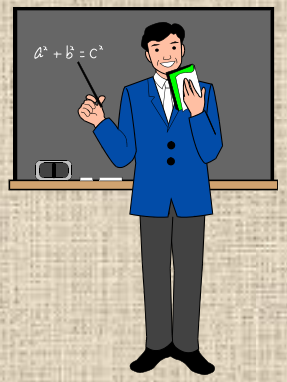
RADIATION IN ALASKA

....and the incident in Japan



- *Prepared by*:

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  Section of State Laboratories

  Alaska Department of Health and

  Social Services, Division of Public Health

- *Presentation August 17, 2012*

CREDITS – Thanks, to…

- State of Alaska, DH&SS, Labs (DH&SS)
- Conference of Radiation Control Program Directors
- Nuclear Regulatory Commission (NRC)
- Department of Energy (DOE)
- Environmental Protection Agency (EPA)
- Kathy Peavy, Marine Conservation Alliance Foundation
- Alpine helicopters,

Sendai, Japan - March 11, 2011

- Earthquake – major 9.0
- Tsunami – major flooding
- Reactor cooling failures -

DH&SS Involvement

Reactor failure – partial meltdown, and perceived possible consequences in Alaska if there were releases

-

Subsequent to that there have been releases to the air, ocean, and solid materials have crossed the ocean

First, a few definitions:

- What is "radiological"?

Radiological refers to any event involving radiation, including radioactive materials and/or machine sources.

- What is an "event"?

An event refers to any action that has caused significant effects on air, land, water, or the mindset of the affected community.

LEGAL DEFINITIONS

- A radiation accident is defined by federal agencies as an "incident involving a whole body dose of more than 25 rem (0.25 Sv), or partial body doses of more than 600 rem (6.0 Sv).
- NOTE: A *whole body* dose of 600 rem (6 Sv) is lethal if left untreated.

RADIATION or RADIOACTIVITY?

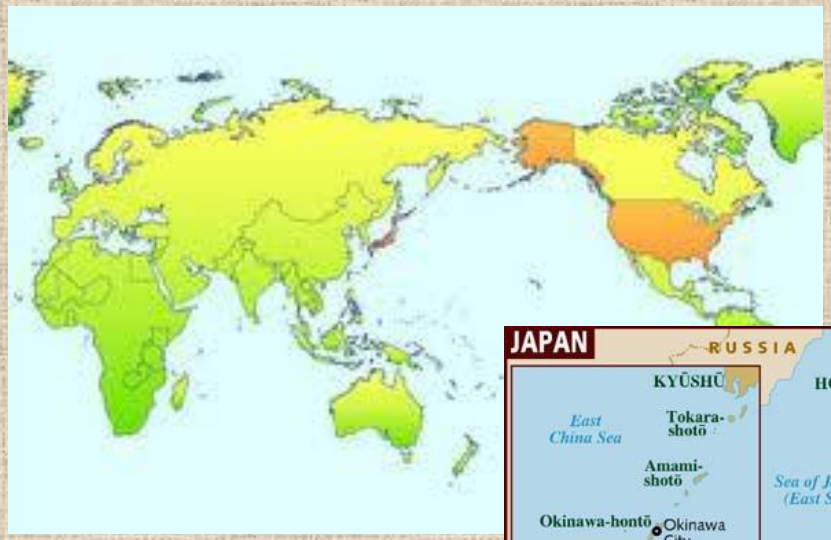
- In general, radiation refers to the energy or particles streaming from a device, which can be turned off. These are not radioactive materials.
- Radioactivity refers to disintegrating atoms which cannot be stopped from disintegrating, so they must be shielded. These are radioactive materials.

SUMMARY OF PAST EVENTS IN ALASKA

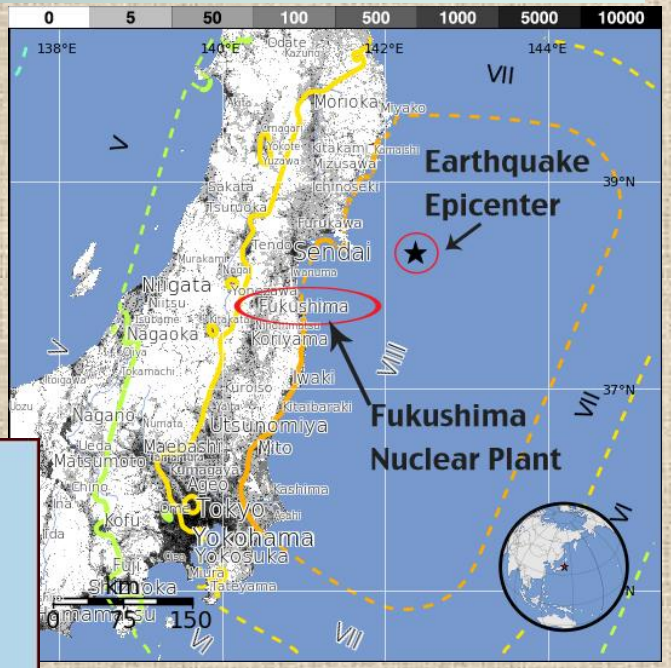
- B36 – 1950
- 131-I Experiments-1956
- Project Chariot-1959-62
- Amchitka Testing -1965-71
- Ft. Greely Reactor-62-72
- Chernobyl-April 4, 1986*
- Playground Pipe –June 1991
- Monitoring-1991-95
- RTG Generators-1992
- B61-11 Bomb-1997
- Tokaimura-9/1999*
- North Pole Fire-2001
- Pipe #2-August 2002
- Eagle - clocks – 2004
- Kotzebue – NPS – 2005
- Fukushima* - 2011

* *Events that happened outside Alaska, but affected Alaskans*

U.S, Japan - Map




JAPAN
RUSSIA
KYŪSHŪ
HOKKAIDŌ
East China Sea
Tokara-shotō
Amami-shotō
Okinawa-hontō
Okinawa City
Miyako-shotō
Yaeyama-shotō
Sapporo
Daisetsuzan National Park
Sea of Japan (East Sea)
Aomori
Niigata
Sendai
Noto-Hanto Peninsula
HONSHŪ
JAPAN
PACIFIC OCEAN
SOUTH KOREA
Matsue
Mt Fuji
TOKYO
Yokohama
Hiroshima
Kyoto
Osaka
Nagoya
Nagasaki
KYŪSHŪ
SHIKOKU
Kirishima National Park
Seagaia
See Inset
0 400 km
0 240 miles

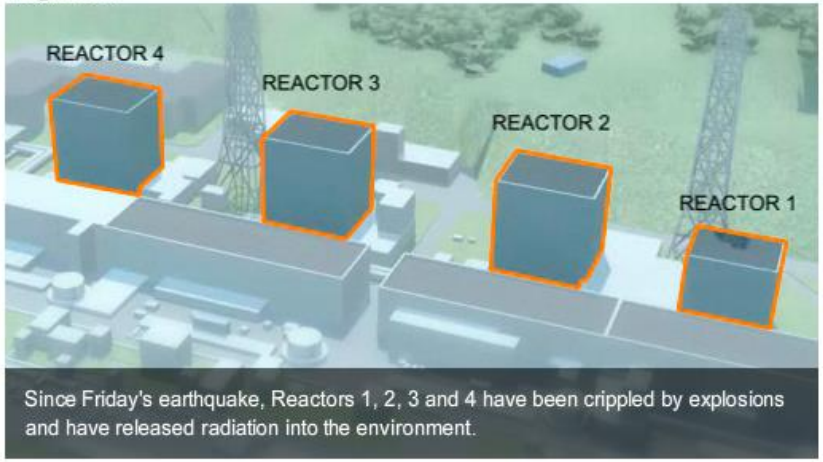

0 5 50 100 500 1000 5000 10000
138°E
140°E
142°E
144°E
39°N
37°N
Morioka
Earthquake Epicenter
Sendai
Niigata
Fukushima
Nagaoka
Koriyama
Iwaki
Fukushima Nuclear Plant
Nagano
Utsunomiya
Maebashi
Mito
Matsumoto
Tokyo
Yokohama
Yokosuka
Shizuoka
Hamamatsu
0 75 150
km

