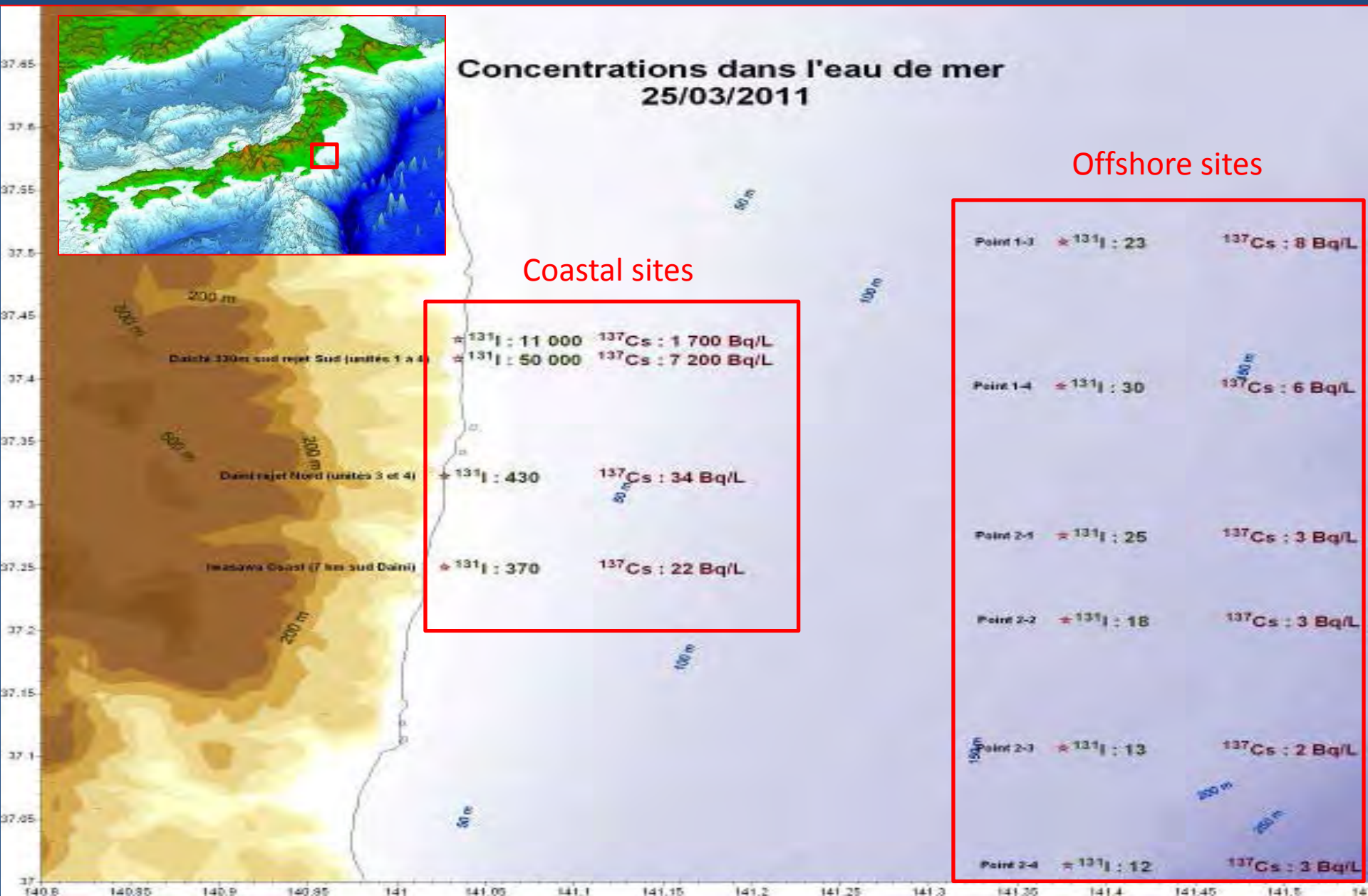


	(Sarai talay) Macro algae	(Poo) Crab	(Plaa da deao) Flatfish
			
137-cesium	50	50	100
131-iodine	10,000	3	9

* half life ($t_{1/2}$) of 131-I 8.04 days
137-Cs 30.17 years
134-Cs 2.06 years

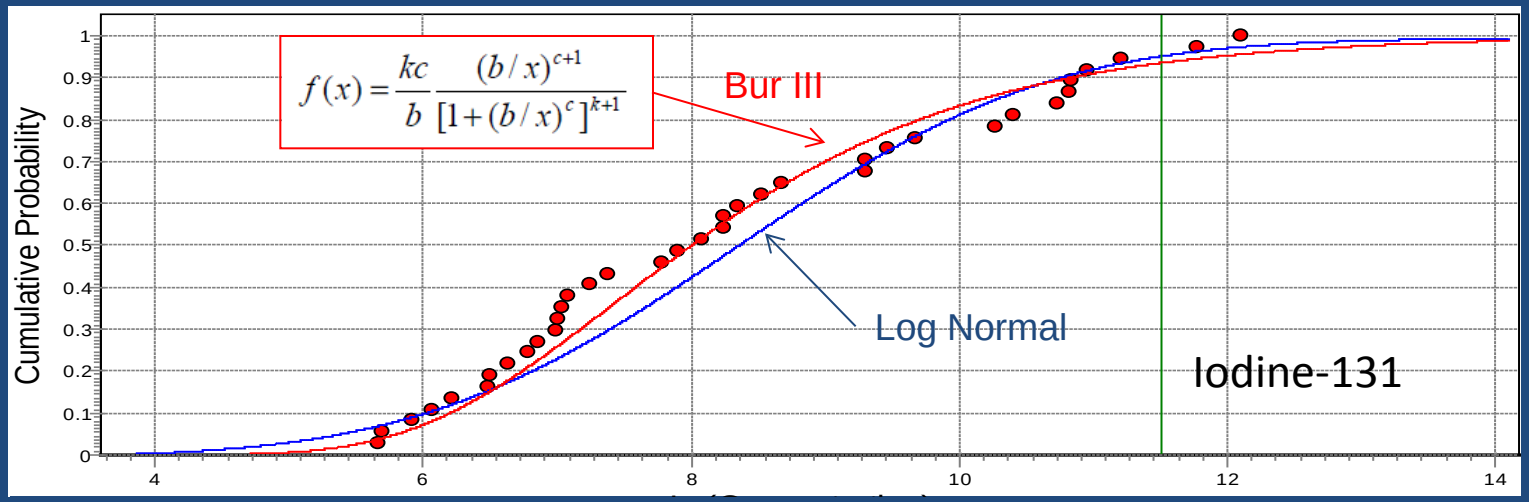
Nori (*Porphyra spp.)*
TF for plutonium = 4,000; $t_{1/2}$ = 14 – 24k years
but no data for Pu from Fukushima

