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ATLANTIC, OUTERMOST REGIONS AND ARCTIC
MARITIME POLICY ATLANTIC, OUTERMOST REGIONS AND ARCTIC

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RISK OF IMPORTING CONTAMINATED FISH FROM OUTSIDE JAPANESE EEZ FOLLOWING NUCLEAR ACCIDENT AT FUKUSHIMA

1. INTRODUCTION

The risk of contaminated fish from inside the Japanese exclusive economic zone reaching the EU food chain is remote. Only Japanese vessels fish inside their exclusive economic zone. All these fish are landed in Japan and monitored for radioactivity in Japan. EU Imports to the EU from Japan amount to €30 million per year, which is 0.2% of EU fish imports and less than 0.05% of the market[1]. Controls are in place to check these again on entry to the EU. Radioactive contamination is easy to measure in a non-destructive way.

However radioactivity has been detected outside the Japanese exclusive economic zone and certain species of fish may feed inside the zone but subsequently be caught outside by non-Japanese vessels. The risk that these fish find their way onto the European market is analysed in this report.

2. RELEASE

The main radionuclides that could affect human health are iodine 131 (^{131}I) and caesium 137 (^{137}Cs). These are volatile and therefore released from the fuel at relatively low temperatures. Other dangerous radionuclides are likely to remain within the reactor core, even when, as at Fukushima, the fuel rods have disintegrated or melted. ^{131}I has a half-life of eight days and ^{137}Cs of thirty years. Because of its short half life, ^{131}I is primarily a risk in the first weeks of the accident. Their distribution in the ocean will depend on their chemical properties – whether they are dissolved or precipitated. ^{134}Cs, with a half life of two years, has identical chemical properties to its heavier brother, and so monitoring for the presence of one will also give an indication of the presence of then other.

The Japanese Nuclear Safety Commission reckon that most of the release into the atmosphere happened over the first five days (see Figure 1). The amount released directly into the ocean from a pit below reactor 2 is unknown. According to a press

[1] http://trade.ec.europa.eu/doclib/docs/2006/september/tradoc_113403.pdf

release from the Prime Minister's office (and many articles in the international press) this leak was plugged on 7 April 2011.[2]

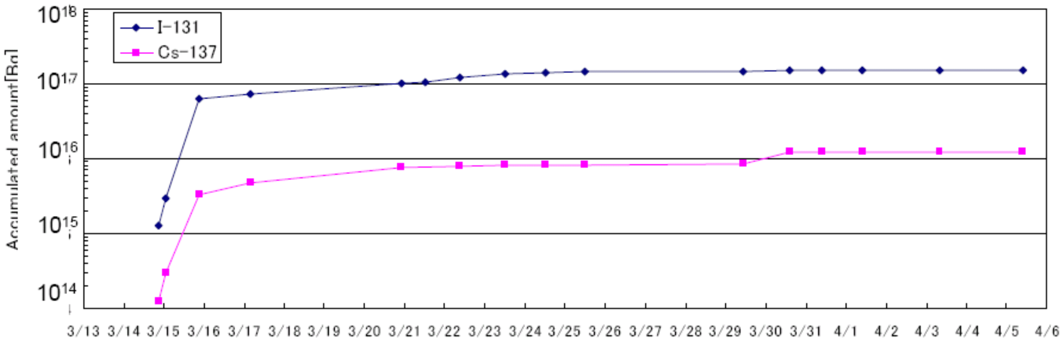

Figure 1 Estimate of total release of ^{131}I and ^{137}Cs into atmosphere. This is the emission into the atmosphere accumulated from the occurrence of the accident to the specific day; not the amount emitted within the day. (Nuclear Safety Commission of Japan reply to question of Director-General of Nuclear Emergency Response Headquarters[3]) 12 April 2011)

The French Centre National de la Recherche Scientifique (CNRS) and Toulouse University).have undertaken some mathematical simulations of the transport of contamination[4]. They made two major assumptions for the input flux of ^{137}Cs:

(1) They tuned the leaks from the reactor to match the measured concentrations of radionuclides in the sea at 30 and 300metres from the nuclear plant.