Fukushima Daiichi Nuclear Plant

Published: March 15, 2011

Accident at Fukushima Daiichi Nuclear Plant

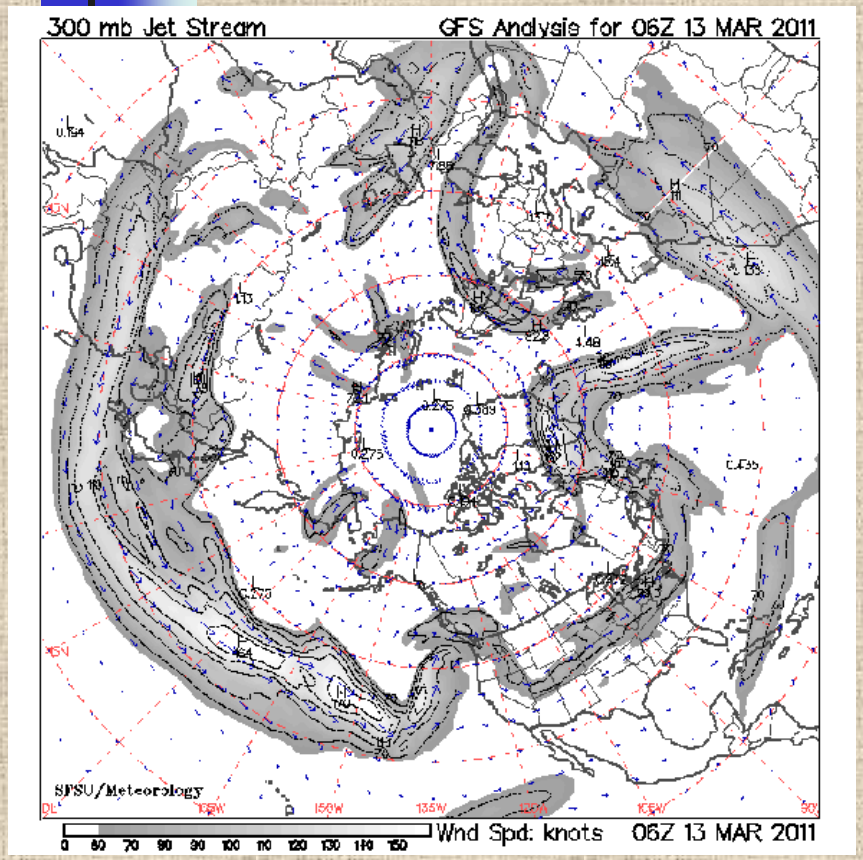
The worst nuclear accident since the Chernobyl explosion in 1986 is unfolding in nor at the Fukushima Daiichi power plant. Three reactors have been critically damaged a caught fire.

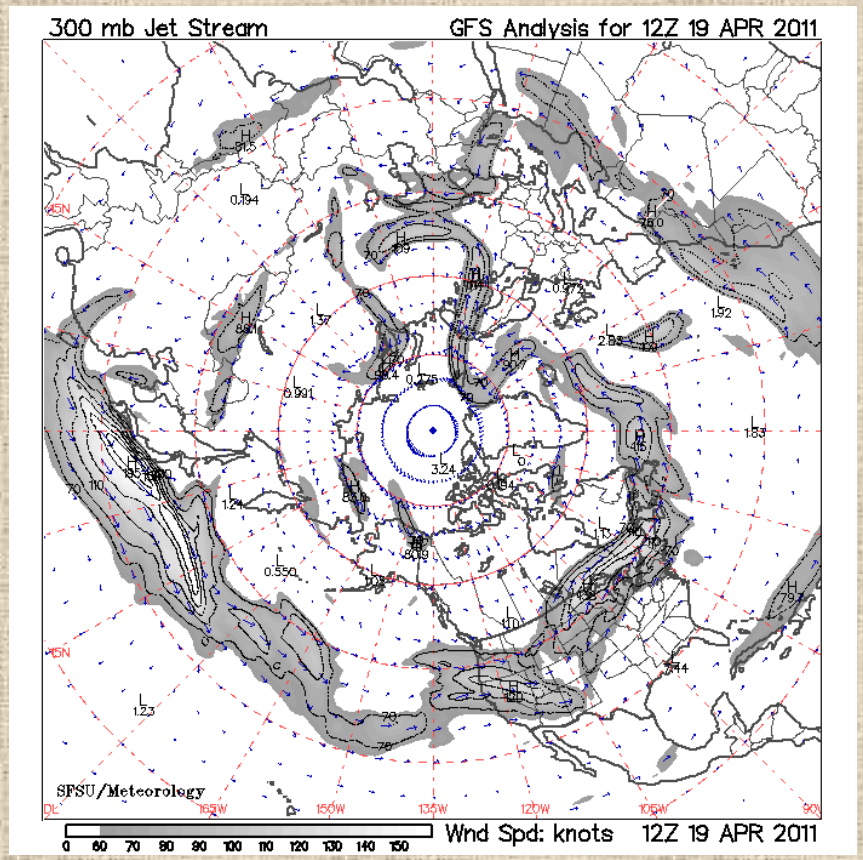


Since Friday's earthquake, Reactors 1, 2, 3 and 4 have been crippled by explosions and have released radiation into the environment.