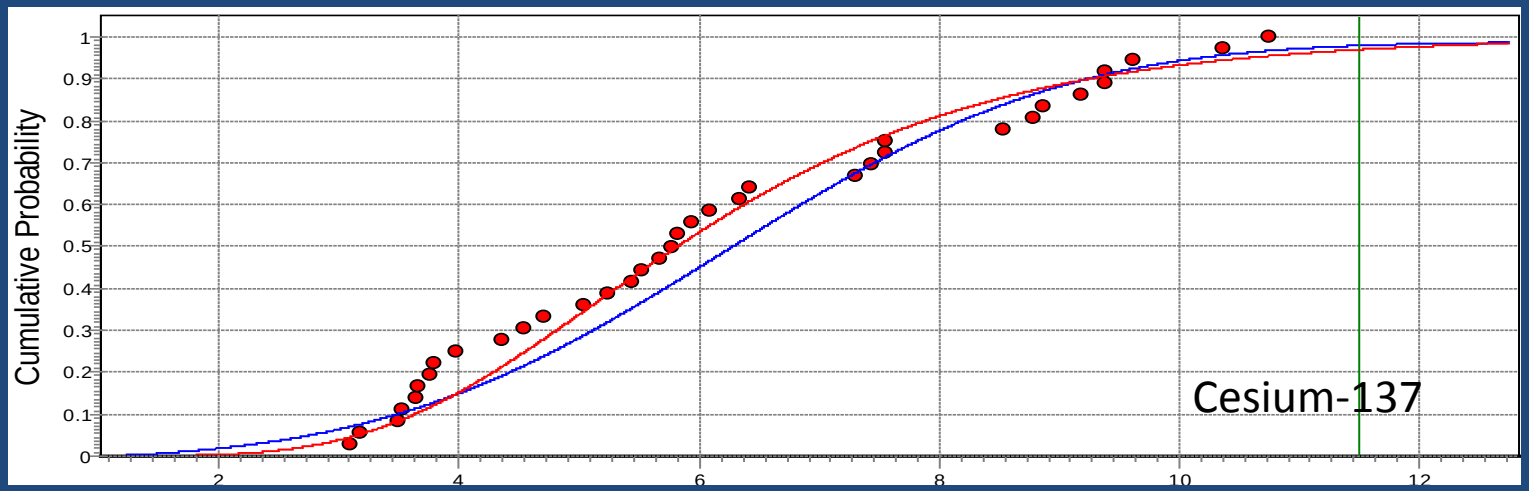
Location of coastal & offshore sampling sites (MEXT, 2011)



Probability distribution functions for ^{131}I & ^{137}Cs in coastal seawater

(Szymczak, 2011)



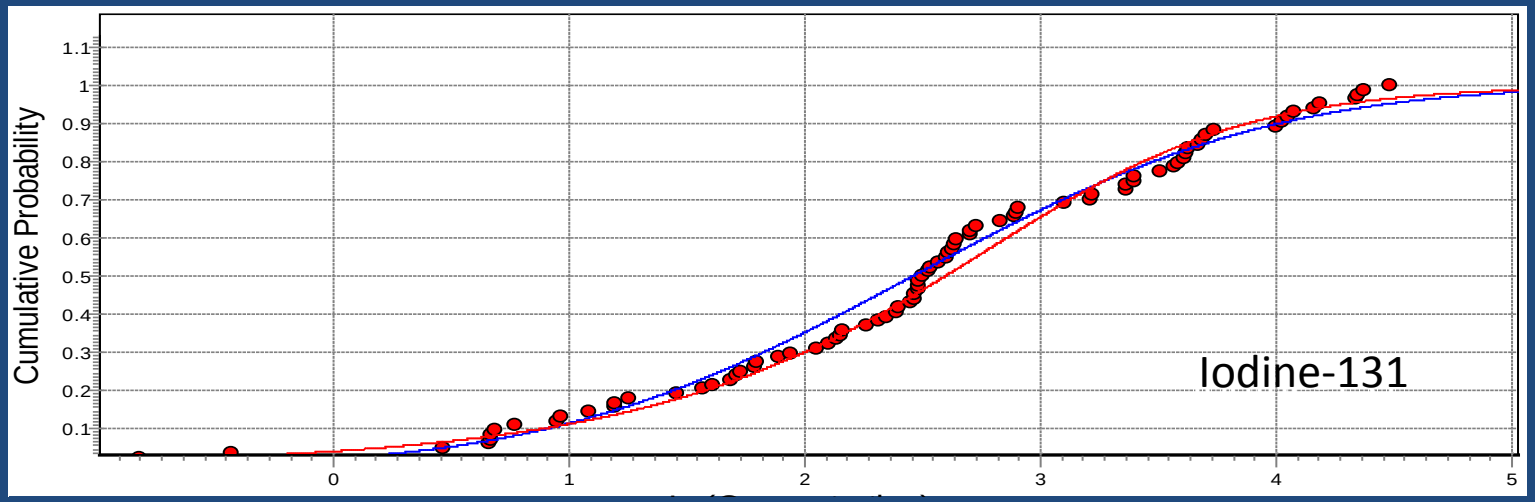


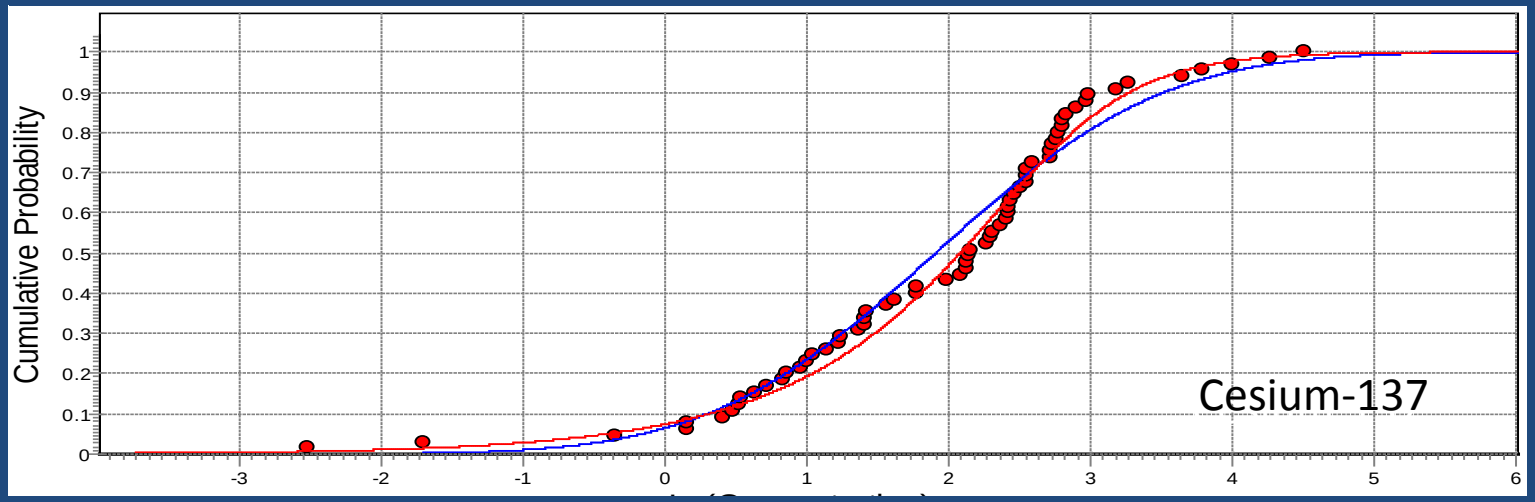
Ln activity (Bq/L)