(2) They assumed that all the airborne radioactive emissions were deposited within 200km from the source. They indicate that this was based on simulations from an atmospheric model and would be ready to change this assumption if there were counterindications.

This second assumption is significant because a corollary would be that most of the contamination arriving outside the 200-mile Japanese exclusive economic zone would be seaborne; not deposited from the atmosphere.

3. MEASUREMENT IN PACIFIC

The main sampling points in the Pacific are 30 km east of Fukushima (Figure 2). The results show relatively high concentrations near the surface and lower near the bottom (100-200 metres depth). The concentrations at the surface are not decreasing but the radiocuclides are dispersing. From April onwards half the samples have concentrations below detection levels and the latest readings indicate only 20% of

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2 Press briefing at the Prime Minister's Office for members of the foreign press

3 http://www.mofa.go.jp/j_info/visit/incidents/pdfs/press/20110412/foreign-press-briefing-20110412-nsc.pdf

4 http://sirocco.omp.obs-mip.fr/outils/Symphonie/Produits/Japan/SymphoniePreviJapan.htm

the samples have levels above detection limits. These latest measurements show almost identical ^{131}I and ^{137}Cs concentrations.

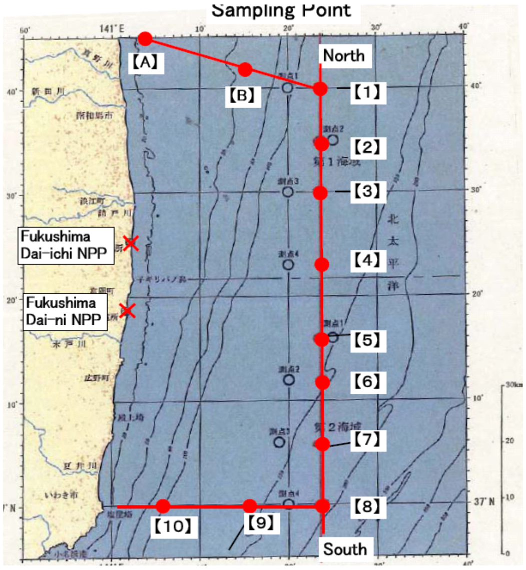

Figure 2 Measuring points for sampling seawater.