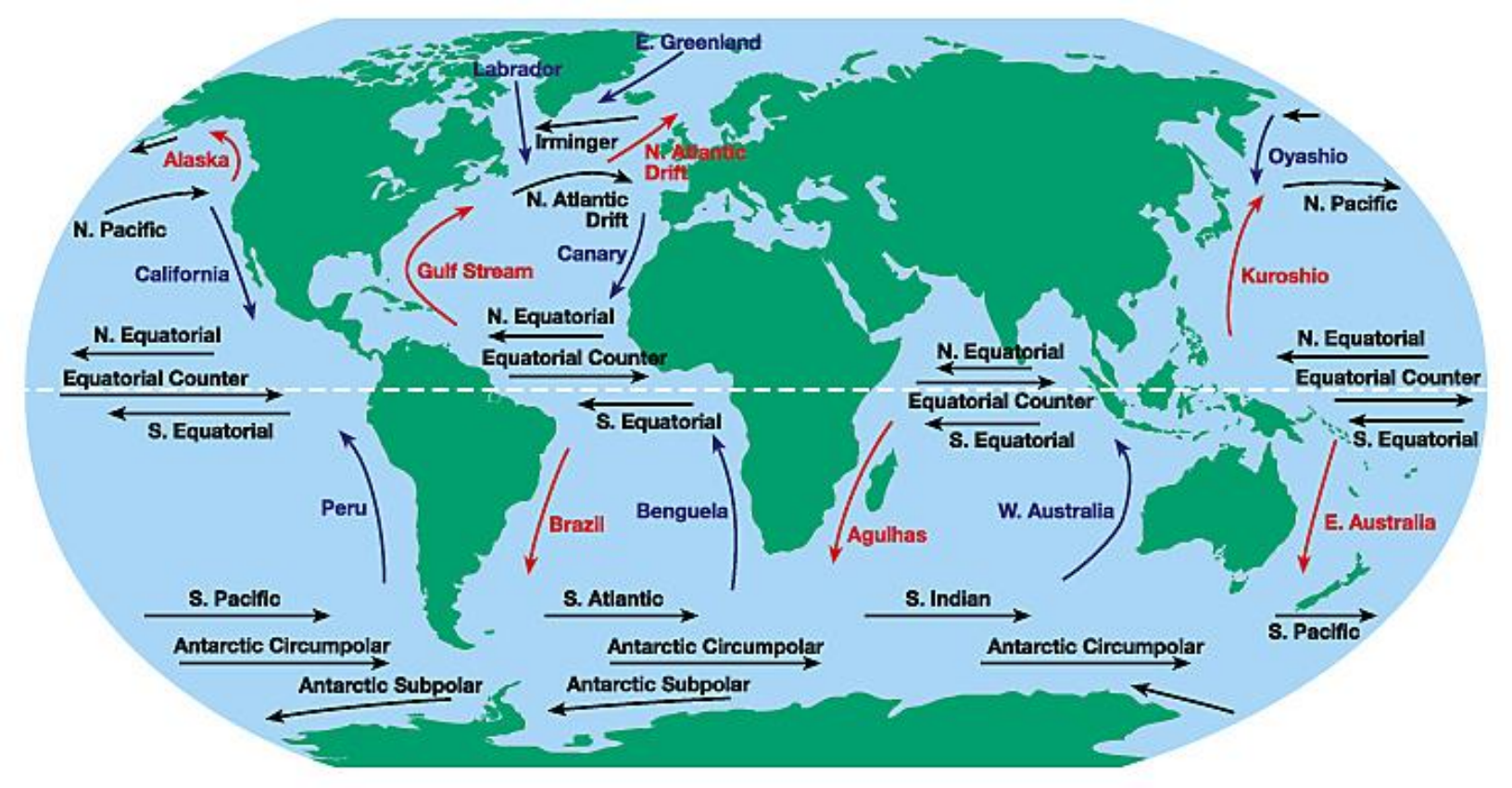
1 2 3 4 5 6 7 8 NEXT

CURRENTS – JET STREAM





CURRENTS - OCEAN

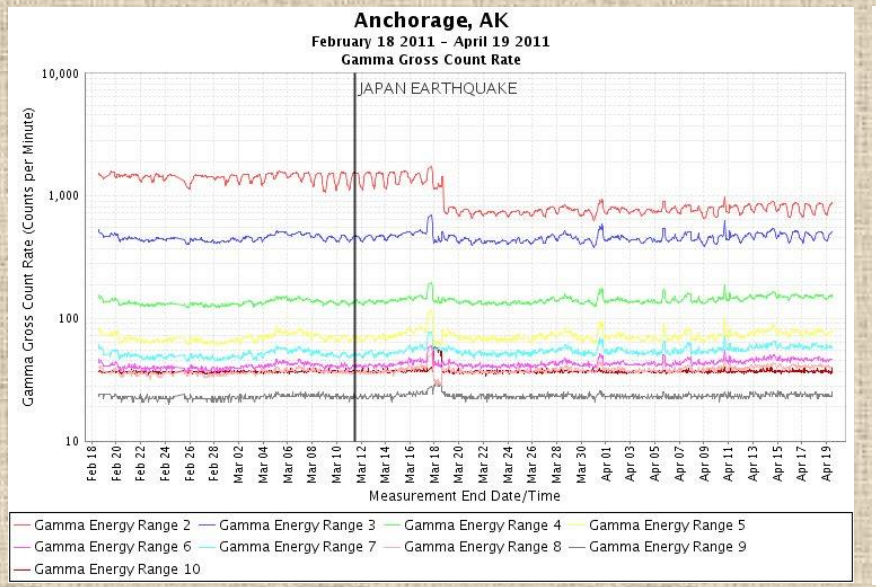


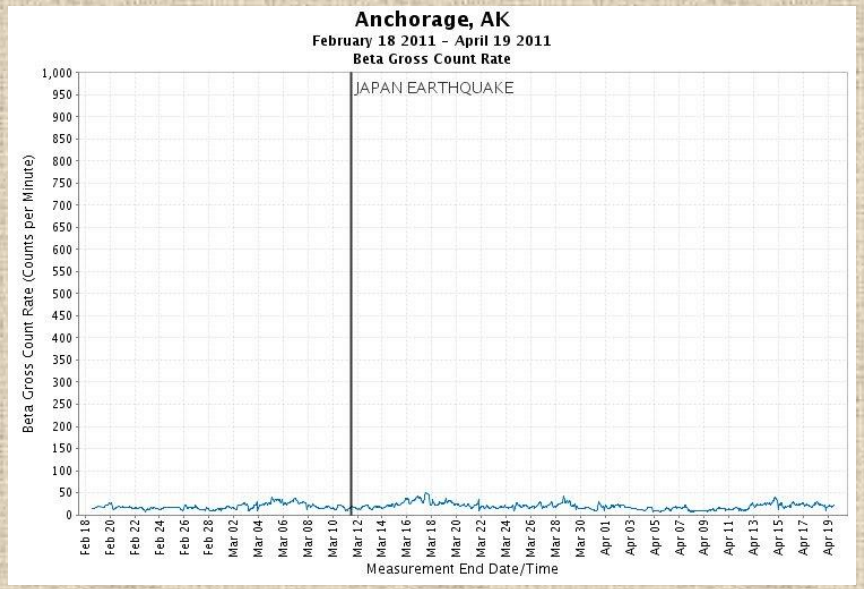
COMPARATIVE DISTANCES

- Sendai to Los Angeles - 5,336 miles
- Sendai to San Francisco - 4,995 miles
- Sendai to Honolulu - 3,791 miles
- Sendai to Anchorage - 3,284 miles
- Sendai to Dutch Harbor - 2,666 miles
- Sendai to Adak - 2,241 miles
- Sendai to New York City - 6,735 miles

