Amchitka Expedition Update:
Initial Specimen Screening and Future Laboratory Testing

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Introduction

The *Amchitka Independent Assessment Science Plan* (June 24, 2003) was developed by CRESP to assess, for Native Communities, the U.S. Fish & Wildlife Service, the Alaskan Department of Environmental Conservation, U.S. Department of Energy and other stakeholders, whether there are currently increased radiation health risks related to underground nuclear test shots to organisms residing around Amchitka Island and to consumers of these organisms. It will also provide a baseline of biological and other data that should aid in the development of a long-term stewardship plan.

The *Amchitka Expedition Summary* (June 10, 2004) described the basic hypotheses that CRESP would be testing and the implementation plans it would be pursuing in furtherance to the Science Plan, beginning with the collection of extensive physical and biological samples on Amchitka and Kiska (reference site) and in the waters that surround them between June 12 and August 8. Much of this work was carried out with a research team of 25 and a six-man crew aboard the *Ocean Explorer*. Additional marine samples were collected with the assistance of a NOAA trawling expedition during the same time frame. Complete copies of the Amchitka Independent Assessment Science Plan and the Amchitka Expedition Summary are available for download on the CRESP web site (www.cresp.org).

This *Amchitka Expedition Update* will discuss the samples and other data collected by the CRESP expedition teams, and provide an overview of specimen testing, data management and quality assurance programs currently being undertaken by the joint CRESP team at Rutgers University, Vanderbilt University, University of Medicine & Dentistry of New Jersey and the University of Pittsburgh, and through the use of INEEL as an independent testing laboratory.

Purpose and Scope

There is public and agency concern that residual radionuclides from nuclear tests may enter the marine food chain causing ecological and human health effects. The specific objectives of the Science Plan are:

- To determine whether or not radionuclide releases from the shot cavities to the marine environment pose significant risks to human health and the ecosystem.

- To reduce uncertainty about the extent of the hazard and nature of the risks to human health and the ecosystem associated with any potential current or future radionuclide release to the marine environment, and the factors that may affect such risks.
- To devise and communicate an appropriate basis for a monitoring plan that would detect potential significant future risks to human health and the marine ecosystem as early as practical.

Central to this effort is sampling of marine biota, with particular reference to the food web and potential exposure to humans and other important ecological species, particularly those at high trophic levels. The CRESP field expedition, conducted in collaboration with people of the Aleutian area and coordinated with ongoing field studies under the auspices of Aleutian/Pribilof Islands Association (A/PIA) and the State of Alaska, sought to address four major questions:

1. Are the marine foods safe to eat with respect to radionuclides?
2. Within the context of available data from eco-receptors, is there any indication that biota are at risk from radionuclides?
3. Can the data from the study be used to determine which species are the best bioindicators to be used to design future monitoring, and
4. If the full range of physical and biological data obtained from the expedition that indicates radionuclides above background, can we attribute increased levels of radionuclides to a particular source?

Our results represent only one point in time.[1] Within a context of multiple species, multiple locations within Amchitka transects and the reference site, and multiple radionuclides, some of the possible outcomes from this single expedition are given below:

1. Results are indistinguishable for all radionuclides in comparison to other Amchitka sampling locations, off-site reference site(s) or relevant literature values.
2. Some radionuclides exhibit elevated levels near Amchitka but are below thresholds of concern to human health and the ecosystem and the source of elevated levels is unknown.
3. Some radionuclides exhibit lower levels near Amchitka but are below thresholds of concern to human health and the ecosystem, and the reasons for the decreased levels are unknown.
4. Some radionuclides exhibit elevated levels near Amchitka and are above thresholds of concern for ecosystem impacts but below thresholds of concern for human health, and the source of elevated levels is unknown.
5. Some radionuclides exhibit elevated levels near Amchitka and are above thresholds of concern for ecosystem and human health, but the source of elevated levels is unknown.

[1] Only a long-term bio-monitoring plan would provide needed information over time.

6. Some radionuclides exhibit levels above thresholds of concern for ecosystem impacts and human health, but results are indistinguishable amongst the Amchitka sites and the reference site.
7. Any of cases 1-5 above, but the isotopic signature suggest Amchitka as the source.
8. Any of cases 1-6 above, but the isotopic signatures suggest a source other than Amchitka test shots.
9. Any of cases 1-6 above, but the isotopic signatures suggest both Amchitka test shots and other sources of radionuclides are contributing to the levels found.