Hazard	Unit	Max	Min	Average	Median	S.D.	Sample
Cs-137	Bq/L	47000	22	4390	330	9550	36
I-131	Bq/L	180000	290	20100	3210	37800	37

Probability distribution functions for ^{131}I & ^{137}Cs in offshore seawater

(Szymczak, 2011)



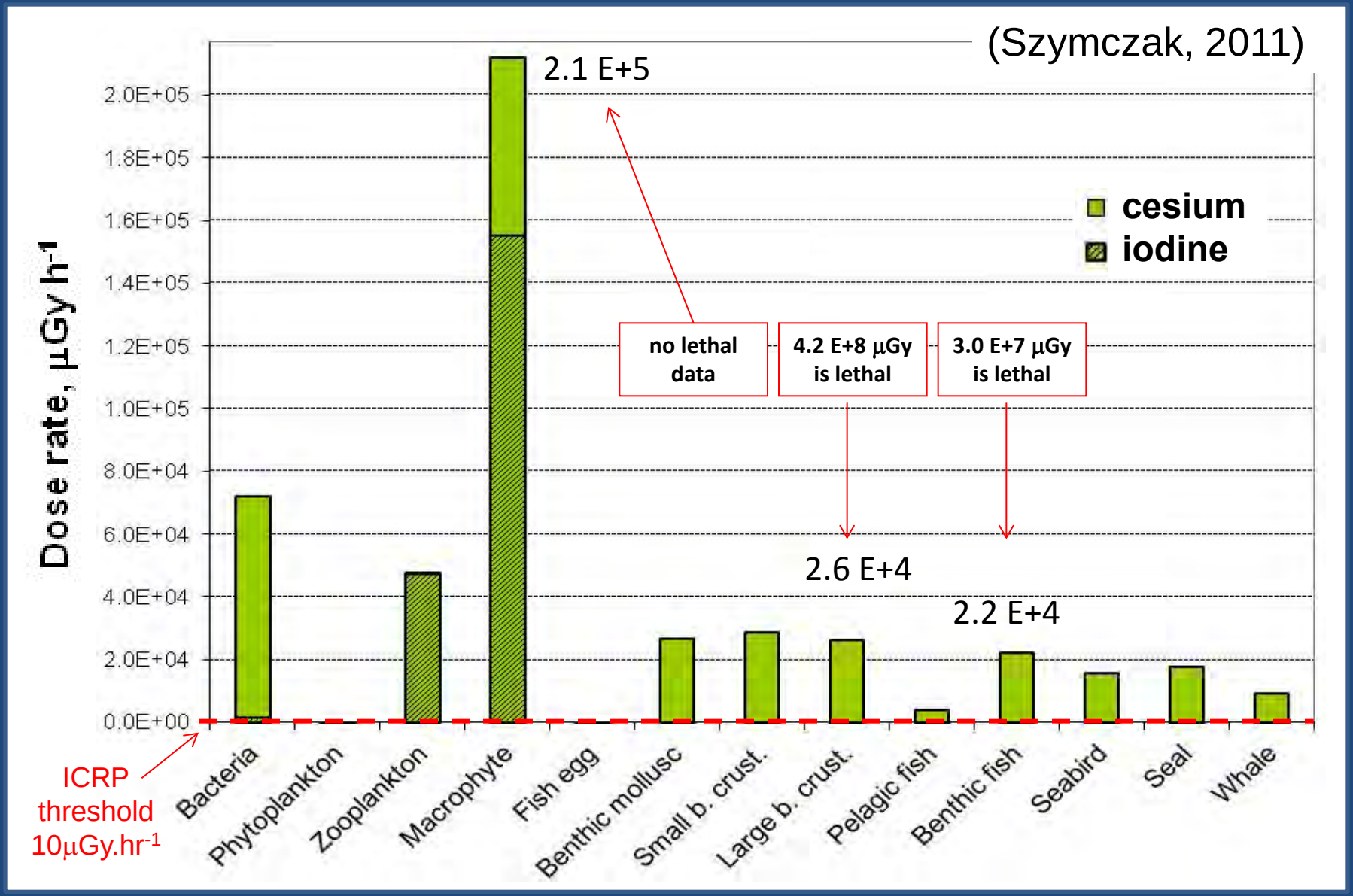


Ln activity (Bq/L)

Hazard	Unit	Max	Min	Average	Median	S.D.	Sample
Cs-137	Bq/L	90	0.08	12.6	8.64	15.8	65
I-131	Bq/L	88.5	0.22	20.7	12.3	20.9	84

Combined total dose for coastal seawater sites (CAE v1.15)