MONITORING

Monitoring results – Anchorage

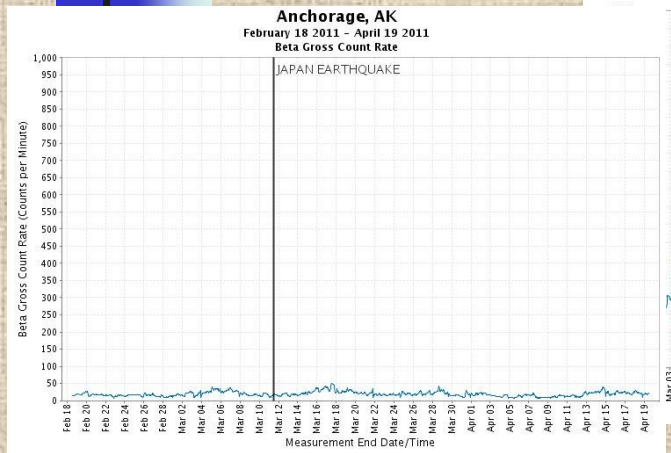


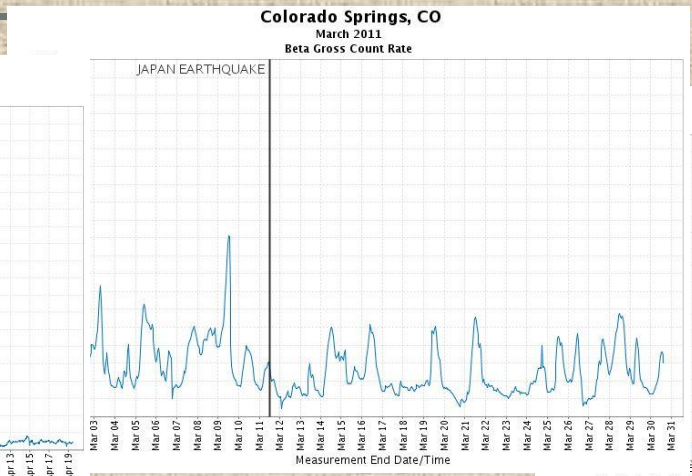


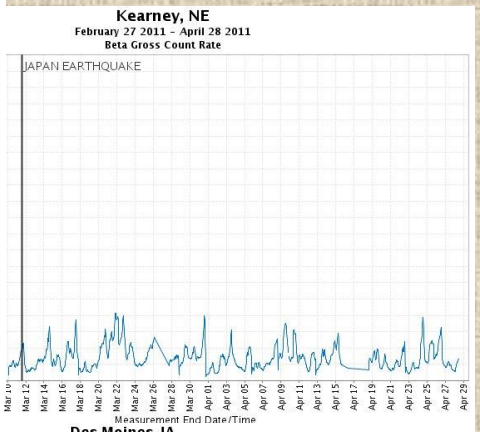
Gamma

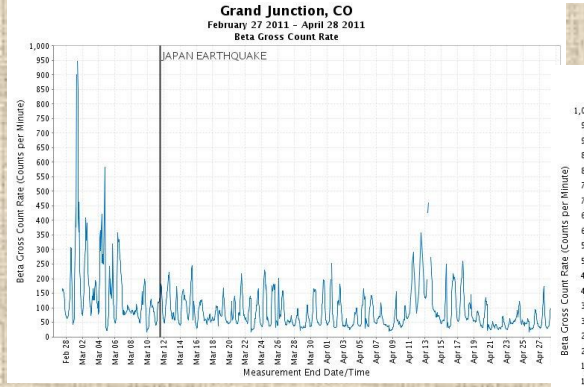
Beta

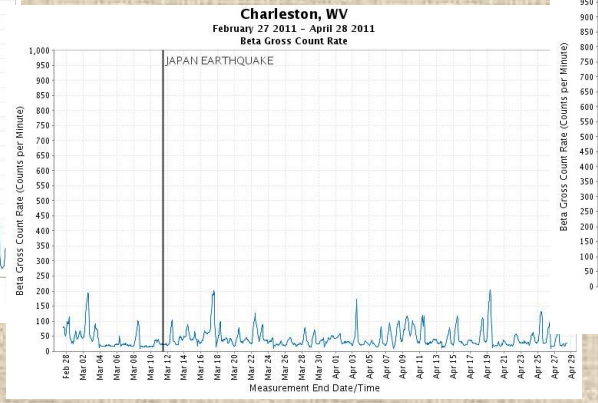
SAMPLES OF BETA RESULTS IN OTHER STATES. . . .

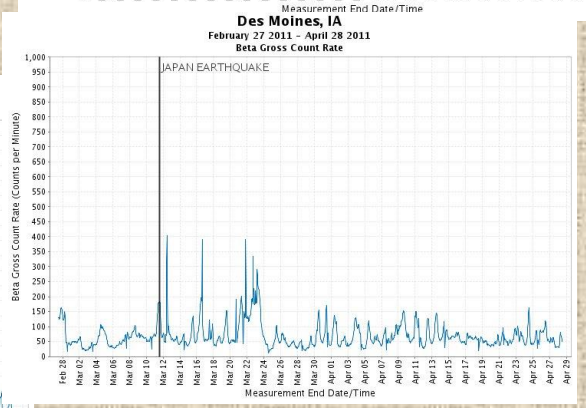




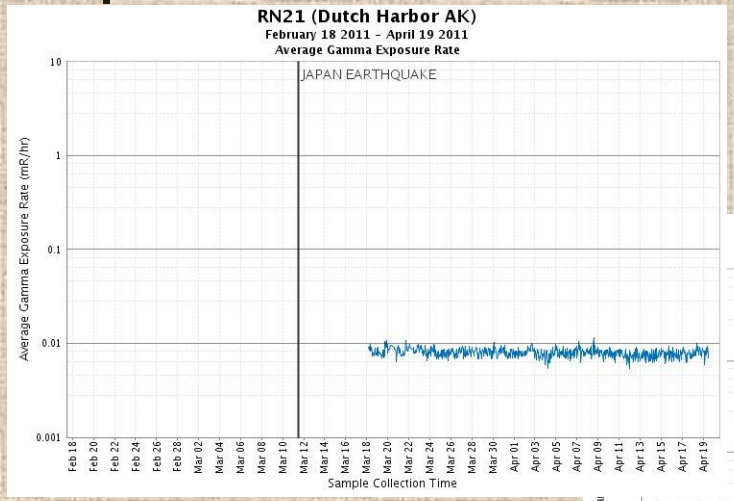


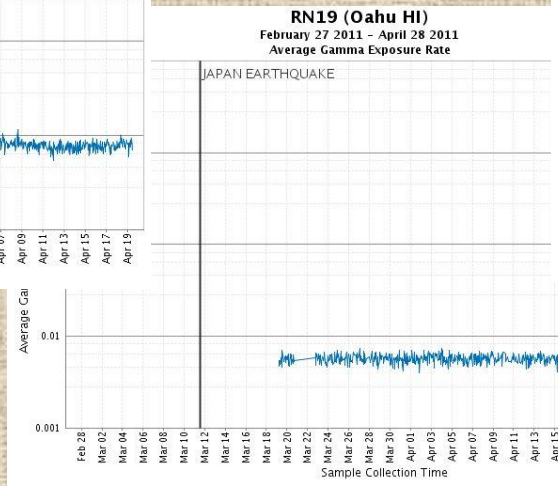


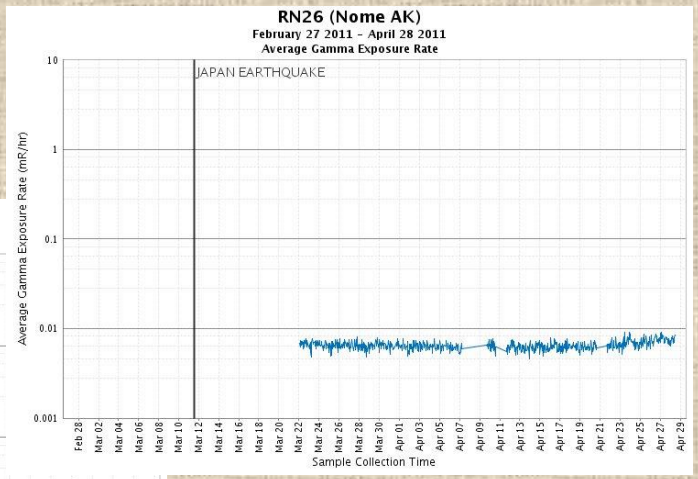




RAD NET Results – Mobile







INTERNATIONAL NUCLEAR EVENT SCALE

- Level 7 **MAJOR ACCIDENT**
  - *Chernobyl 1986*
  - *Fukushima 2011*
- Level 6 **SERIOUS ACCIDENT**
  - *Kysthym NFRP 1957*
- Level 5 **ACCIDENT WITH OFF-SITE RISK**
  - *Sellafield NR 1957*
  - *TMI 1979*
  - *Tokaimura 1999*
- Level 4 **ACCIDENT W/O SIGNIFICANT OFF-SITE RISK**
  - *Sellafield 1973*
  - *Jaslovske B. 1977*
  - *St. Laurent 1980*
- Level 3 **SERIOUS INCIDENT**
  - *Vandellos 1989*
- Level 2 **INCIDENT**
- Level 1 **ANOMALY**
- Level 0 **NO SAFETY CONCERN**