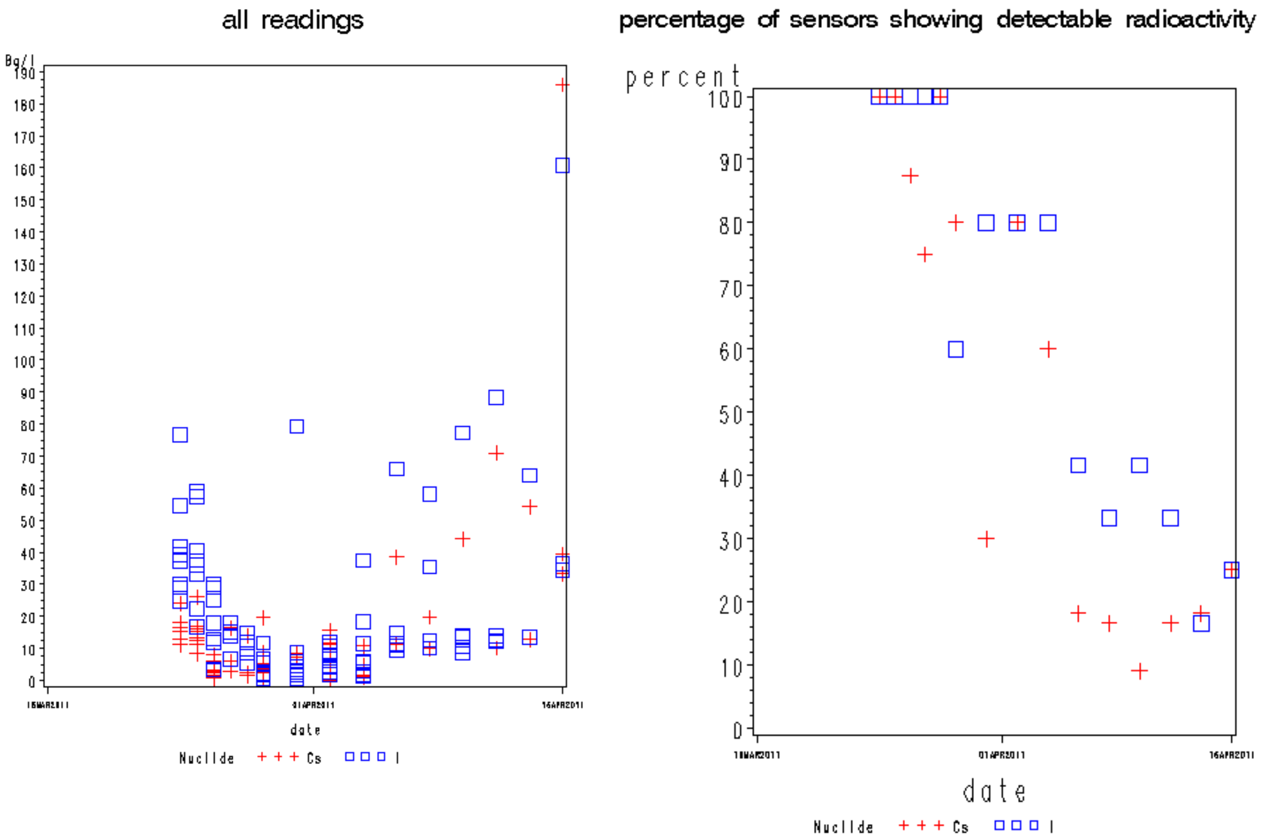

Figure 3 analysis of measurements from seawater sensors 30km from shore (DG-MARE analysis, measurements taken from postings on web-site of Ministry of Education, Culture, Sports, Science and Technology web-site).

Although these radioactivity levels are high,. They are considerably lower than the values nearer the plant (see Figure 4)

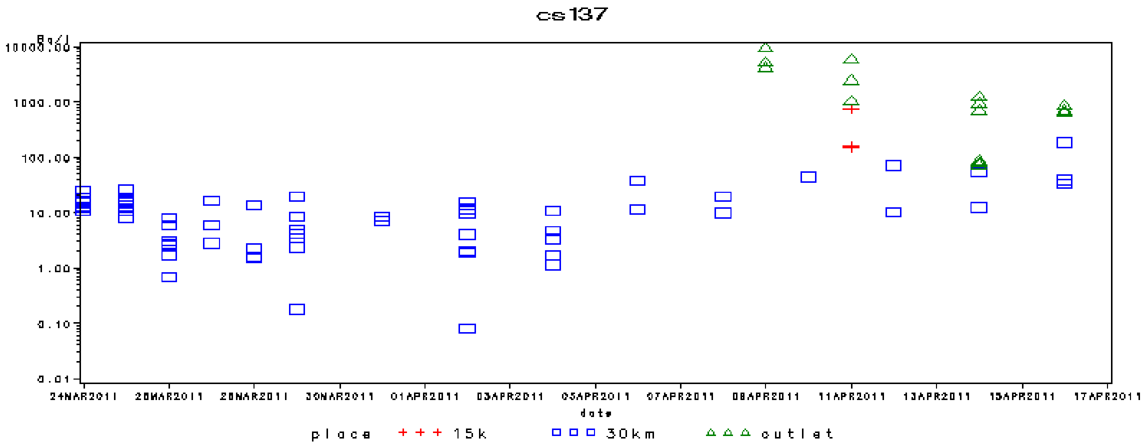

Figure 4 Radioactivity levels near the plant, 15km from plant and 30km from plant. Note the logarithm scale. Analysis by DG-MARE. Data from webs-sites of Tokyo Electric Power Company, Incorporated (TEPCO) and Ministry of Education Culture, Sports, Science and Technology –Japan (MEXT)