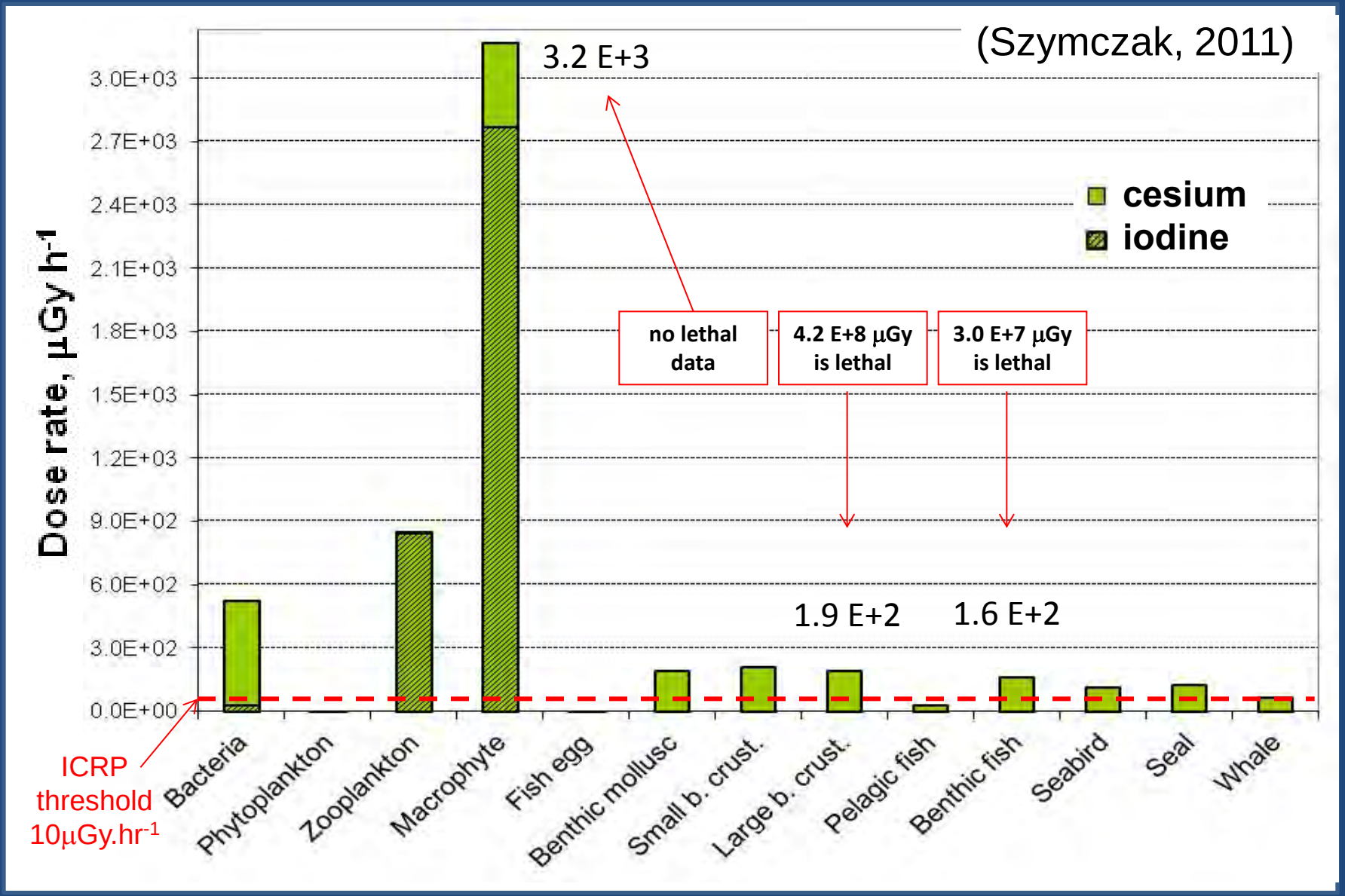
(worst case, 134+137Cs = 94000 Bq/L & 131I = 180000 Bq/L)



Coastal worst case	Reference Brown seaweed	Reference Crab	Reference Flatfish
Dose rate (mGy d^{-1}) >1000	**Deleterious effects expected at very high dose rates. No LD_{50} data**	**Mortality in adults [420 Gy $LD_{50/40}$]**	**Mortality in adults [$LD_{50/50}$ 30 Gy]; mortality in eggs [LD_{50} 1Gy]**
100 - 1000	**Effects on growth rate.**	**Probable effects on growth rates and reduced reproductive success**	**Some mortality expected in larvae and hatchlings**
10 - 100	**Potential effects on growth rate and reproductive success.**	No information	**Reduced reproductive success**
1 - 10	No information.	No information	**Possible reduced reproductive success due to reduced fertility in males**
0.1 - 1	No information	No information	No information
0.01 – 0.1	No information	No information	No information
< 0.01	Natural background	Natural background	Natural background

Combined total dose for coastal seawater sites (CAE v1.15)

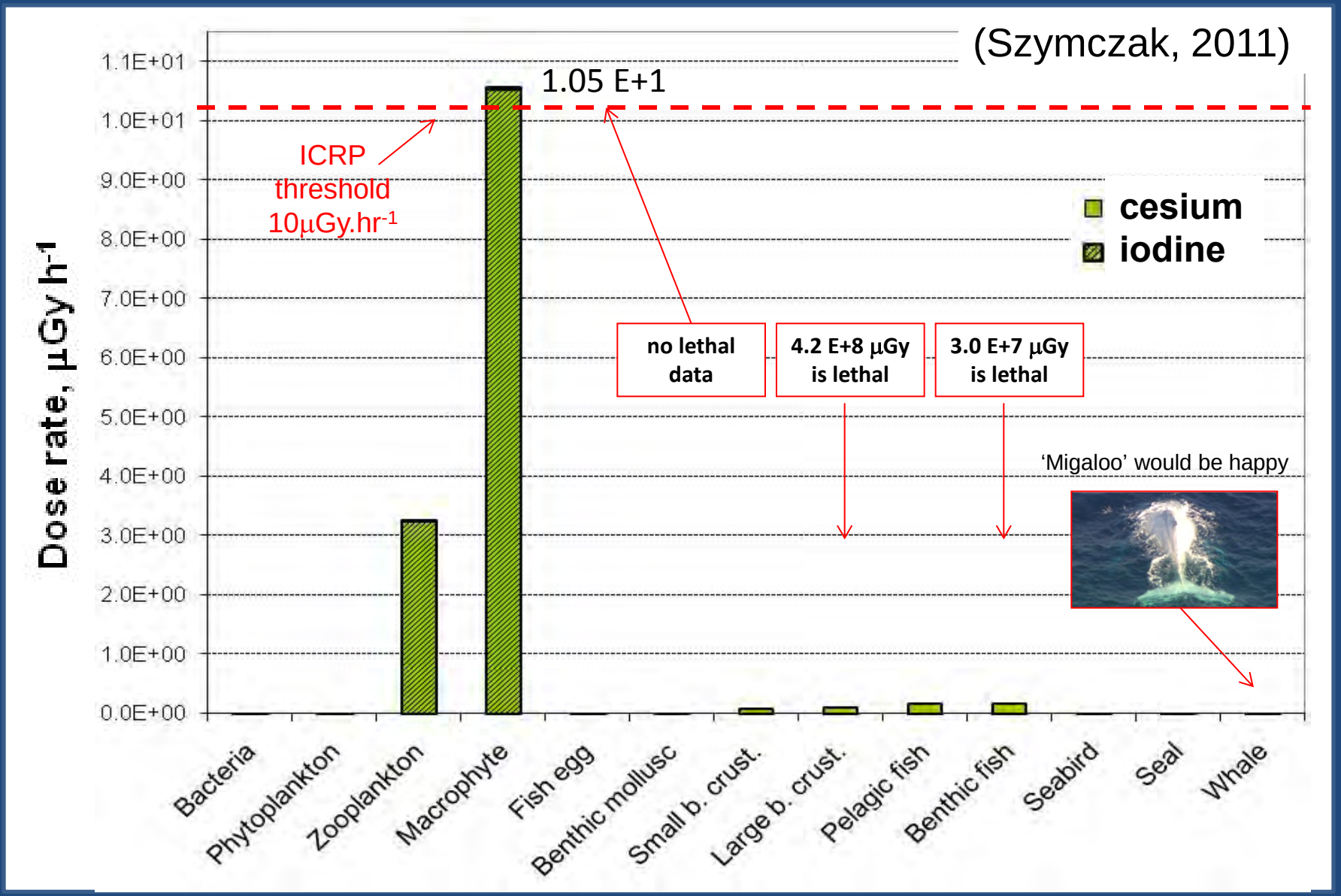
(median, 134+137Cs = 660 Bq/L & 131I = 3210 Bq/L)