Radiation Units -

- Roentgen – Of interest only to physicists
- Rads and Grays – Absorbed dose, most useful for describing partial body exposures
- Rems and Sieverts – Equivalency unit, useful for describing whole body exposures
- Curies and Becquerels – Indicate number of atoms disintegrating, but reveal little about the exposure dose or internal exposure received from a radioactive material

RADIATION & RADIOACTIVITY "DOSE"

- The term "Dose" is used in many ways with respect to radiation, which causes some confusion. Examples:
  - **Exposure dose – measured in rads, rems,**
    - **(Actually, there are ten different variations)**
  - **Activity dose – measured in curies, Becquerels**
  - **Volume dose – measured in ml or cc**
  - **Chemical dose – quantity of a given chemical per volume of compound (measured in mg or ug)**

RADIATION

Type		a.m.u.	Charge	Effect
Alpha	(α^+)	+4	+2	A↓4, Z↓2
Beta	(β^-)	1/1836	-1	A n.c., Z↑1
Neutron	(n°)	≈ 1	0	A↓1, Z n.c.
Fission	($\nearrow\searrow$)	varies	varies	A↓, Z↓
Gamma (X-rays)	(γ)	0	0	No change in Mass or charge

ELEMENTS & NUCLIDES

Of the 2,683 different known *un*stable nuclidic species……

- The number of radionuclides with a half-life > 1 day is about 370
- There are approximately 300 different radionuclides that make up the radiological fission products of a nuclear detonation. Cs-134 is a marker.

HOW DEADLY IS IT?

(Deaths in U.S., 1999)

- Heart Disease 725,000
- Malignancies 550,000
- Smoking 400,000
- Iatrogenic disease 250,000
- Radiation (Gofman) 250,000
- Cardiovascular 167,000
- Chronic Lung 124,000
- Influenza 94,900
- Diabetes 65,000
- Motor vehicles 43,200
- Suicide 29,300

(*NSC, CDC, Internet*)

- Staph infections 20,000
- Radiation/radon-EPA 20,000
- Foodborne deaths 5,000
- Choking (food) 1,800
- Airline accidents 487
- E. coli infection 60
- Lightning 48
- Insect stings 40
- Avalanche 32
- Radiation/REAC/TS 30
- Shark attacks (US) 2
- Sunlamp UV exposure 1*

**Excludes delayed possible cancer deaths*

COMPARATIVE EXPOSURES

Radiation Source Exposure (mSv)

Japan - contamination in AK	0.000000000002
Background - All sources – Alaska	6.2
TSA - Airport Scanner - claimed	0.00002/scan
Transcontinental flight	0.2/flight
DEXA scan	0.001/scan
Chest x-ray (trained operator - AK)	**0.09**
Mammogram	0.04
Chest x-ray (un-trained operator)	**5.4**
Barium enema	7.0
CT abdomen	10.0
Coronary angiogram	8-60.0
Japan - 3 workers	170-180
Radiation sickness	1,000
Death	6,000

RADIATION IS WHERE YOU FIND IT…

- Hospital imaging
- Dental
- Radiation therapy
- Industrial radiography (oil Companies)
- School science labs
- Airport baggage
- Cruise ship baggage
- Federal offices
- Electron microscopes

- Consumer Products
  - Ceramic dishes
  - Welding rods
  - Watches & clocks
  - Glues
  - Shift quadrants
  - Fertilizers
  - Camp light mantles
  - Aircraft instruments
  - Building materials
  - Loss Prevention tags

RADIATION IN OUR ENVIRONMENT

- Air, soil, water
- Medical
- In our body normally
- Consumer products
- Found naturally in foods
- Irradiated foods
- Cosmic, terrestrial, and primordial

Consumer products

- Coleman lantern mantles
- Fiesta ware, Vaseline glass, other ceramic products
- Luminous wrist watches
- Welding rods
- Wood glue
- Marble counter tops
- Certain fruits and nuts - bananas, almonds
- Fertilizers (high phosphate)
- Instrument dials
- Jewelry
- Clay figures from South America
- Radon gas from the ground
- Television sets
- Airport scanners and baggage systems
- Tobacco products
- Eyeglasses
- False teeth
- Aircraft counterbalance weights
- Lead protective aprons

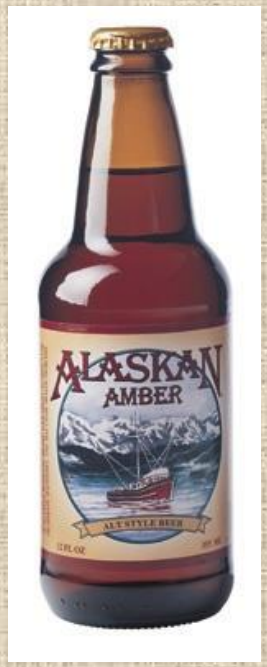
Foods

- *Naturally radioactive**
  - *Bananas (3,520 pCi)/kg*
  - *Brazil nuts (6,000 pCi)/kg*
  - *Carrots (3,400 pCi)/kg*
  - *White potatoes (3,400 pCi)/kg*
  - *Beer (390 pCi)/kg*
  - *Red meat (3,000 pCi)/kg*
  - *Lima beans (4,640 pCi)/kg*
  - *Water (0.17 pCi/kg)*

*All the above, except the beer, also contain radium

- *Irradiated*
  - *Meat, poultry*
  - *Grains, cereals*
  - *Fruits*
  - *Onions, carrots, potatoes, ginger*
  - *Mangos, papaya, guava*
  - *Fish, seafood*
  - *Spices*
  - *Low sodium salt*

… a “hot” meal…



I have a meal of:	Calories	Fat- gm	K-40	Ra-226
hamburger sandwich (4 oz)(beef)	510	26	336	0.056
Medium fries **(potato)**	380	19	398	0.117
Reg. **beer** (12 oz.)	153	0	131	
Banana split desert	1030	39	370	0.105
Totals	2073	84	1235	0.278

…so I had a single meal that included 1235 pCi of potassium 40 and 0.28 pCi of radium-226.

As an afternoon snack If I also ate 4 oz of brazil nuts, my radioactive material intake for the afternoon would be boosted to:

1862.2 pCi potassium 40 (1.86 nanocuries) **190**.678 pCi radium 226.

OR a grand total intake for the day of 2.053 nCi (*2053 pCi*)

The tuna found in California contained 4.2 pCi/kg of cesium-137

Typical radionuclides found in a 70 kg human body (YOURS)

- Uranium (30 pCi)
- Thorium (3 pCi)
- Potassium 40 (120 nCi)
- Radium (30 pCi)
- Carbon-14 (0.1 uCi)
- Tritium (H-3) (0.6 nCi)
- Polonium (1 nCi)

ACUTE BIOLOGICAL EFFECTS of RADIATION (Threshold, non-stochastic, or Deterministic)

- Erythema
- Epilation
- Desquamation
- Coma
- Death

- Acute Radiation Syndrome (ARS)(Nausea, vomiting, diarrhea)

WARNING!

Graphic Images of Short term (acute) radiation injury.

NOTE: These Injuries are all *IATROGENIC in nature*!