The project's biological sampling and laboratory programs were designed to provide results that would be scientifically defensible and relevant under any combination of potential outcomes envisaged above.

Biological Samples

The expedition's field sampling plan was designed to do three things: 1) assess the current risk to the organisms in the marine ecosystem (from Kelp to eagles, seabirds, mammals, and top-predatory fish), 2) assess current risks to humans, and 3) collect sufficient information on radionuclides to help select bioindicator organisms for a long-term biomonitoring plan. The sampling plan was comprehensive, and recognized that top-trophic level species are indicators of bioaccumulative contaminants (e.g. strontium, cesium). Further, it is largely the top-trophic level organisms that the people eat. Each of the species groups within these top-trophic levels is important, and tells us something different about the food web, potential radionuclide distribution in the marine ecosystem, and potential human exposure.

Physical Data

As more fully discussed in the *Science Plan*, the potential exists for radionuclides from the test shots to be carried into the marine environment by freshwater through seeps along faults and fractures, or by diffuse flow. The exact location of where these seeps or discharges may meet the marine environment, and thus the exposure pathway through the food chain to top-trophic level organisms, is extremely important to evaluate. Moreover, because this is an area of extensive tectonic movement and seismic activity, pathways to the surface and ocean may change in the future. To address these issues, CRESP researchers from the Institute of Marine Sciences at University of Alaska, Fairbanks and University of Alberta, Canada used: a) side-scan sonar to depict and characterize the sub-surface Amchitka rock mass; b) a CTD to detect salinity differences between the sea and any fresh water seeps emanating from Amchitka ground water sources especially along the transects from the nuclear test sites; and, c) magnetotulleric and audio-magnetotulleric testing of the subsurface of the island, again along the cross island transects contiguous to the nuclear test sites, to characterize the Amchitka rock mass and to identify the depth and location of the most likely groundwater pathways from the island into the sea. Very preliminary results from these initiatives helped other researchers identify areas in the sea where multi-trophic biological sampling would best detect the presence or accumulations of radionuclides in that marine environment related

to the test shots.

Sampling Approach

The initial design in the *Amchitka Science Plan* was to have a three-pronged sampling approach that was representative of Aleut subsistence foods, reflected key species within the commercial fishery, and was indicative of the Amchitka marine ecosystem. Where possible, the initial selection included species that could represent two or more of these groups, and that represented different trophic levels. Within this sampling framework, the team expected to collect organisms that represented different degrees of mobility. The initial sampling plan was also based on best available knowledge about the organisms that would be present. This information was obtained from the literature, from advice of people who had worked on Amchitka or elsewhere in the Aleutians, and from the team's own experience in the Aleutians in 2003. Optimally, they hoped to have four specimen composites per species per study location, and the number of study locations depended upon the mobility of individual species. Sedentary species were expected at the three test sites areas (Long Shot, Milrow, Cannikin) and at the reference site (Kiska), while highly mobile species were expected only around Amchitka and at Kiska. The initial list served primarily as a basis for identifying the most relevant species, and it was understood that it might become necessary to collect ecological equivalents if dictated by actual conditions at proposed sampling areas.

The actual sampling in the summer of 2004 followed the initial design, including the employment of Aleut hunters/fishers, marine ecologists (including divers), and a fisheries biologist on a NOAA trawler. Sufficient samples of organisms were obtained at all trophic levels to represent the marine system, to sample commercial fisheries, and to provide a range of organisms that subsistence Aleuts eat. It was extremely important to have Aleut hunters/fishers as part of the sampling regime because they were able to hunt and fish using current methods, as well as traditional methods of searching the intertidal areas for subsistence foods (kelp, Gumboots, Chinese Hats, and mussels). The Aleuts also hunted birds and fished with contemporary methods now used in their villages. As an added bonus, the marine ecologist team also collected some of the same species, allowing for a comparison of different sampling methods. All three teams (Aleuts, marine ecologists, fisheries biologist) collected some species, such as Pacific Cod.