Coastal median	Reference Brown seaweed	Reference Crab	Reference Flatfish
Dose rate (mGy d^{-1}) >1000	Deleterious effects expected at very high dose rates. No LD_{50} data	Mortality in adults [420 Gy $LD_{50/40}$]	Mortality in adults [$LD_{50/50}$ 30 Gy]; mortality in eggs [LD_{50} 1Gy]
100 - 1000	**Effects on growth rate.**	Probable effects on growth rates and reduced reproductive success	Some mortality expected in larvae and hatchlings
10 - 100	**Potential effects on growth rate and reproductive success.**	No information.	Reduced reproductive success
1 - 10	No information.	**No information**	**Possible reduced reproductive success due to reduced fertility in males**
0.1 - 1	No information.	No information	No information.
0.01 – 0.1	No information	No information.	No information.
< 0.01	Natural background	Natural background	Natural background

Combined total dose for offshore seawater sites (CAE v1.15)

(median, 134+137Cs = 17.28 Bq/L & 131I = 12.3 Bq/L)



Offshore median	Reference Brown seaweed	Reference Crab	Reference Flatfish
Dose rate (mGy d^{-1}) >1000	Deleterious effects expected at very high dose rates. No LD_{50} data	Mortality in adults [420 Gy $LD_{50/40}$]	Mortality in adults [$LD_{50/50}$ 30 Gy]; mortality in eggs [LD_{50} 1Gy]
100 - 1000	Effects on growth rate	Probable effects on growth rates and reduced reproductive success	Some mortality expected in larvae and hatchlings
10 - 100	Potential effects on growth rate and reproductive success.	No information.	Reduced reproductive success
1 - 10	No information	No information	Possible reduced reproductive success due to reduced fertility in males.
0.1 - 1	**No information**	No information	No information
0.01 – 0.1	No information	No information	No information
< 0.01	Natural background	**Natural background**	**Natural background**

^{210}Po-based dose rates for marine organisms & tissues*

Organism	Tissues Dose-Equivalent Rate (μGy/hr)			#Fukushima coast
Phytoplankton	2.6	-	28.0	<1
Mixed zooplankton	21.0	-	145	880
Euphausiid macrozooplankton	24.5	-	35.9	
Mesopelagic carid shrimp	31.5			
Mesopelagic penaeid shrimp	429			
Mesopelagic penaeid hepatopancreas	5081	-	34164	
Benthic polychaete	17.5	-	333	
Alvinellid polychaete	1577			
Benthic isopod	27.2	-	41.2	210
Benthic isopod hepatopancreas	447			
Benthic amphipod	28.9			
Benthic shrimp	44.7	-	210	
Benthic shrimp hepatopancreas	2716	-	3241	
Bivalve mollusc	25.4	-	118	190
Bivalve mollusc hepatopancreas	78.8	-	280	
Cephalopod	28.0	-	96.4	
Cephalopod hepatopancreas	438	-	1752	
Pelagic fish muscle	8.8	-	51.7	9
Fish liver	26.3	-	2584	
Fish pyloric caecum	61.3	-	18659	
Fish gonad	26.3	-	1498	

* recalculated from Fowler (2011); # Szymczak (2011)

Data gaps, uncertainties & constraints

- Water/organism, food/organism & sediment/organism radionuclide transfer factors (TFs) are limited & not specific to the Pacific region
- Marine organism radiological dose assessment models are primitive c.f. human i.e. no organs & refer to 'similar taxonomy or physiology'
- Need a better understanding of the relationships between dose effects on different life cycle stages and food webs……..for REAL marine biota
- Ecological risks come from mixtures of chemicals or stressors – recommendations are based on the unrealistic assumption that pollutants occur in isolation from each other – need Probabilistic ERA
- Better ocean radionuclide transport models are also needed
- Pubic confidence via education & public relations

Marine benchmark study on the possible impact of the Fukushima radioactive releases in the Asia-Pacific Region
IAEA RCA Project RAS/7/021 (2011-15)

- Australia
- Bangladesh
- China
- Fiji *
- India
- Indonesia
- Japan
- Korea, RO
- Malaysia
- Myanmar
- New Zealand
- Pakistan
- Palau *
- Philippines
- Singapore
- Sri Lanka
- Thailand
- Vietnam

Also…..

- Cambodia *
- Cook Is
- Kiribati
- Marshall Is.
- Nepal *
- Solomon Is

RCA

- 19 countries
- 50% of the world's population
- >100 new power reactors in the next 10 years

TRADEWINDS


Palau
Marshall Islands
Kiribati
Cook Islands
Solomon Islands
Fiji
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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Google earth

Marine benchmark study on the possible impact of the Fukushima radioactive releases in the Asia-Pacific Region (RAS/7/021)

Lead Country Coordinator – Mr Ronald Szymczak, TRADEWINDS Australia

Technical Backstopping - IAEA Environment Laboratories (EL) Monaco

Implementation – IAEA Technical Cooperation (TC) for RCA

Participating Countries - 16 RCA Member States + 7 non-RCA

Project duration - 4 years, starting from 1 July 2011

Project budget – Australia, Japan, Korea RO, New Zealand & USA
Total = EUR 1,115,687

End-Users - Nuclear regulators, environmental agencies, nuclear power plant operators (existing and future), fisheries departments, marine aquaculture organisations & companies, tourism departments & agencies

Marine benchmark study on the possible impact of the Fukushima radioactive releases in the Asia-Pacific Region (RAS/7/021) is addressing 'limitations & data gaps' via……..