4. DISTRIBUTION IN OCEAN

The French "*Institut de Radioprotection et de Sûreté Nucléaire (IRSN)*" report a modelling exercise for the ocean[5]. According to their model:

> *The swirling structures present to the east of Fukushima are unstable. They mix the surface waters between the latitudes of 35°30'N and 38°30' (Figure 5). It is to be expected that the coastal zones located between those latitudes to be impacted by the dispersion of radioactive pollution. The long term migration of the surface waters will be southwards but will not extend beyond the latitude of Tokyo . The Kuroshio current will then carry the plume towards the centre of the Pacific. A simulation of this migration of the radioactive pollution has been produced by Mercator–Ocean (Figure 6). According to that simulation, the radionuclides dissolved in sea water in the vicinity of the Fukushima-Daiichi power station (the green spot on the map in Figure 6) should drift for 90 days along the red trace shown on the map. The simulation shows that the coastal currents carry the polluted waters up to the Kuroshio current (the thick white swathe) and disperse to the north of that current. The diffusion is relatively turbulent but the dissolved radionuclides are contained by the Kuroshio current*.

[5] http://www.irsn.fr/EN/news/Documents/IRSN_Fukushima-Accident_Impact-on-marine-environment-EN_20110404.pdf

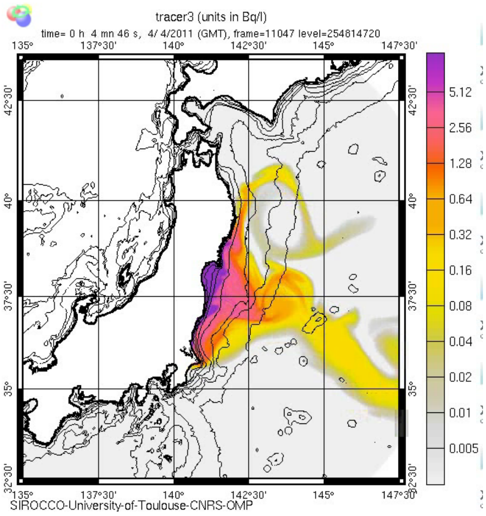

Figure 5 Simulation of the dispersion in sea water of the atmospheric fallout on 4th April

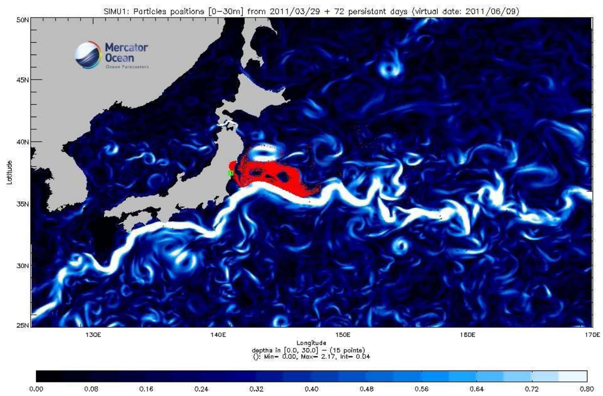

Figure 6 Simulation of the migration of radioactive pollution (Mercator-Ocean)

5. LESSONS FROM CHERNOBYL

These levels are about one order of magnitude higher than peak measurements in the Baltic after the Chernobyl accident, These rose to 5.2Bq/litre immediately after the accident and were lower by a factor of ten three months afterwards[6].They were lower by a further factor of ten by 1990, four years after the accident (Figure 7)