Samples Collected

The samples collected represented a wide range of organisms and will allow an examination of radionuclides among study sites, and between Amchitka and the reference site. There were two aspects of sampling that were key: 1) Having sufficient samples of some species in different study sites to allow for a statistical comparison, and 2) Having a few samples from a range of key species that would add to the team's understanding of the marine ecosystem around Amchitka that serves as the base for key food chains (ultimately leading to humans). Representative species that fall into category 1 include kelp, Green Sea Urchin, Rock Jingle, Rock Greenling, Black Rockfish, Pacific Cod, sculpins, Gulls, Eiders and Puffins. Sufficient numbers of specimens were collected in some species in category 1 for excellent coverage of the marine environment; for example, several hundred individual Sea Urchins (at several different water depths), over a hundred individuals of Black Rockfish, Pacific Cod, sculpins, and Rock Greenling, and 40-50 individual each of Gulls, Puffins and Pigeon Guillemots.

Species in category 2 include Atka Mackerel, Halibut, Eagle, and Octopus. Although fewer specimens were collected, they are all top level predators, and each individual is important in its own right. For example, a range of different sized Halibut were collected, including one weighing a hundred pounds. In addition, a number of subsistence foods in the intertidal beaches near the test shots and at the reference site were collected, including Chinese Hats (Limpets) Gumboots (Chitons) and Blue Mussels.

A final key feature of the expedition's collection was the diversity of ages represented. Both young (representing very local exposure) and adult Glaucous-winged Gulls were collected (adults can reach more than 30 years in age). Whereas Kelp, Sea Urchins, and Jingles do not reach great ages, some of the fish collected can reach between 50 and 100 years of age in the Northern Pacific/Bering Sea ecosystem.

In summary, the specimens collected:

- Represented three groups (Aleuts, fisheries, marine ecosystem)
- Represented intertidal to benthic, and sea surface organisms
- Represented several trophic levels from primary producers, to consumers, to top-level predators (including halibut, seabirds, Pacific cod)
- Represented a range of mobilities, from sedentary kelp to highly migratory fish
- Aleut hunters/fishers collected subsistence Aleut foods
- Collected samples from all three Amchitka test sites and a reference site (Kiska)
- Collected sufficient samples for statistical analysis for key trophic levels, while having adequate samples from a wide range of species to represent the marine ecosystem
- Collected organisms that ranged in lifespan from months to many years

Receipt and Control of Specimens in New Jersey

A total of 38 coolers containing the samples and specimens collected by the J. Burger, S. Jewett and Aleut teams on the *Ocean Explorer* were air shipped, via Alaska Air, from Adak, Alaska to Newark, New Jersey on July 22nd. To minimize the possibility of losing significant samples, the team did not pack all the same species from the same location in one cooler. A total of 7 additional coolers, with marine samples from J. Weston's team on the NOAA *Gladiator* trawler were shipped on August 8th. Together, the 45 coolers weighed a total of nearly 3,000 pounds. Each was appropriately sealed, numbered and a chain of custody form attached for control purposes, prior to their shipment. All were picked up and transported by refrigerated truck to a refrigerated warehouse located in the NJ-NY Port Authority area of Newark.

During August and September the 38 coolers from the *Ocean Explorer* were delivered to the Rutgers laboratory for purposes of completing a full inventory of the specimens collected, resorting them into groupings of fish, birds and others, and entering this data with new Chain of Custody information into a centralized database managed by V. Vyas. All of the fish specimens were transferred to freezers in the laboratory in anticipation of preparing the first shipment of samples to the INEEL and Vanderbilt labs for testing. Samples of each species were also retained for purposes of developing laboratory

methods and procedures, and the remaining newly numbered coolers were returned to the refrigerated warehouse for storage.

Two Analytic Streams

The Rutgers team under J. Burger will be responsible for receiving, preparing, and sending specimens to the analytical laboratories, and for maintaining appropriate Chain of Custody and tracking records. D. Kosson and M. Stabin at Vanderbilt will have overall responsibility for managing the specimen testing and analysis program that will be conducted at INEEL and Vanderbilt laboratories. The analysis at INEEL will focus on testing soft tissue, bone and kelp for the large number of isotopes expected to be present. A subset of these will also be analyzed at Vanderbilt for these analytes for interlaboratory comparison. A separate Vanderbilt analytic stream will focus on Cs-137 and other relevant gamma emitters.

