FINAL Research proposal 3rd part Fukushima field work

Sea water contamination at Fukushima Daiichi

Radioactive materials from the crippled Fukushima Daiichi nuclear power plants are dispersed into the seawater via various routes:

- leakage of highly radioactive cooling water out of several basement structures of the nuclear power plant (520 tons of water with a total contamination of 5E+18 Bq)
- deliberate release of slightly radioactive water from storage tanks (10393 tons of water with a total contamination of 1.5E+11 Bq)
- deposition of airborne contamination

For comparison: the annual allowed discharge limit of Fukushima Daiichi is 2.5E+14 Bq, the La Hague reprocessing plant is allowed to emit 6E+13 Bq annually.

There are various dispersion models available. The dispersion model developed by Sirocco shows the following of dispersion patterns (http://sirocco.omp.obs-mip.fr/outils/Symphonie/Produits/Japan/SymphoniePreviJapan.htm):

- dissolved radionuclides move north-east in the direction of the Kinkasan peninsula leading to concentrations of 50 Bq/l up to 80 km from the plant
- particulate radioactive materials don't travel out of the 30 km evacuation zone
- the level of sea water contamination caused by deposition of radionuclides in the air is low (up to 0.13 Bq/l)
- due to sea water currents most water flowing through the Fukushima area will probably end up in the Kuroshio current and flows and in the eddie north-east of Japan

The dispersion model developed by ASR (http://www.asrltd.com/japan/plume.html) shows the dispersion of free floating material (fish larvae, algae, phytoplankton, zooplankton...) and shows a slightly different pattern:

- free floating material travels mainly to the coastal area south of the plant of far south as Katsuura (250 km from Fukushima)
- free floating material travels north up to 60 km from Fukushima Daiichi NPP
- free floating material end up in the Kuroshio current and is dispersed over a large area east of Fukushima

Monitoring of sea water and fish contamination

The sea water contamination is currently monitored by the Japanese authorities and Tepco. Tepco monitors close to the plant and up to 15 km (http://www.tepco.co.jp/en/index-e.html). MEXT monitors daily the contamination at 30 km at various measuring points (http://www.mext.go.jp/english/radioactivity_level/detail/1304192.htm). The measured values differ per day and per location, but generally the contamination levels are:

- 1E+13 Bq/l inside plant structures
- 1000 Bq/l directly at the plant
- 100-400 Bq/l at 15 km distance
- 10-100 Bq/l at 30 km distance

At 30 km the levels of radioactive materials are very variable and depending on location, time and sampling depth. The highest radiation is measured directly east of the plant: 161 Bq/l for I131 and 186 Bq/l for Cs-137 (15-4-11).

Contamination in fish is measured by the Japanese fisheries authority (http://www.maff.go.jp/e/index.html). High levels of Cs-137 (12500 Bq/kg) are found in Sand Lance, lower levels of radioactive materials are found in clams, eels and anchovies. All analyzed fish are caught in the area south of Fukushima by fisherman that cooperate with the authorities. North of Fukushima no fish monitoring system is put in place since most of the harbours and fishing boats are destroyed by the tsunami. Seaweed and shellfish are not part of the monitoring program.

Fish species and fishery

Marine life species at interest for sampling:

(Note: in bold those that might be more common in the area we are heading to in this season)

Shellfish:

- **Clams(あさり):** Kaneda coastal area (Chiba prefecture, South of Fukushima) is quite famous for clam collections. They are mostly collected end April-May. They are collected from shore, searching in the sand.
- **Mussels(イガイ):** attached to rocks. Season: summer (June - September), common in Chiba coastal area.
- Raze clam (Solen marginatus): in sand beaches, season: spring to summer, Region: in Kaneda (Chiba) and Ibaraki.
- **Japanese scallop**, or yesso scallop: it is both wild and farmed (common in Japanese cuisine, (http://www.edf.org/page.cfm?tagID=15789). Season: all year, but more June to August. Region: Aomori (mainly North of Japan), but also north of Fukushima, Sanriku area (Iwate). Apparently they were tested in Russia (http://www.reuters.com/article/2011/03/16/us-japan-quake-russia-fareast-idUSTRE72F3QJ20110316)

Seaweed:

- **Hijiki Seaweed:** Hijiki is green to brown in colour when found in the wild. A fisherman and a professional diver harvest the hijiki with a sickle at the time of the low tide of the spring tide of May from March.
- **Wakame** – (*Undaria pinnatifida*): a sea vegetable, or edible seaweed, commonly farmed in Japan. Location: North of Fukushima (Iwate – largest producer, and Miyagi) and some farmed in South Fuskushima (Chiba and Kanagawa)– Season: all year, but best in spring (March-April)
- **Konbu:** (kelp) contain a lot of iodine. Region: harvested in Sanriku area (mainly north island Japon, but also some north of Fukushima, Miyagi and Kesennuma, Iwate - Sanriku) Season: May-September.