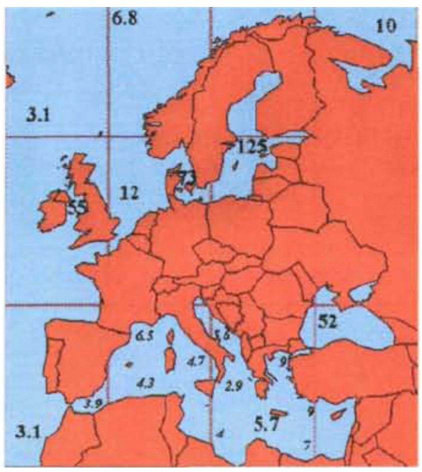

Figure 7 Average Levels of ^{137}Cs in European seas after the Chernobyl accident (Paul Povinec, Scott Fowler, Murdoch Baxter) IAEA bulletin 1/1996) Bqm^{-3}

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6 Rikki Ilus, "The Chernobyl Accident and the Baltic Sea" Boreal Environment Research, Helsinki, 22 February 2007.

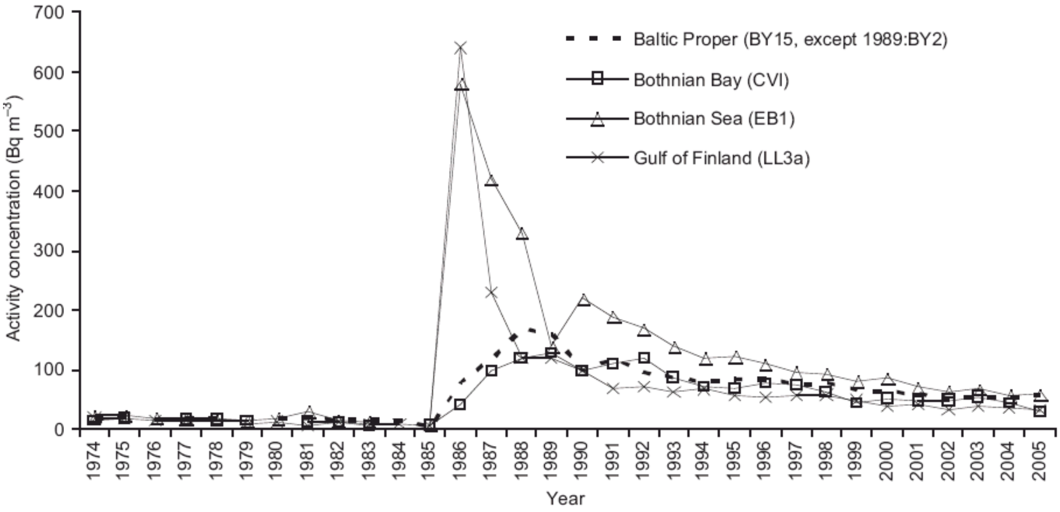
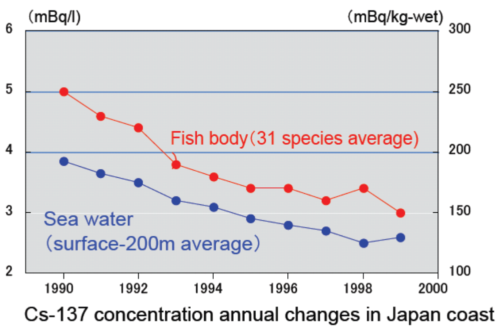


Figure 8 Levels of ^{137}Cs in Baltic following Chernobyl. Note that units are Bqm^{-3}, and that levels immediately after accident were higher – 5000 Bqm^{-3}