Isotopes of interest for analysis in this study are ^{137}Cs, ^{152}Eu, ^{60}Co (gamma emitters), $^{238, 239, 240, 241}$Pu, $^{234, 235, 236, 238}$U, ^{241}Am (alpha emitters), and ^{90}Sr, ^{3}H, ^{99}Tc, ^{129}I (beta emitters). Of these, ^{137}Cs is most likely to accumulate in muscle (soft tissue) and cause human health risks through consumption. The other isotopes that are expected to result from the test shots accumulate preferentially in either skeletal material (bones or exoskeletans) or specific organs, with a lesser distribution in muscle. Detection limits for analyses will be below levels necessary to detect human health risks based on conservative estimates of lifetime consumption and risk thresholds. More limited analysis will be used to ascertain the distribution of specific isotopes amongst the sample types for a given biota. Ratios of isotopes of Pu (indicative of nuclear detonations) and U (indicative of nuclear reactor releases and enrichment processes), both of which accumulate in skeletal materials, will be used to the extent possible to identify whether Amchitka test shots are the likely source of measured radionuclides in samples. Thus, the analysis of soft tissue will provide the primary insight into human health risks from consumption, food chain transfers in the marine ecosystem, and provide a baseline for comparison with future studies. The analysis of skeletal material will provide indicators of sources of contamination, information about food chain accumulation, and also provide an important baseline for comparison with potential future studies.

Initial Screening Analysis

The CRESP team will use an initial screening analysis as a basis for understanding the occurrence and indication of origin of radionuclides in a wide range of organisms at different trophic levels in the marine ecosystem, for foods that are consumed by the Aleuts, and for organisms that are harvested commercially. This initial screen will consist of the analysis of muscle tissue for ^{137}Cs and ^{90}Sr and analysis of corresponding skeletal material for the full range of isotopes.

The rationale for the choice of organisms for screening was based on the *Science Plan's* initial three-pronged approach (Aleut foods, commercial fisheries, marine food web) and the availability of organisms within the marine ecosystem around Amchitka and the Kiska reference site. Within these constraints, organisms were selected based on their mobility (Table 1) and life history traits (Table 2).

The rationale for the number of organisms to be screened was a function of mobility (Table 3). When organisms were sedentary, one composite was screened from each of the three Amchitka test shots areas, and from Kiska. When organisms were mobile, one composite from the Pacific side and one from the Bering Sea side of Amchitka (in the region of the test shots) were chosen. When organisms were highly mobile one composite from the Amchitka region and one from Kiska were chosen (Table 2).

Organisms that are very important to the human food chain (i.e. Halibut, King Crab, Octopus), but were collected in much smaller numbers will be examined during the next phase of radionuclide analysis, as will organisms that are key to marine food web (i.e. Eagle, other kelp or invertebrates).

Use of Spiked, Blank and Blind Samples

Spiked samples and blanks (control samples) using commercially obtained samples of fish and other species will also be included in material sent to analytical laboratories as part of the analytical quality control. Spiking of samples will be done by the RESL laboratory, also located at INEEL but a distinct organization and facility from the INEEL group carrying out analysis. RESL is a DOE laboratory responsible for quality assurance and quality control programs associated with radionuclide analysis throughout the country, both in the public and private sectors.

Each analytical batch of samples sent by Rutgers to the INEEL laboratory will be identified only by a coded identification number. Laboratory personnel will thus be blinded from knowing the sample origin (i.e. physical location from which the sample originated), specific species type (species types will be encoded, but distinguishable, i.e. Cod may be species A and Rockfish species B), and whether a sample is a spike or a blank. They will know that a sample is soft tissue, bone or kelp, by the batch identifier, and thus able to properly conduct appropriate tests.