Fish:

- **Japanese sandlance**（コウナゴ）**:** very small fish (max 15cm), large schools by the sand, usually in spring (now- end of March to April-May), important food fish in Japan (with rice), very traditional. Region: Iwate, Ibaraki. (some info:http://www.fao.org/fishery/species/3261/en)
- Japanese sardine (Sardinops melanostictus マイワシ**):** spring-summer (March) they come to Japan, both close to shore and offshore, swimming quite close sea surface; one of most important commercial fisheries of Japan for sashimi and sushi. This species is mainly caught by "small pelagic purse seining". (till 24cm) (info at: http://www.fao.org/fishery/species/2893/en)
- **Achovy (Engraulis japonicus** カタクチイワシ**):** Marine, pelagic near the surface, mainly coastal, but to over 1,000 km from the shore, forming large schools, tending to move more northward and inshore (into bays and inlets) in spring and summer, but without well-defined migrations, on the surface, big schools, very important fishery for the area, fish food for population, small (max 16cm), purse seines, (contaminated offshore Ibaraki) (some info: http://www.fao.org/fishery/species/2915/en)
- **Fat greenling** *(Hexagrammos otakii あいなめ)*: demersal, 57 cm, rocky coastal areas. Season: spring (April-June best season) Location: any area close to coast – Iwate, Sanriku coast (http://www.fishbase.org/summary/speciessummary.php?id=6598)
- Pacific herring: Season April- June Region: Iwate
- Conger eel (*Conger myriaster* 穴子**):** ocean, demersal (300-800m), sandy muddy bottoms, out coast of Japan, highly commercial. Season: any season, best June-August. Areas: Chiba (Kaneda), Iwate, Kanagawa and Tokyo bay (http://www.fishbase.org/Summary/SpeciesSummary.php?ID=302&AT=conger+eel)
- Monkfish (Lophiomus setigerus)/angler fish: demersal, sandy mud bottom, 50-100m. Fishery: bottom trawling. Season: winter to spring (April – end of the season) Location: offshore coast Ibaraki Fukushima (Iwaki).

(http://www.fishbase.org/Summary/SpeciesSummary.php?ID=7517&genusname=Lophiomus&speciesname=setigerus),

- Pacific saury (also called mackerel pike or sanma in Japanese) (*Cololabis saira* さんま)- family Scomberesocidae. Max 40cm. Location: offshore, pelagic oceanic, usually near surface in schools. Sanriku area. Season: peak season September (migratory specie: these fish feed off in the seas near Hokkaido. By the time they return south to the fishing grounds in the seas off of Iwate in September and October). Common seafood in Taiwanese and Japanese meal. One of most important fish for Japanese fisheries. Testes by Chinese fishery agency on this fish for radioactive contamination. (info: http://www.fishbase.org/summary/speciessummary.php?id=303 or http://www.fao.org/fishery/species/3001/en)
- **Flounders** (Karei): live in the local coastal habitat, can be fished during this season, and important fishery target for local fishermen.
- **Soles** (Hirame)
- **Rockfish** (Mebaru): live in the local coastal habitat, can be fished during this season, and important fishery target for local fishermen.

Research goals

Scenario 1: research from RW inside 12 mile zone

Research goals (in order of importance):

- Determine at which locations radioactive nuclides have accumulated in which species of seaweed and what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis). Determine water and/or sediment contamination of sampling location (general Bq/kg analysis + I131 and Cs137 analysis).
- Determine at which locations radioactive nuclides have accumulated in which species of shellfish and in what quantities they are present. (general Bq/kg analysis + I131 and Cs137 analysis). Determine water and/or sediment contamination of sampling location (general Bq/kg analysis + I131 and Cs137 analysis).
- Determine in which fish species radioactive nuclides have accumulated and in what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis). Determine water and/or sediment contamination of sampling location (general Bq/kg analysis + I131 and Cs137 analysis).

