BROAD GAMMA ANALYSIS OF FOOD CHAIN ORGANISMS

by Joanna Burger

Our initial human health screen was aimed at species that are key
in understanding the risk to human consumers, and involves a broad
range of radionuclides. However, the cost involved results in a
limit in the number of analyses that are possible.   Thus our
strategy is to have a three-pronged approach of having a INEL
human health screen, a broad gamma analysis of a larger number of
more different species, and a follow-up analysis of more species
at INEL with the full range of isotopes.
      What follows are a series of tables that lay out the strategy
for selection of species for the broad gamma screen at Vanderbilt.

TABLE 1. FEATURES USED IN SELECTION OF SPECIES FOR BROADER
RADIOCESIUM AND OTHER GAMMA ANALYSIS
───

FEATURE   IMPORTANCE

───

Bioindicator   Indicates whether the organisms represent
                        direct exposure to humans through consumption,
                        direct exposure to higher level predators, or
                    to the organisms themselves

Methodological   Includes whether it will be useful in the
                    future as a bioindicator for protective
                        sustainability

Societal   Indicates whether it is understandable and
                        useful to the Aleuts, resource trustees,
                        commercial fisheries, and other publics

Mobility   Indicates whether the organism represents
                        local, landscape, or regional exposure

TABLE 2. BIOINDICATOR QUALITIES FOR HUMAN EXPOSURE, TOP-LEVEL PREDATORS, AND SELF-EXPOSURE

FEATURE	IMPORTANCE	SPECIES
Human Exposure	Can it directly affect people because they are eaten by people	All species, Except: brown algae eagle
Food-chain Exposure	Is it at the base of the food chain	All algae
Receptor Exposure	Can it directly impact the health of top-level predators (predatory fish, marine birds, and marine mammals	Blue Mussel Limpets Chiton Sea Urchin Atka Mackerel Black Rockfish Red Irish Lord Rock Sole Dolly Vardin Rock Greenling
Top-level Predators	Bioindicators of exposure of humans and of other top-level predators	Eagle Glaucous-winged Tufted Puffin Pigeon Guillemot Octopus Halibut Pacific Cod
Self-exposure	Bioindicator of effects of exposure on the organisms themselves	All species

TABLE 3. METHODOLOGICAL CONSIDERATIONS
_____

FEATURE	SPECIES
Easy to use in the field eggs	All fish, birds, eider
	Aleut foods (mussels, limpets, All algae except A. fistulosa
Can be used by non-specialists species all	Data could be, but species identification is not Readily identified could, such as birds, Aleut foods, and common fish
Easy to analyze and interpret data	Only common, abundant species
Useful to test management questions	All top-level predators, Aleut foods, primary Producers.
Can be used for hypothesis testing	Common abundant species that can be tested statistically.
Can be conducted in reasonable time	The constraint here is the remoteness of the study site

TABLE 4. EFFECTS OF MOBILITY FOR GAMMA ANALYSIS AT VU

_____

MOBILITY	IMPORTANCE	SPECIES
Sedentary	Provides an indication of point exposure	Fucus Alaria nana Alaria fistuloa Ulva Hedophyllum Blue Mussels Limpets Snail Chiton
Locally mobile	Integrates exposure over a small area	Sea Urchin Rock Jingle Black Rockfish Rock Greenling Rock Sole Glaucous-winged Gull Northern Rockfish
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 Red-Irish Lord Dolly Varden Eagle
Migratory	Provides an indication of regional exposure	Atka Mackerel Pacific Cod Halibut Sea Lion

_____

TABLE 5: RATIONALE FOR SPECIES SELECTION FOR GAMMA ANALYSIS (about 300 for VU)

_____

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.
    Ulva - This green algae is eaten by people, and data are available.
    Hedophyllum - There are data on this green algae from the region

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.
    Blue Mussel - They are not very abundant, but are eaten by people and marine birds, and are used extensively in other regions as a bioindicator.
    Limpets - Known as Chinese Hats by Aleuts, they are prized as food, and are eaten by marine birds. We have them collected by our Aleut collectors in their traditional manner
    Snail - Eaten by higher level organisms, including humans, they are prized by Aleuts.
    Octopus - Top level predators of extreme interest to Aleuts.
 This was a species added after meetings with Aleuts in Nikolski, Atka, and Unalaska.
    Brown Crab - Important to commercial fisheries.

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. Northern/Dusky Rockfish were captured by the NOAA trawl, and are of commercial interest.

Sculpin (Yellow Irish Lord, Red-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.

Rock Sole - Of interest both commercially and for Aleuts, intermediate in the food chain.

Dolly Varden - Of interest to the Aleuts, this species is unusual in having a fresh/saltwater phases. The Aleuts on our collecting trip were particularly interested in this species.

BIRDS (all are year round residents on or near Amchitka):
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 invertebrates, 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.

Eagle - They are top level predators of particular interest to a wide range of stakeholders, including the U.S. Fish & Wildlife Service

MARINE MAMMALS

Sea Lion - Our Aleut hunters/fishermen conducted a subsistence hunt while on the trip, and have requested that we examine radionuclides in this animals that they were eating.

TABLE 6. RATIONALE FOR SELECTION OF GAMMA NUMBERS AT UV.

---

1. Where possible, samples 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 analysis.

Fucus	Sea Urchin
Ulva	Brown Crab
Hedophyllum	Rock Jingle
Alaria nana	Rock Sole
Alaria fistulosa	Black Rockfish
Glaucous-winged Gull	Rock Greenling
(adults, chicks, eggs)	Yellow-irish Lord
Blue Mussels	Red-Irish Lord
Chinese Hats	Snails

2. 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 (adults and eggs)
Pigeon Guillemot
Tufted Puffin

3. Species that are highly mobile or migratory will be examined from Amchitka and from Kiska

Ocean Perch
Atka Mackerel
Walleye Pollock

4. Species where we obtained few individuals that are of high interest to Aleuts and others. Unlike the others above, analyses may be by individual.

Eagle
Halibut
Octopus
Sea Lion

APPENDIX 1. Features of bioindicators for human and ecological health assessment. These features apply for making decisions before and after remediation and restoration, and to evaluate the efficacy and integrity of management, remediation, or other environmental actions (adopted for Amchitka Project, after Burger and Gochfeld 2001).

_____

Biological Relevance * Provides early warning
                    * Exhibits changes in response to stress
                    * Changes can be measured
                    * Intensity of changes relate to
                      intensity of stressors
                    * Change occurs when effect is real
                    * Changes are biologically important and
               occur early enough to prevent
               catastrophic effects
                    * Change can be attributed to a cause

Methodological Relevance * Easy to use in the field
                    * Can be used by non-specialists
                    * Easy to analyze and interpret data
                    * Measures what it is suppose to measure
                    * Useful to test management questions
                    * Can be used for hypothesis testing
                    * Can be conducted in reasonable time

Societal Relevance   * Of interest to the public
                    * Easily understood by the public
                    * Methods transparent to the public
                    * Measures related to human health or
                      ecological integrity
                    * Cost-effective
                    * Of interest to regulators and public
                      policy makers

_____

Burger, J. and Gochfeld, M. 2001a. On developing bioindicators for human and ecological health. Environ Monit Assess 66:23-46.