6. Relationship Between Concentration in Seawater and Concentration in Fish



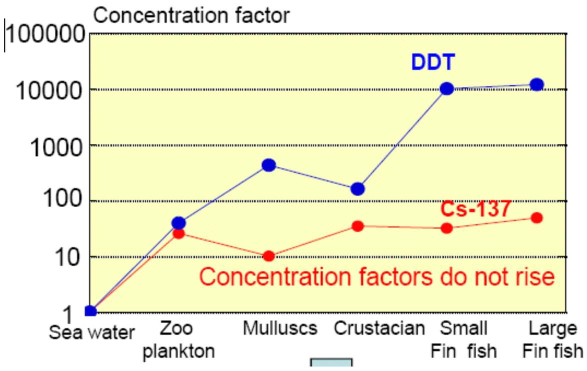


Figure 9 Relationship between concentration of ^{137}Cs in seawater and in fish (from Japanese Fisheries Agency)

Figure 10 Relationship between concentration in seawater and concentration in sea life (from Japanese Fisheries Agency)

The Japanese Fisheries Agency have released the results of studies on the relationship between the levels of ^{137}Cs in seawater and in fish. Their research shows that the level does not, like DDT, accumulate up the food chain, but instead reaches an equilibrium. They indicate that a concentration of 1 Bq/l in seawater leads to a concentration of between 5 and 100 Bq/kg in sea animals. However the French *Institut de Radioprotection et de Sûreté Nucléaire* (IRSN) figures are different[7].

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[7] http://www.irsn.fr/EN/news/Documents/IRSN_Fukushima-Accident_Impact-on-marine-environment-EN_20110404.pdf

The accumulation capacity is dependent on the metabolism of each species. In the case of caesium, the concentration factors vary from 50 for molluscs and seaweed to 400 for fish. For iodine, the concentration factors vary between 15 for fish and 10,000 for seaweed.

This means that the contamination observed at the 30km point is enough to risk pushing the contamination of fish over the Japanese limits (500 Bq/kg for ^{137}Cs and 2000 Bq/kg for ^{131}I.)