Workshops

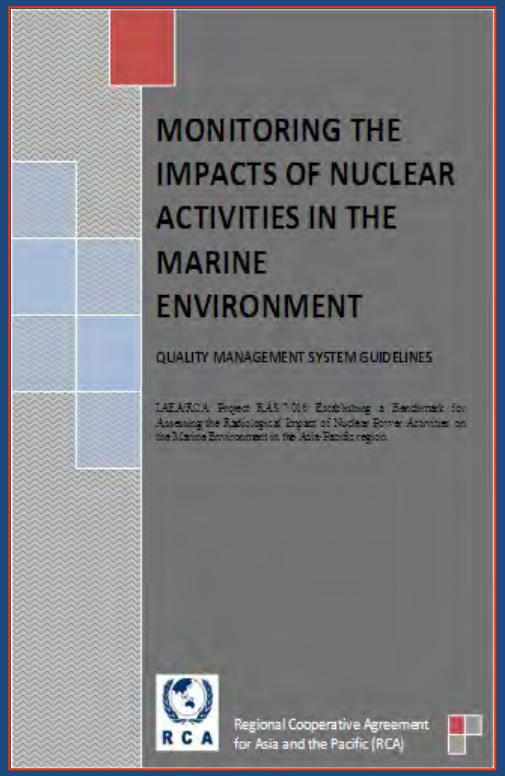
- Quality Management System Guidelines
- Regional & Global Databases (ASPAMARD & MARiS)
- Radiological Dose & Risk Modeling

Regional Training Courses

- Radioecology & dose assessment
- Ecological risk analysis
- Radiochemistry
- Oceanographic sampling training cruises
- QMS Guidelines implementation

Expert missions

- Providing specific assistance to RCA MSs



IAEA RCA Project RAS/7/021 (2011-15)

Capacity building

Twelve countries (AUL, BGD, CPR, FIJ, IND, INS, JPN, MAL, PAK, PHI, THA & VIE) were/are assisted to establish and/or develop new laboratory facilities for marine radiochemistry and/or radioecology, as well as new methods for a broader range of radionuclides in marine samples.

CPR HP gamma spectrometer

CPR Radioecology aquaria

IAEA RCA Project RAS/7/021 (2011-15)

Measurement results & data analysis

The project outcome is strongly linked to the success of ASPAMARD. The ASPAMARD Focal Point is developing an online data submission system. A website platform has been created and is expected to become functional later in 2015. The new system will firstly allow accessibility of the data via internet and later increase efficiency and reduce risks associated with manual transfer of data. The project data submission deadline was 30th June 2015. **20835** new data from JPN were uploaded and/or submitted and **352** from other participating GPs in 2015. **119,965** new data were added during this project.

134,137-cesium in Oceania* SW (ASPAMARD, 2015)

Year	No. of samples	Cs-134 (Bq/m^3)		Cs-137 (Bq/m^3)	
	(n)	range	median	range	Median
2011					
2012					
2013	11	ND	N/A	0.81 – 1.41	0.97
2014	13	ND	N/A	0.72 – 1.24	1.06
2015	4	ND	N/A	0.89 – 1.15	1.00

* AUL, CKI, FIJ, KIR, NZE, PLW, RMI & SOL

134, 137-cesium in Asian Seas* SW (ASPAMARD, 2015)

Year	No. of samples	Cs-134 (Bq/m^3)		Cs-137 (Bq/m^3)	
	(n)	range	median	range	median
2011	409	ND	N/A	0.01 – 6.44	1.57
2012	36	ND	N/A	0.01 – 3.39	1.15
2013	59	ND	N/A	0.19 – 3.75	1.18
2014	37	ND	N/A	0.61 – 2.55	1.15
2015					

* INS, KAM, MAL, PHI, ROK, SIN, THA & VIE

134,137-cesium in Indian Ocean* SW (ASPAMARD, 2015)

Year	No. of samples	Cs-134 (Bq/m^3)		Cs-137 (Bq/m^3)	
	(n)	range	median	range	median
2011		ND	N/A		
2012	26	ND	N/A	0.59 – 3.39	1,37
2013	22	ND	N/A	0.28 – 1.42	0.84
2014	37	ND	N/A	0.19 – 2.55	1.15
2015	11	ND	N/A	0.17 – 1.22	0.29

* AUL, BGD, MYA, THA, IND, INS, PAK & SRL

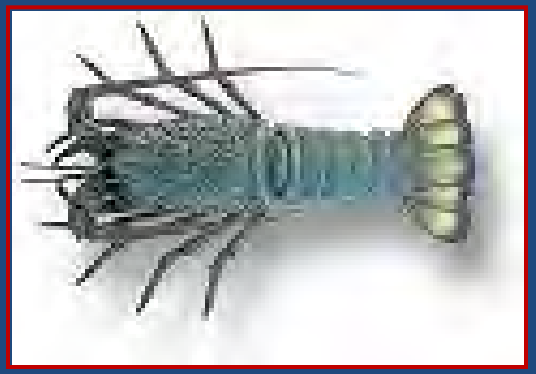
134,137-cesium in NW Pacific* SW (ASPAMARD, 2015)

Year	No. of samples	Cs-134 (Bq/m^3)		Cs-137 (Bq/m^3)	
	(n)	range	median	range	median
2011	197	ND – 756.9	34.7	ND – 825.5	38.6
2012	187	ND – 9.7	1.1	ND – 18.1	5.5
2013	325	ND – 2.7	0.6	ND – 7.8	2.1
2014	231	ND – 1.3	0.4	ND – 6.1	1.7
2015					

* CPR

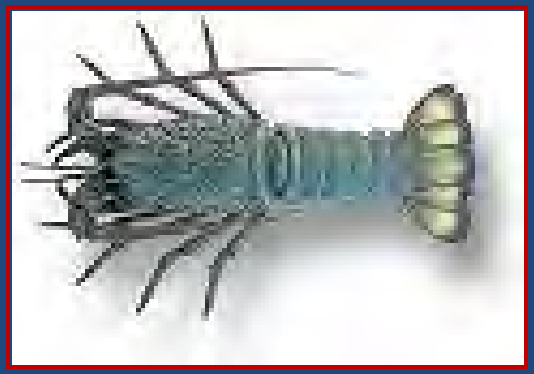
137-cesium in Asia/Pacific marine biota (ASPAMARD, 2014)

MEMBER STATE	SAMPLING PERIOD	No. OF SAMPLES	RANGE OF VALUES, Bg/kg wet wt.	MEAN ± SD Bq/kg wet wt.	MEDIAN Bq/kg wet wt.
Australia	6 Sept. 2012 - 5 June 2013	20	0.014 - 0.28	0.119 ± 0.086	0.094
Indonesia	14 Oct. 2011	9	0.004 - 0.11	0.029 ± 0.036	0.011
Korea	26 March - 30 Aug. 2011	134	0.014 - 0.25	0.092 ± 0.039	0.089
Pakistan	2005, 2009, 2011	59	<1.33	<1.33	
Philippines	28 Nov. 2008 - 22 Nov. 2013	127	0.40 - 4.03	1.11 ± 0.86	0.73
Thailand *	10 Oct. 2010 - 23 Aug. 2011	6 *	0.0019 - 0.0032	0.003 ± 0.0005	0.003
Vietnam	March 2008 – Nov. 2009	16	0.001 - 0.269	0.12 ± 0.09	0.12