Focus area (see appendix I for map of target area's):

- Seaweed sampling locations have to be determined based on local knowledge and available literature
- Shellfish sampling locations have to be determined based on local knowledge and available literature
- Fishing is the areas where most contaminated fish is caught (currently east of Iwaki 20 km out of the cost)
- fishing all along the 12 mile border from Chosi (35°43 N, 141° 7 E) to the border of the evacuation zone (37°2 N, 141°14 O)

Scenario 2a: research from RW outside 12 mile zone

Research goals (in order of importance):

- Determine in which fish species radioactive nuclides have accumulated and in what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis).
- Determine if seawater contains radioactive nuclides and in what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis). Compare with available data from Japanese authorities.

Focus area: (see appendix I for map of target area's)

- fishing all along the 12 mile border from Chosi (35°43 N, 141° 7 E) to the border of the evacuation zone (37°2 N, 141°14 O)
- water sampling in the corner between the 30 km border and MEXT measuring point 8 (37°00′N, 141°24′E)

- sampling of free floating sea weed in the whole area north of Chosi
- (water sampling in the area between MEXT measuring point 8 (37°00′N, 141°24′E), 9 and 10 (37°00′N141°05′E) and Hitachi (36°35′N)

Additional research options if weather conditions are bad and we cannot get to the focus area:
- fishing all along the 12 mile border from Kinkasan (38°03'N, 141°32'E) to the border of the evacuation zone (37°38'N, 141°17'E)
- water sampling in the corner between the 30 km border and MEXT measuring point 1 (37°40'N, 141°24'E)
- sampling of free floating sea weed in the whole area south of Kinkasan
- (water sampling in the area between MEXT measuring point 1, A and B and Kinkasan)

Scenario 2b: land based research using a chartered vessel

Research goals (in order of importance):
- Determine at which locations radioactive nuclides have accumulated in which species of seaweed and what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis). Determine water and/or sediment contamination of sampling location (general Bq/kg analysis + I131 and Cs137 analysis).
- Determine at which locations radioactive nuclides have accumulated in which species of shellfish and in what quantities they are present. (general Bq/kg analysis + I131 and Cs137 analysis). Determine water and/or sediment contamination of sampling location (general Bq/kg analysis + I131 and Cs137 analysis).
- Determine in which coastal fish species radioactive nuclides have accumulated and in what quantities they are present (general Bq/kg analysis + I131 and Cs137 analysis).

Focus areas (see appendix I for map of target area's):
- Seaweed sampling locations have to be determined based on local knowledge and available literature
- Shellfish sampling locations have to be determined based on local knowledge and available literature
- Fishing in the areas where most contaminated fish is caught (currently east of Iwaki up to 20 km out of the coast)

Equipment list

1) Gammaspectrometer [Berthold]
Can detect which isotopes are present in what quantities (Bq/kg) in various samples (water, sediment, food). Very low detection limit (1 Bq/kg), can analyse seawater samples with low contamination levels`
Location: GPJ office.

2) Bequerel monitor [Berthold]
Can detect what quantity radioactive material (Bq/kg) is present in various samples (water, sediment, food) but cannot identify which isotopes. High detection limit (20 Bq/kg), can analyse only seawater samples with high contamination levels.
Location: Rainbow Warrior

3) Portable gammaspectrometer [ICX Identifinder]
Can detect radiation levels (Sv/h) and analyse which isotopes are the source of the radiation. Can be determined in the field and underwater (up to 10 m).
Location: Rainbow Warrior

Research plan

NOTE: for specific sampling procedures see RSA protocol

Seaweed sampling:
1. Determine sampling location(s) (based on knowledge from local people on wild seaweed and at seaweed farms)

2. Measure and record radioactivity using portable gammaspectrometer
3. Collect samples of different seaweed species at spots with highest radioactivity / collect seaweed samples from the Rainbow Warrior
4. If possible, collect seawater sample at sample location
5. Collect sediment sample at sample location
6. Identify seaweed species and document weight, disintegration status and picture
7. Optional: Analyse seaweed samples on the spot using the Bequerel monitor
8. Optional: In case of high activity, analyse which isotopes are present using the portable gammaspectrometer
9. Store seaweed samples in the freezer
10. Analyse seaweed, sediment and water sample on shore using the Berthold gammaspectrometer

Shellfish sampling:

1. Determine sampling location(s) (based on knowledge from local people on wild shellfish and at shellfish farms)
2. Measure and record radioactivity using portable gammaspectrometer
3. Collect samples of different shellfish species at spots with highest radioactivity / collect shellfish when found on the shore
4. If possible, collect seawater sample at sample location
5. Collect sediment sample at sample location
6. Identify shellfish species and document weight, disintegration status and picture
7. Optional: Analyse shellfish samples on the spot using the Bequerel monitor
8. Optional: In case of high activity, analyse which isotopes are present using the portable gammaspectrometer
9. Store shellfish samples in the freezer
10. Analyse shellfish, sediment and water sample on shore using the Berthold gammaspectrometer