ACUTE RADIATION INJURY – MEDICAL *DIAGNOSTIC* PROCEDURES

WHOLE BODY ACUTE EXPOSURE EFFECTS

- 20 R — Increased chromosome aberrations
- 20-50 R — Lymphopenia, neo-natal effects
- 100-300 R — Nausea, vomiting, fatigue (ARS)
- 200 R — Neoplastic changes
- 350 R — Erythema
- 450 R — LD 50/30, epilation, sterility
- 500 R — Cataracts, diarrhea
- 600 R — 100% lethal if untreated
- 1000 R — Severe GI damage
- 3000 R — Neurovascular Damage

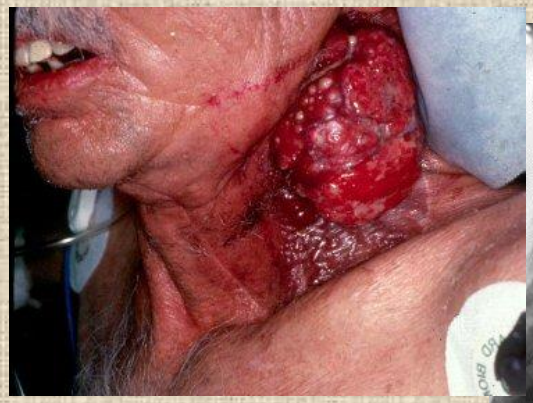
LONG TERM (CHRONIC) BIOLOGICAL EFFECTS (Non-threshold, stochastic, probabilistic)

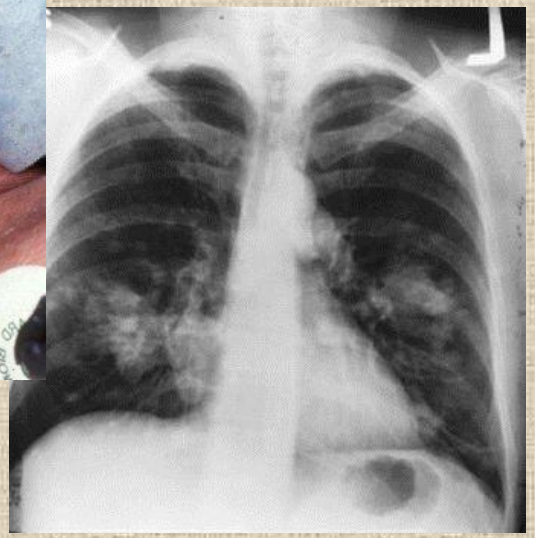
- Life span shortening
- Genetic Mutations(?)
- Cancer
  - **Leukemia**
- Cataracts
- Reduced intellect

WARNING!

Graphic images of long term radiation injury

LONG TERM RADIATION EFFECTS





UNCERTAINTIES RE: EXPOSURE

- Quantity of exposure
- Energy of the radiation
- Latent period and delayed effects
- Size and volume of area exposed
- Specific type of tissue exposed
- Oxygenation of tissues
- Fractionation
- Age and gender
- Individual idiosyncrasies
- Type of radiation
- Synergism

LAW OF BERGONIE & TRIBONDEAU *France- 1906*

- Varying sensitivities of different tissues

(a). Stem (immature) cells are more radiosensitive than mature cells.

(b). Younger tissues and organs are more radiosensitive than older ones.

(c). Radiosensitivity increases as the level of metabolic activity of the body increases.

(d). As cell proliferation rate and tissue growth rate increase, radiosensitivity also increases.

What is the difference between a radiological event and a media event?

A Medical CT abdomen exam is reported to expose a patient to 10.0 mSv of x-rays.
10 millisieverts = 10,000 micro-sieverts
10,000,000 nano-sieverts =
10,000,000,000 pico-sieverts

A Medical lung study in nuclear medicine used 200 microcuries of 131-radioIodine tagged to MAA*.
200 microcuries = 200,000 nano-curies
= 200,000,000 picocuries
Radioiodine-131 was detected at some monitoring stations ranging from 0.1 to 2 pico-curies.

Radio-iodine 131

From the late 1950's until the late 1960's radio-iodine 131 was deliberately administered to patients for medical imaging studies of virtually every part of the body. It was plentiful, cheap, and safe relative to other radioactive materials. It is still used today for some nuclear medicine studies and thyroid treatments.

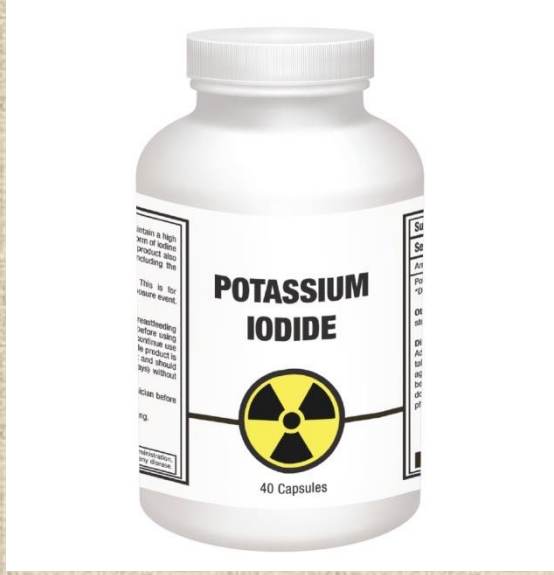
"Alaska's Dutch Harbor shows highest radiation in U.S." from Japan crisis

By Richard Mauer | The **Anchorage Daily News**
Published: March 30th, 2011 05:16 PM

During the worst week of the Japanese nuclear crisis, the EPA's radiation monitor in Dutch Harbor recorded the highest levels of radioactive iodine fallout in the United States among reporting stations, the agency said.

Despite the relatively high levels in the Aleutian Island community on March 19 and 20, state and federal health officials continued to say Tuesday that the amounts of radioactive byproducts were way too small to pose a health risk. [*NOTE: All above is absolute B.S.*]

Potassium Iodide ("KI")
(The "radiation pill")



KI Dosing Schedule - CDC

	Predicted Thyroid gland exposure (cGy)	KI dose (mg)	Number or fraction of 130 mg tablets	Milliliters (mL) of oral solution, 65 mg/mL	Proportion of Adult KI Dose
Adults over 40 years	≥ 500	130	1	2 mL	100%
Adults over 18 through 40 years	≥ 10	130	1	2 mL	100%
Pregnant or Lactating Women	≥ 5	130	1	2 mL	100%
Children 1 month through 3 years	≥ 5	32	Use KI oral solution	0.5 mL	25%
Infants birth through 1 month	≥ 5	16	Use KI oral solution	0.25 mL	12%

Potassium Iodide

- One element (iodine)
- One gland (thyroid)
- One significant disease ("possible" increased cancer risk)
- Only useful if gland is not already saturated (metabolic)
- Lactating breasts release up to half the ingested iodine
- Untoward effects (some mimic radiation over exposure)
- Some individuals cannot tolerate at all (anaphylactic shock)
- Entire rest of body is still irradiated
- Cancer, if it develops, has a Long latent period (20+ years)

Activity vs. Exposure

Activity = number of *atoms* disintegrating per second

Exposure = amount of *energy* deposited in tissues

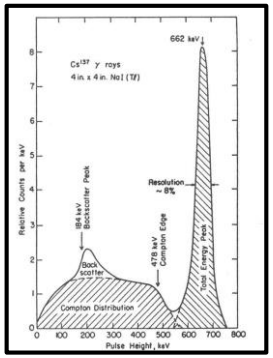
GM Survey Meters w/Probes

Personnel Monitoring Devices

SpecTech UCS-20 and well counter

Analysis of Scintillator Peak - 1

- **NaI (Tl) scintillation peak for Cs-37: 662 keV**
- **Large crystal: 10x10 cm**
- **Only photons that lose**
  y (i.e. Compton
  final
  ctric event)
  te to the "Total
  Peak"