Radionuclides in Australian marine biota (ARPANSA, 2015)

Client Sample Identifier	Sample Reference Date	Polonium separation date	Radioactivity Concentration (Bq/kg)		
			Caesium-137	Caesium-134	Polonium-210
Spanner Crab Meat Raw	6/09/2012	8/11/2012	<0.028	<0.033	1.22 ± 0.21
Barramundi fresh local fillets	6/09/2012	8/11/2012	<0.028	<0.033	<0.020
Spanish mackeral Cutlets	6/09/2012	8/11/2012	0.279 ± 0.060	<0.060	7.3 ± 1.1
Saddletail snapper fillets (large mouth Nannygai)	6/09/2012	8/11/2012	0.112 ± 0.032	<0.042	0.229 ± 0.060
Morton Bay Bug meat green	6/09/2012	8/11/2012	<0.043	<0.033	2.68 ± 0.48
Local green cutlets tiger prawns	6/09/2012	8/11/2012	<0.023	<0.036	2.12 ± 0.36
Scallop meat Local	6/09/2012	8/11/2012	<0.028	<0.035	3.02 ± 0.47
Squid whole Local	6/09/2012	8/11/2012	<0.035	<0.035	3.14 ± 0.59
Coral trout fillets local - fresh	6/09/2012	8/11/2012	0.195 ± 0.040	<0.047	0.264 ± 0.070



IAEA RCA Project RAS/7/021 (2011-15)

Data quality management (QMS)

Eight (8) countries (AUL, CPR, IND, NZE, PHI, ROK, SIN & SRL) have or assisted to develop institutional certification to ISO9001, 8 countries (AUL, INS, MAL, NZE, PHI, SIN, SRL & VIE) host laboratories undertaking relevant project work with accreditation to ISO17025, 5 countries (BGD, CPR, IND, PAK & ROK) have national accreditation equivalent to ISO17025 and 2 countries (AUL & ROK) have ISO14001 accreditation. 4 countries (CKI, FIJ, IND, PHI & THA) are working towards achieving ISO17025 accreditation.

IAEA RCA Project RAS/7/021 (2011-15)

Radiological Dose & Ecological Risk Analysis (ERA)

Thirteen countries are performing radiological dose/risk analyses, i.e. AUL, CPR, MAL, ROK, CPR, PAK, PHI, also now CKI, FIJ, KIR, PLW, RMI & SOI have some capability.

The project agreed that it is useful to evaluate risk from NORM (particularly 210-Po) to assist with putting risk from anthropogenic isotopes (and Fukushima) into perspective with natural background radiation.

Australia is collaborating with UK & USA under the IAEA MODARIA project initiative to develop more refined radiological dose assessment models.

ERICA-Tool Radiological ERA for Asia-Pacific (Szymczak, 2015)

Organism	Total Dose Rate (TDR) per organism [µGy h-1]		ICRP Screening Value [µGy h-1]	Risk Quotient (RQ) Value [unitless]	
	min	max		Expected (min)	Conservative (max)
Benthic mollusk *	1.60E-05	3.26E-03	10	1.60E-06	9.79E-04
Benthic fish *	2.22E-05	2.65E-03	10	2.22E-06	7.95E-04
Flounder *	1.69E-05	2.43E-05	10	1.69E-06	7.28E-06
Pelagic fish *	3.38E-05	1.98E-02	10	3.38E-06	5.93E-03
Grouper *	1.07E-05	1.53E-05	10	1.07E-06	4.60E-06
Skipjack tuna *	8.54E-06	4.09E-05	10	8.54E-07	1.23E-05
Crustacean (crab) *	1.20E-05	1.35E-03	10	1.20E-06	4.04E-04
Prawn *	6.70E-07	8.48E-06	10	6.70E-08	2.27E-06
Squid *	8.32E-06	4.96E-06	10	8.32E-07	1.29E-06
Sea cucumber	1.37E-05	1.92E-05	10	1.37E-06	4.52E-06
Coral polyp	4.58E-05	6.58E-05	10	4.58E-06	1.98E-05
Polychaete worm	2.58E-05	4.77E-05	10	2.58E-06	1.43E-05
Mammal	4.98E-05	1.02E-04	10	4.98E-06	3.06E-05
Vascular plant	9.82E-06	1.20E-05	10	9.82E-07	3.61E-06
Macroalgae	1.46E-05	1.91E-05	10	1.46E-06	4.38E-06
Phytoplankton	3.37E-07	4.84E-07	10	3.37E-08	1.45E-07
Zooplankton	9.72E-06	1.36E-05	10	8.64E-07	2.59E-06
Reptile	1.06E-04	1.52E-04	10	1.06E-05	4.55E-05
(Wading) bird	6.29E-05	9.03E-05	10	6.29E-06	2.71E-05

Radiological Dose Impact/Response Models

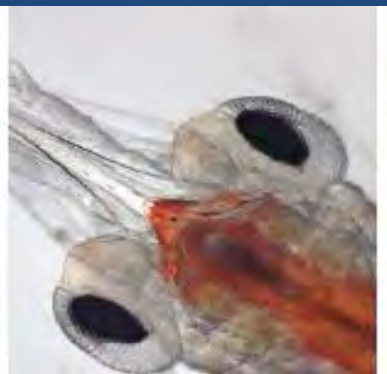
- Current state of radiobiology models is very poor - e.g.;
  sea turtle (*tao talay*) = chicken (*gai*)
  dolphin (*lo maa*) = goat (*pa*)
  prawn (*goong*) = grasshopper (*ta ka tan*)

- No radiation dose-response experiments on tropical organisms

- Important 'representative' organisms for tropical ecosystems;
  sea cucumber (*pling talay*), grouper (*plaa gao*), tuna (*plaa tuna*),
  sea turtle (*tao talay*); mantis shrimp (*gung*), coral (*pa ga rung*)

- Genomics is the key to a better understanding of dose impacts






Australian radiological development activities – RAS/7/021

MODARIA (IAEA) – A dose evaluation activity has been initiated within the Exposure and Effects on Biota Working Group (#8) of the IAEA Modelling and Data for Radiological Impact Assessments (MODARIA) programme. Australia is leading the activity in conjunction with USA & UK.

UNSCEAR – Australia is the Committee Chair until Dec 2014 and Group Leader for Fukushima public and environment dose assessment for the United Nations Scientific Committee on the Effects of Atomic Radiation.