7. MEASUREMENTS IN FISH

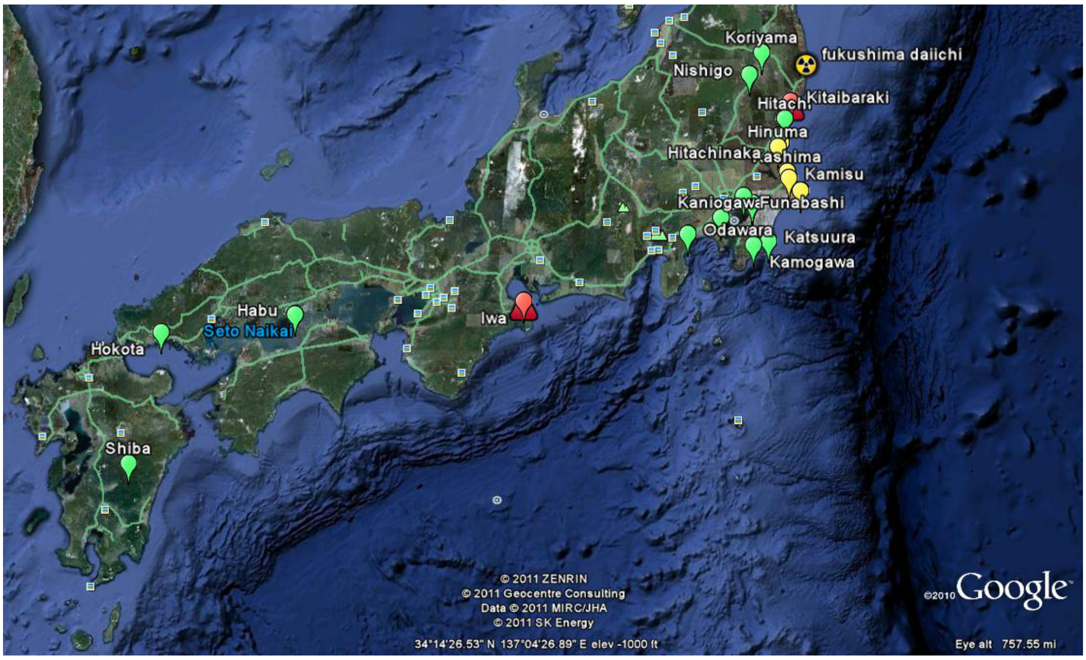

Figure 11 Ports where contamination in fish has been measured. The red icons show where levels of ^{137}Cs are higher than 100Bq/kg (maximum level is 500). Yellow icons show where levels have been detected but they are lower than 100Bq/kg. Green icons show where measurements have been made but levels are below threshold for detectability. The red triangles are where levels are above maximum permissible limits.

Levels of ^{131}I and ^{137}Cs in fish are measured in ports and reported by the Japanese Fisheries Agency through the Ministry of Foreign Affairs web-site. The Agency obtain the data from web-sites of individual prefectures.

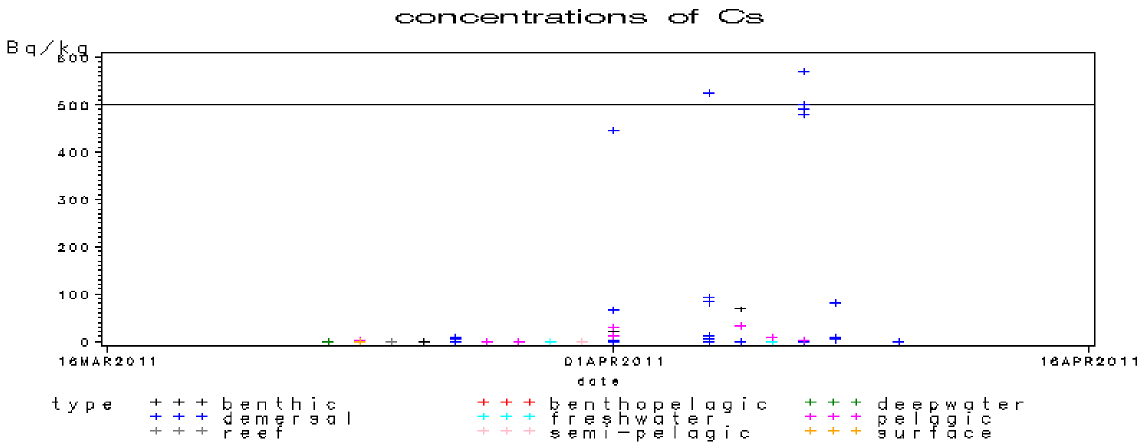

Figure 12 Levels of radioactivity of ^{137}Cs in fish caught in Japanese waters (analysis by DG-MARE based on data from Japanese Fisheries Agency). The Japanese data are on a species level. The preferred environment of these fish (pelagic/demersal etc) was determined from FISHBASE

Figure 12 shows the recorded levels of contamination for sampled fish. The samples record average levels. The precision and confidence levels of these measurements are not known. The Japanese Agency has been asked for this information and a reply is awaited.

Table 1shows the highest recorded contamination for a sample of each species

The highest contamination is observed for the Japanese sandlance which is found in sand bottoms in coastal areas. Presumably there is something in the life cycle of this fish which means that it is especially susceptible. Curiously these high values are not only recorded for fish landed near the accident site but also at Iwa which is nearly 500km away (Figure 11) although they may have been landed here after having been caught elsewhere.

In general the contamination is highest for bottom-feeding (demersal or benthic) fish rather than those that feed in the water column (pelagic) although the levels in anchovy are significant.

Activity from ^{131}I is greater than that of ^{137}Cs.