LEVELS OF CONCERN

- Legal limits for RAM out-of-control
  - Exposure – 2 mR line (0.002 R/hr)
  - 100 mR/year to the public
- Biological limits – Emergency 80 R WB
- Package limits of concern in terms of risk - - >200 mR/hr surface, >10 mR/hr @ 1 meter
- Package limits for contamination > 2200 dpm or >0.001 uCi (swipes)

INSTRUMENT LIMITATIONS

- Long response time
- Paralyzable (dead time)
- Energy dependent
- Speed of scan
- Distance of detector
- Directionality
- Geotropism

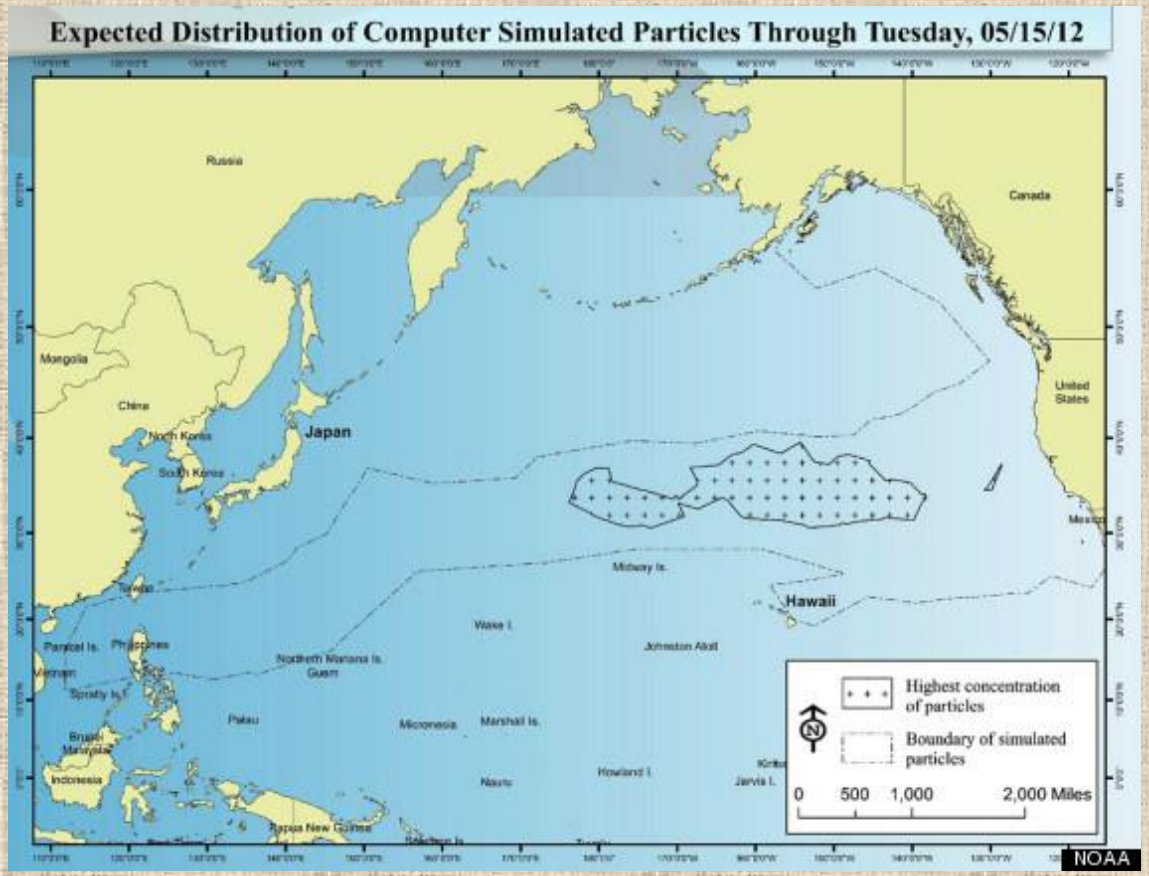
CHARACTERISTICS OF SELECTED RADIOACTIVE MATERIALS

Iodine-131	**Cesium-137**	**Cobalt-60**
Γ 2.2	Γ 3.3	Γ 13.2
HVL 0.23	HVL 0.65	HVL 1.2
SpA 1.25E5	SpA 8.7E1	SpA 1.13E2
d 4.93	d 1.87	d 8.9
T½ 8.02 days	T½ 30.07 yrs	T½ 5.27 yrs
4.54E8 Ci/gal	3.16E5 Ci/gal	4.10E5 Ci/gal
9.99E8 R/hr	1.04E6 R/hr	5.41E6 R/hr
2,000,000	1,404	1,822

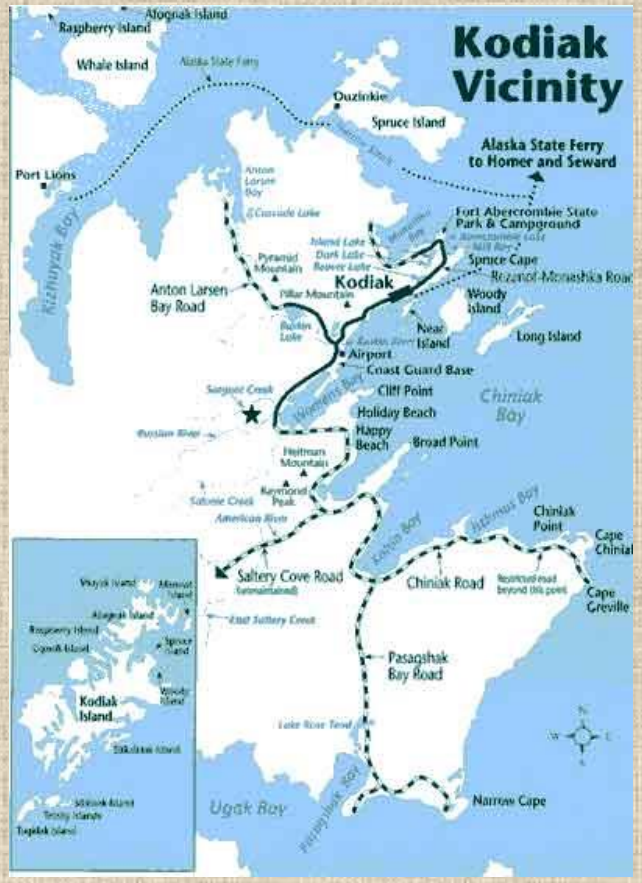
Specific Activity Examples

Nuclide	$T_{1/2}$	Mass	SpA Ci/gm
Tc^{99m}	6 hours	99	5,276,094
I^{131}	8 days	131	125,000
Ir^{192}	74 days	192	9191
Co^{60}	5.27 years	60	1131
Sr^{90}	28.8 years	90	138
Cs^{137}	30 years	137	87
Pu^{239}	24,100 years	239	0.062