More Extensive Analysis

More extensive laboratory testing and analyses will be performed on selected species within designated trophic levels based on the results obtained in the initial screening analysis and any other data made available to this study. Selection of the species for more extensive analysis will be based on human health risk and indicators of human health, and information about isotope sources based on U and Pu isotope series results reported in the initial screening phase of laboratory analysis. The following algorithm will be used for assigning priority within a given trophic level:

> *Priority number* = log (10 x human health risk)/(10E-6) + (*Pu information* + *U information*)

Under this approach, the larger the *priority number*, the higher the priority for the more extensive analysis of the species within the designated trophic level. The human health value would equal 1 for a 10E-6 risk level. The *Pu information* would equal 0.5 if characteristic Pu isotope ratio is measurable. The *U information* would equal 0.5 if the characteristic U isotope ratio is measurable. Thus, the value of the source information would be equal to 0, 0.5 or 1. Tie values would favor human health if the risk value was

greater than 10E-6 and would favor source information if the risk value was less than 10E-6.

Water and Sediment Analysis

Water and sediment sampling in all shot site areas surrounding Amchitka Island was performed to fulfill the Radiological Health and Safety provisions of the overall Amchitka Expedition, Health and Safety Plan and to supplement the physical and biological data collected on the expedition. By design, the dive collections occurred in marine areas of highest probability of discharge of radionuclides from freshwater seeps through faults and/or fractures. Water and sediment samples were taken in both offshore and near shore areas where expedition members would be handling equipment, such as the CTD probe and collecting biological specimens. The samples were screened for radioactivity by the expedition project leader C. Volz, to insure that expedition personnel were not exposed to radiation in excess of HASP exposure guidelines.

Radionuclides trapped in marine sediments and desorbed from sediment to water could be a major source of contaminants to benthic organisms and thus to higher-level trophic organisms feeding on them. Detection of some radionuclides in sediment samples may be indicative of radionuclide discharges and movement within environmental pathways, even if they do not represent a direct input into human food pathways. Bottom water and sediment samples were taken to help evaluate and redesign research questions and address uncertainties outlined in the Science Plan, resulting from this linkage.

Table 1. Mobility Traits Influencing Selection of Screening Species

Mobility	Importance	Species
Sedentary	Provides an indication of point exposure	Fucus Alaria nana Alaria fistuloa
Locally mobile	Integrates exposure over a small area	Sea Urchin Rock Jingle Black Rockfish Rock Greenling Glaucous-winged Gull
Mobile	Provides an indication local movement within a few km of designated site	Yellow-Irish Lord Ocean Perch Walleye Pollock Tufted Puffin Pigeon Guillemot Common Eider Brown King Crab
Migratory	Provides an indication of regional exposure	Atka Mackerel Pacific Cod

Table 2: Rationale for Species Selection for Screening Analysis

Primary Producers:

The following species are all primary producers in the marine ecosystem, are sedentary (and thus represent local exposure), and are the base of food chains. There is good representation of the sedentary species from the four study sites (Milrow, Long Shot, Cannikin, Kiska), and for the mobile species from Amchitka and Kiska.

Alaria fistulosus - This kelp occurs at several depths, representing the subtidal environment.

Alaria nana - This kelp occurs mainly in the intertidal.

Fucus - This brown algae occurs in the intertidal, and there is reference data from other places.

Invertebrates:

Invertebrates are often the primary consumers in marine ecosystems, are eaten by organisms higher on the food chain, and are fairly sedentary representing local exposure. They are also eaten by the Aleut people.

Green Urchin - Urchins were abundant in most of the diving transects at 15, 30 and 60 feet and thus represent good coverage of the marine floor environment. They are a primary food of Sea Otters, a species of concern. They are also eaten by Eiders and Gulls (based on the literature and on stomach contents we examined). And they are considered a delicacy by Aleuts.

Rock Jingle - They are less abundant, but are sedentary.

Vertebrates:

Vertebrates are often secondary or tertiary consumers, and have different degrees of mobility. The species selected, at some stage in their life cycle, are all eaten by Aleuts and some are part of commercial fisheries.

FISH:

Rock Greenling - This is a sedentary species, each male maintaining a small territory, hence representing local exposure that lives in the kelp zone. It is eaten by Aleuts (as are its eggs), and is eaten by fish higher on the trophic chain, such as Cod and Gulls.

Black Rockfish - This is a relatively sedentary species (representing local exposure) that lives in the kelp zone and just outside the kelp zone. It is eaten by Aleuts and is a little higher on the food chain than the Rock Greenling.