Fish sampling:

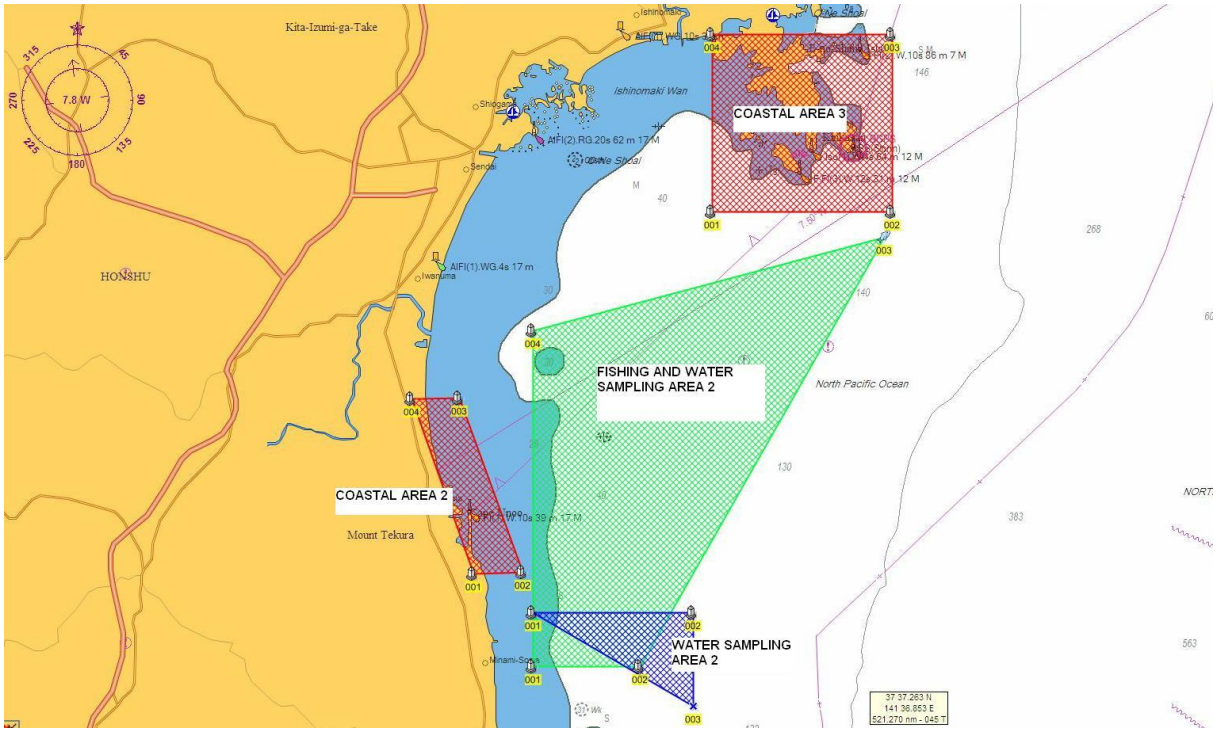
1. Define good fishing locations and periods (based on knowledge from Japanese fisherman and information on currents, sea temperature and currents)
2. Catch fish from the Rainbow Warrior, RIBs or chartered vessel using appropriate fishing method.
3. Purchase fish from local fisherman that are present in the area.
4. Identify fish species and document weight, length and picture
5. If possible, identify which part of this fish species accumulates most radioactive materials
6. Analyse previously determined parts of the fish using the Bequerel monitor
7. Analyse the whole fish using the Bequerel monitor
8. In case of high activity, analyse which isotopes are present using the portable gammaspectrometer
9. Store fish samples in the freezer
10. Analyse samples on shore using the Berthold gammaspectrometer

Seawater sampling:

1. Determine exact sampling location using portable gammaspectrometer
2. Take 1 litre water samples at a few different depths
3. Analyse water samples on board using the Bequerel monitor
4. In case of high activity, analyse which isotopes are present using the portable gammaspectrometer
5. Store water samples in the fridge
6. Analyse samples on shore using the Berthold gammaspectrometer

APPENDIX I

Target area's north of Fukushima:



Target area's south of Fukushima