Table 1Maximum recorded levels of radioactivity in fish

type	**common**	**^{137}Cs**	**^{131}I**
benthic	**brackish-water clam**	**68**	**96**
	clam	19	30
	fukutokobushi abalone		
	sea cucumber		
benthic Maximum		68	96
benthopelagic	rainbow trout		5.5
	whitespotted char		13
benthopelagic maximum			13
deepwater	alfonsino		
deepwater maximum			
demersal	chestnut octopus		4
	conger eel	12	220
	fat greenling	10	260
	flathead flounder		
	Japanese amberjack		6.4
	Japanese icefish	94	260
	Japanese littleneck clam	8.1	103
	Japanese sandlance	570	4080
	marbled flounder	8	8
	monkfish		21
	olive flounder	4	13
	Pacific cod		
	slime flounder	7	26
	tit olive flounder		
	willowy flounder		35
demersal maximum		570	4080
freshwater	common carp		6.3
freshwater maximum			6.3
pelagic	anchovy	30	130
	chub mackerel		3.6
	halfbeak	11	7.2
	Japanese jack mackerel		
	Japanese sardine	8.5	16
	skipjack tuna	33	
	southern mackerel		
pelagic Maximum		33	130
reef	seabass		5.9
reef Maximum			5.9
semi-pelagic	spear squid		13
semi-pelagic maximum			13
surface	hijiki seaweed		65
surface Maximum			65
Maximum		**570**	**4080**

8. RISK

The contamination decreases as we move away from the release point and we would expect it to decrease still further as the ocean dilutes it. Furthermore the Pacific to the east of the Japanese exclusive economic zone is deep so there is no demersal fishing.

The main risk of contamination entering the food chain is from pelagic fish feeding inside the contaminated zone and being caught outside. The main species that is caught commercially in this area the albacore which is fished by Chinese, Russian and Taiwanese vessels.

High contamination of albacore caught inside the zone would provide an early warning of this possibility. So far the Japanese monitoring programme has not included albacore.

No contamination above one tenth of permissible levels in pelagic species has been observed for ^{137}Cs which\, because of its long half-life, is the primary risk. Because, as we have seen, the contamination does not accumulate further up the food chain, we might expect similar levels in albacore.

Whilst not alarming, the risk is finite. The contamination in some coastal waters is of such a level that contamination of fish beyond the permissible limits is possible. Furthermore the contamination is heterogeneous. There may be areas that are not being sampled where the contamination is higher.

9. WHAT OTHERS ARE DOING.

DG-MARE has obtained information from the Japanese ministries for fisheries and science as well as the power company TEPCO. They have been admirably prompt in placing updated information on the web in English. However it is rather fragmented and not in machine- readable form. The information provided on the graphs and maps in this short report was derived from numbers published in more than 30 reports.

DG-MARE has contacted the United States National Oceanic and Atmospheric Administration (NOAA) who have indicated that they intend to offer measuring instruments to the Japanese but have not done so yet.

The International Atomic Energy Agency have reported the instrument readings but have not drawn any conclusions.

The French *Institut de Radioprotection et de Sûreté Nucléaire* (IRSN) have reported results of ocean circulation models.

There may be other studies of which we are unaware.

10. WHAT WE SHOULD DO NEXT

A full assessment of the impact of the Fukishima accident on the marine environment will take time. The International Atomic Energy Agency's report on the impact of Chernobyl on the Baltic was released ten years after the event. However decisions need to be made now if we are to avoid on the one hand risks to the public or on the other unnecessary restrictions on trade. Bearing this in mind we would propose.

(1) Strengthening contacts with the Japanese authorities in order to

(a) clarify details of their contamination measurements – precision, reason for no measurements of significant fisheries information

(b) obtain measurements in machine readable form

(2) Continuing to accept fish from the Pacific although samples of products, especially those containing albacore, should be subject to check.

(3) Continuing to monitor results of Japanese measurements

(4) Establishing a meeting of specialists to discuss results so far and coordinate further work

(5) Publishing this assessment on DG-MARE's Maritime Forum and inviting comments.