Sculpin (Yellow Irish Lord) - This is a less sedentary (but not migratory) species that is larger than Black Rockfish, eats invertebrates, and is an Aleut food.

Atka Mackerel - This is a deep water, bottom fish that is relatively low on the food chain, but is of commercial value and is migratory.

Pacific Cod - This fish can reach 50-60 pounds, and eats smaller fish, such as Rock Greenling and Atka Mackerel, as well as Octopus, squid, fish eggs, and crabs (all found in our specimen's stomachs). It is both a preferred fish for the Aleut people and a major commercial species. It is mobile to migratory.

Ocean Perch – Top-level predator of commercial interest that is mobile.

Walleye Pollock - This predatory fish is a major commercial species that is mobile.
Halibut - This fish is a top-level predator, can reach large sizes (up to 500 pounds) and advanced ages, and is highly prized both by Aleuts and commercial fisheries, and is migratory.

BIRDS (all are residents):
Eiders - Common Eiders are hunted extensively by Aleuts and their eggs are also eaten. It represents a low trophic level for birds, eating mussels, snails, and urchins.
Gulls - Glaucous-winged Gull eggs are considered a delicacy by Aleuts, and gulls represent an omnivorous species. We found urchins, starfish, and fish (including Dolly Varden and Greenlings) in their stomachs. Since there are nesting colonies at each of the test sites, and they normally feed within 5 miles of their colony, they represent local exposure. They do not migrate and so represent longer-term exposure in the vicinity of Amchitka. They also can live to be 30 + years old.
Young Gull - There were nesting colonies adjacent to each of the 3 test shot areas, and on Kiska. Since parents feed their young entirely from local foods (usually within 5 miles of nesting colonies), they represent local exposure.
Tufted Puffin - They eat entirely fish of small to intermediate sizes. They are less localized to test shots, and represent local exposure within a local area. Birds were moving back and forth from the Long Shot to the Cannikin shoreline.
Pigeon Guillemot - They eat mainly small fish, and are localized to the sides of islands during the breeding season. Birds were moving back and forth from the Long Shot to the Cannikin shoreline.

Table 3. Rationale for Selection of Screening Numbers

- Where possible, one sample from each of the four study sites (Milrow, Long Shot, Cannikin, Kiska) for species that are sedentary or are locally mobile will be selected for screening:

Fucus	Sea Urchin
Alaria nana	Rock Jingle
Alaria fistulosa	Black Rockfish
Glaucous-winged Gull	Rock Greenling
(adults, chicks)	Yellow-Irish Lord

- Species that are mobile within a few km of a designated site will be examined from both sides of Amchitka (Bering Sea/Pacific Ocean), and from Kiska:

Common Eider (eggs)
Pigeon Guillemot
Tufted Pigeon

- Species that are highly mobile or migratory will be examined from Amchitka and from Kiska:

Ocean Perch
Atka Mackerel
Walleye Pollock

- Where specimens were available for both the inshore sampling and the NOAA trawl, species will be screened from both sampling methods. This was true only for Pacific Cod, and will include both sides of Amchitka from the near-shore sampling, and from Amchitka and Kiska for the NOAA trawl:

Table 4: Specimens for the INEEL Screen of Soft Tissue **

Kelp: Total = 12

- Alaria fistulosa - 4
- Alaria nana - 4
- Fucus - 4

Fish: Total = 23

- Black Rockfish - 4
- Ocean Perch - 2
- Atka Mackerel - 2
- Rock Greenling - 4
- Walleye Pollock - 2
- Pacific Cod - 5
- Sculpin - 4

Invertebrates: Total = 8

- Sea Urchin - 4

Rock Jingle - 4 Birds Total = 17

- Common Eider eggs - 3
- Tufted Puffin - 3
- Glaucous Gull
  - adult - 4
  - young - 4
- Pigeon Guillemot - 3

** When the sample size is 4, one composite will be selected from near Milrow, Long Shot, Cannikin, and Kiska. When the sample size is 3, one composite will be selected from the Bering side of Amchitka, the Pacific side of Amchitka (near the test shot region), and from Kiska. When the sample size is 2, one composite each will be selected from around Amchitka and from Kiska.