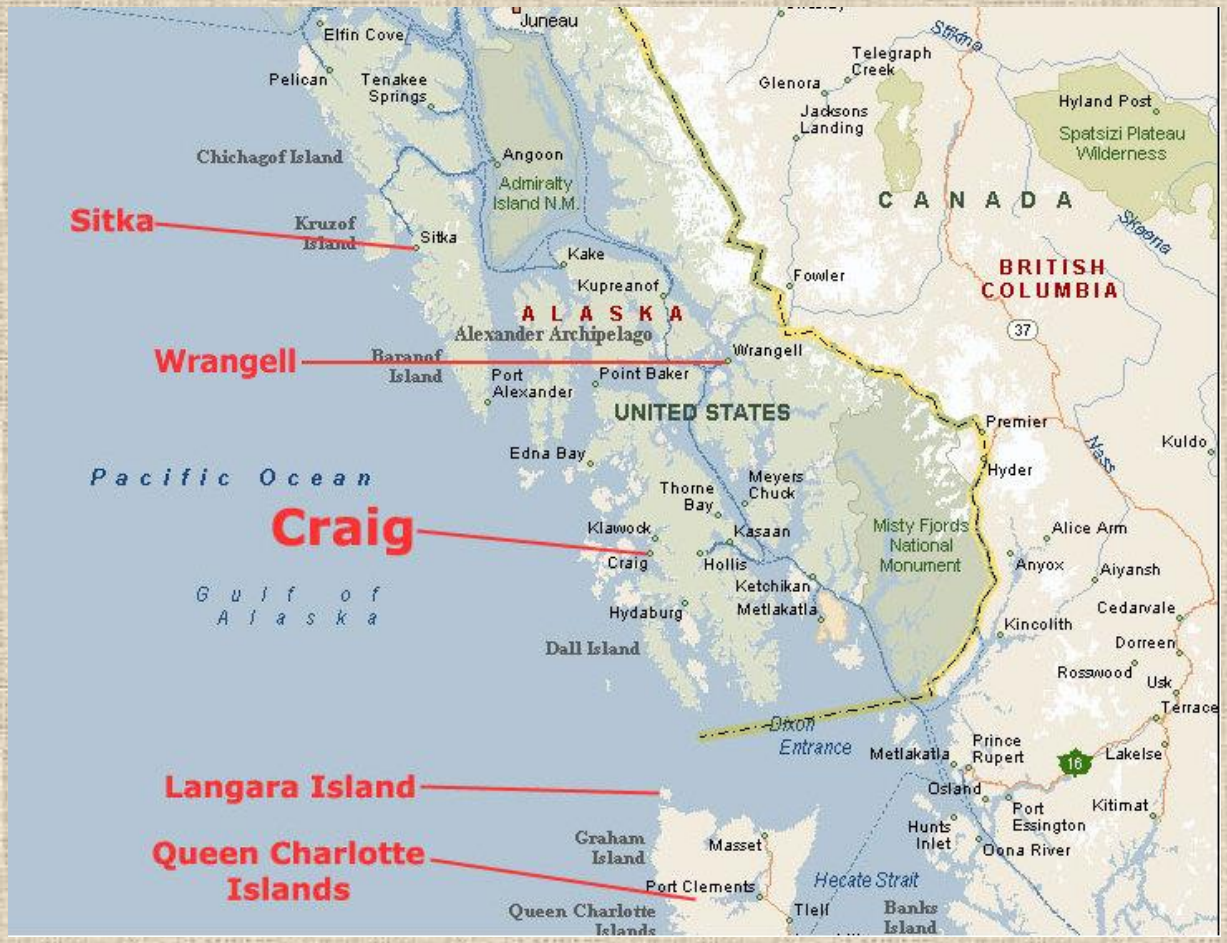
Tsunami Debris Distribution



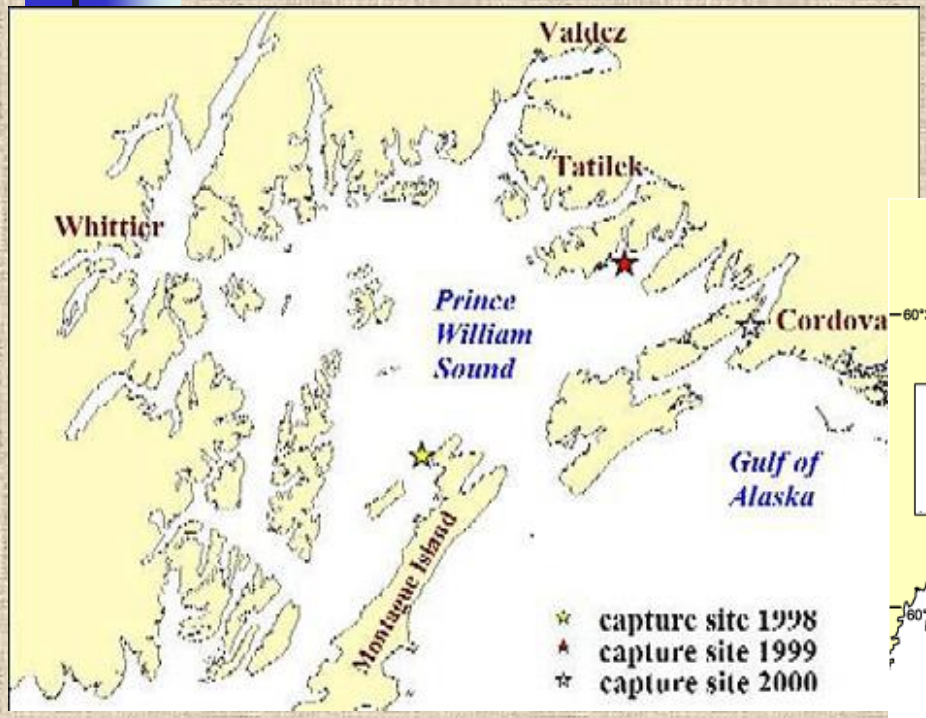
KODIAK ISLAND

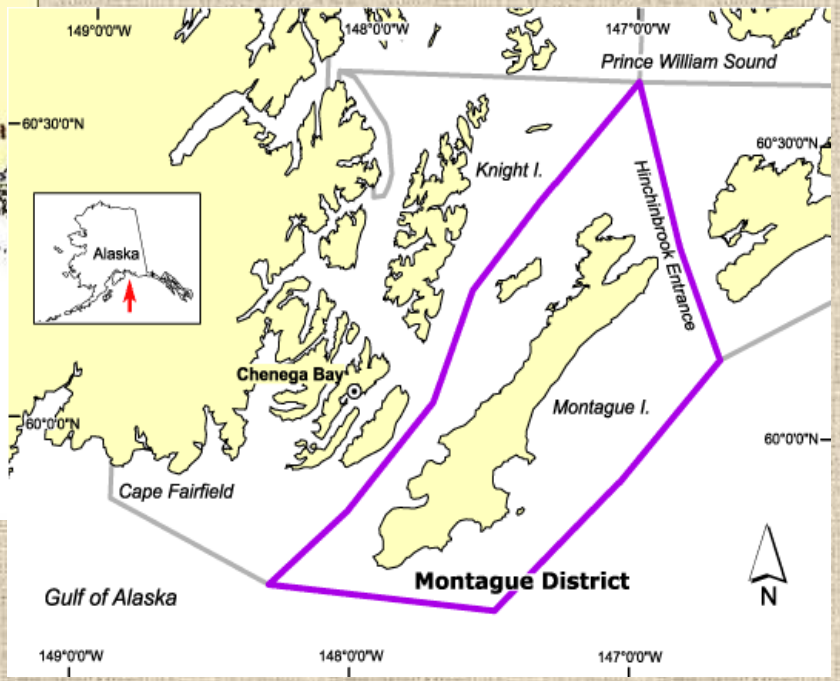


CRAIG (Prince of Wales Island)



Montague Island (PWS)





Montague Island Debris

Bull kelp . . . .

PROTECTION AGAINST RADIATION INJURY

Three fundamental principles

- Time
  - Procedural time, flush out
- Distance
  - Standing distance, tongs, shielding
- Shielding
  - Lead, Dirt, concrete, steel

THE END

REALLY “the end”