International Commission on Radiological Protection (ICRP) – Australia has been appointed to the Main Commission and will Chair ICRP Committee 5 Protection of the Environment for the next four year term.

Environmental Safety Guide - ARPANSA is leading a working group for the production of a Safety Guide for Radiation Protection of the Environment. This is focussed on providing guidance for the assessment of the radiological impact on wildlife in both terrestrial and aquatic settings.

Ecological Risk analysis – advanced Marine Radio-ecological Risk Analysis of the impacts of the Fukushima accident in the Asia/Pacific Region.

Lead Country Coordinator - IAEA/RCA Fukushima Marine Impacts Project

Expert missions - knowledge & technology transfer to RCA Member States

Dose rates (mGy d^{-1}) to Pacific fish from key FDNPP associated and background radionuclides (Johansen et al., 2014)

	FDNPP Port	3 km east of FDNPP	Amchitka Island, AK	California (N. Pacific)	California	Australia	Japan	
	all fish sampled[2]	*H. otakii* (greenling)	*Hexagrammos Sebastes* spp. (greenling, rockfish)	*T. orientalis* (Migratory bluefin)	*T. albacares* (resident yellowfin)	coastal species	Pre-event coastal species of greenling size	
^{134,137}Cs								
	3.4E-1 [3]	1.1E-3 [3]	4.0E-6 [4]	4.2E-6 [5]	1.1E-6 [5]	7.2E-7 [6]	1.7E-6 [7]	
	(1.3E-4	(1.7E-4	(3.3E-6	(2.0E-6	(6.1E-7	(3.9E-7	(1.5E-6	
	3.1E+0)	2.7E-3)	5.3E-6)	2.2E-5)	1.7E-6)	1.1E-6)	2.3E-6)	
^{3}H, ^{90}Sr, ^{110m}Ag								
	7.4E-1 [3*]	1.3E-3 [3]	1.1E-6 [7,8]	1.1E-6 [7]	1.1E-6 [7]	9.8E-7 [7]	9.8E-7 [7]	
	(1.9E-2	(6.0E-4	(2.8E-7	(2.9E-7	(2.9E-7	(1.9E-7	(1.9E-7	
	1.2E+0)	5.5E-3)	5.8E-6)	6.0.E-6)	6.0E-6)	5.5E-6)	5.5E-6)	
^{99}Tc, ^{235}U, ^{239}Pu, ^{240}Pu, ^{241}Am								
	6.2E-5 [8,9]	6.2E-5 [8,9]	7.2E-5 [4,8]	3.9E-5 [8,9]	3.9E-5 [8,9]	4.0E-5 [8,9]	4.0E-5 [8,9]	
	(2.0E-5	(2.0E-5	(2.5E-5	(8.9E-6	(8.9E-6	(8.9E-6	(9.9E-6	
	2.8E-4)	2.9E-4)	1.4E-4)	2.3E-4)	2.3E-4)	2.3E-4)	2.3E-4)	
^{40}K, ^{210}Po, ^{226}Ra, ^{228}Ra, ^{228}Th, ^{238}U								
	1.0E-2 [10,11]	1.0E-2 [10,11]	1.0E-2 [4,10,11]	1.5E-2 [10]	1.5E-2 [10]	2.7E-3 [8,10]	1.0E-2 [10,11]	
	(1.3E-3	(1.3E-3	(3.4E-3	(2.7E-3	(2.7E-3	(9.4E-4	(1.3E-3	
	3.6E-2)	3.6E-2)	3.6E-2)	3.6E-2)	3.6E-2)	8.1E-3)	3.6E-2)	
Total								
	1.1E+0	1.3E-2	1.2E-2	1.5E-2	1.5E-2	2.8E-3	1.0E-2	
	(2.0E-2	(2.1E-3	(3.4E-3	(2.7E-3	(2.7E-3	(9.5E-4	(1.3E-3	
	4.3E+0)	4.4E-2)	3.6E-2)	3.6E-2)	3.6E-2)	8.4E-3)	3.6E-2)	

Asia's nuclear energy growth

Asia is the only region in the world where electricity generating capacity and specifically nuclear power is growing significantly.

In East and South Asia there are over 109 nuclear power reactors in operation, 18 under construction and plans to build >110 within next 10 years

The greatest growth in nuclear generation is expected in China, Japan, South Korea and India.

Source: World Nuclear Association

Research & policy needs in Asia/Pacific region

- Define local ‘reference organisms’
- Asia/Pacific has several very different marine ecosystems & these should be treated separately (coastal, oceanic, coral reefs, etc)
- Monitor radionuclides in local waters & biota – define ‘baseline’
- Undertake radioecology experiments to establish transfer factors
- Consideration should be given to ;
  - fisheries & aquaculture operations
  - organisms of ‘national significance’ (eg. corals)
- Develop emergency response strategies/protocols
- Food web (trophic) analysis & modeling
- Radiation dose-effect experiments on tropical organisms ?

IAEA/RCA Project Concept Paper for 2017-20

Advancing technologies for monitoring and analysis of the potential impact of radioactive releases from nuclear power plants (NPPs) in Asia-Pacific marine ecosystems following the Fukushima Dai-ichi accident

Specific Objective of the project:

Strategic and sustainable analyses of the extent and impacts of radioactive releases from nuclear power plants (NPPs) to Asia-Pacific marine ecosystems

- *more advanced skills, broader range of radionuclides/scenarios*
- *new developments in radiological modelling*
- *support development of new MS laboratories*

ASEANTOM Project Concept Paper for 2017-20

Regional Cooperation Project Concept in South East Asia to Support Regional Environmental Radioactivity Database & Nuclear Emergency Preparedness and Response

Overall Objective of the project:

Develop and implement emergency preparedness and response arrangements both at the national and regional levels to protect the people and the environment, in case of a severe nuclear and radiological incident

Thailand (Lead Country), Brunei Darussalam, C*ambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Vietnam*

Better Public Relations & Education

Conclusions & implications

- In the N Pacific there is a legacy of 'background' radioactivity from nuclear testing (1950/60's) & pre-1972 ocean dumping activities
- The 2011 Fukushima Dai-ichi NPP accident was the biggest ever accidental release of radioactivity to the marine environment (N Pacific)
- N Pacific Ocean currents will transport the Fukushima plume eastwards but dilution/dispersion will reduce soon reduce to <background levels
- Food web transfer may result in future elevated levels in certain species
- Local /site-specific studies are needed to develop regionally appropriate ecological risk analyses & response plans for possible future events
- Naturally-occurring 210-polonium is a significant radionuclide of concern to N Pacific (oligotrophic) ecosystems
- Apart from localised coastal impacts in Japan, the 2011 Fukushima NPP accident has posed no significant radiological threat to marine ecosystems in the N Pacific region

Any questions and/or comments ???

TRADEWINDS