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Collaboration versus communication: The Department of Energy's Amchitka Island and the Aleut Community

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ABSTRACT

Increasingly managers and scientists are recognizing that solving environmental problems requires the inclusion of a wide range of disciplines, governmental agencies, Native American tribes, and other stakeholders. Usually such inclusion involves communication at the problem-formulation phase, and at the end to report findings. This paper examines participatory research, the differences between the traditional stakeholder involvement method of communication (often one-way, at the beginning and the end), compared to full collaboration, where parties are actively involved in the scientific process. Using the Department of Energy's (DOE) Amchitka Island in the Aleutians as a case study, we demonstrate that the inclusion of Aleut people throughout the process resulted in science that was relevant not only to the agency's needs and to the interested and affected parties, but that led to a solution. Amchitka Island was the site of three underground nuclear tests from 1965 to 1971, and virtually no testing of radionuclide levels in biota, subsistence foods, or commercial fish was conducted after the 1970s. When DOE announced plans to close Amchitka, terminating its managerial responsibility, without any further testing of radionuclide levels in biota, there was considerable controversy, which resulted in the development of a Science Plan to assess the potential risks to the marine environment from the tests. The Consortium for Risk Evaluation with Stakeholder Participation (CRESP) was the principle entity that developed and executed the science plan. Unlike traditional science, CRESP embarked on a process to include the Alaskan Natives of the Aleutian Islands (Aleuts), relevant state and federal agencies, and other stakeholders at every phase. Aleuts were included in the problem-formulation, research design refinement, the research, analysis of data, dissemination of research findings, and public communication. This led to agreement with the results, and to developing a path forward (production of a biomonitoring plan designed to provide early warning of any future radionuclide leakage and ecosystem/human health risks). The process outlined was successful in resolving a previously contentious situation by inclusion and collaboration with the Aleuts, among others, and could be usefully applied elsewhere to complex environmental problems where severe data gaps exist.

1. Introduction

Protection and sustainability are important aspect of management for contaminated sites, and are particularly important for nuclear or chemical wastes that cannot be remediated and require continued safe, containment (Burger, 1997c, 2000a, b, 2006; DOE, 1999; Cury et al., 2005). In general, the cleanup at DOE sites will not have removed many of the long-lived radioactive and hazardous contaminants, necessitating long-term stewardship into the indefinite future (DOE, 1999, 2000). The task is also difficult because many large DOE sites have many different habitats and ecosystem types. Buffer lands around the industrial areas of DOE sites deserve suitable protection as valuable ecosystems (Dale and Parr, 1998; Brown, 1998; Burger et al., 2003). While everyone can agree on the importance of site characterization (including ecological evaluation), protection, and sustainability, it is difficult to agree on the methods of achieving these goals, and indeed, of defining them (Moran, 1994; Kimball, 1997; Burger and Gochfeld, 2001; PCSD, 2001).

In this paper we compare traditional approaches to applying science with collaborative approaches, describe the collaborative

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approach used for Amchitka Island with respect to the Aleuts, and draw lessons learned from the collaborative process to solve long-standing complex and contentious problems. We especially focus on the Aleuts because for Amchitka, they are the most directly interested and potentially affected parties, and many live on remote islands where subsistence foods play a large role in their cultural and nutritional lives (Hamrick and Smith, 2003; Fall et al., 2006; Burger et al., 2007c). Further, it is becoming increasing clear that it is essential to consider the needs and rights of tribal peoples, not only because of legal treaty rights (Nez Perce Tribe, 2003), but because they have special knowledge of the distribution and behavior of local biota, their subsistence lifestyles, and their cultural values.

The public, governmental agencies, scientists, and the private sector are increasingly interested in restoring and managing ecosystems that have been damaged by human activities, including physical disruption and contamination. While managers must understand the complex physical, ecological, and contamination conditions of their sites within the context of current and future land uses, human health professionals must understand complex transport pathways that ultimately lead to human exposure and possible harm, while ecotoxicologists examine the pathways, fate and effects of chemicals for ecoreceptors. Public policy makers and the public, however, are interested in plans for protecting both human and ecological health into the foreseeable future (Leitao and Ahern, 2002). Among other characteristics, an ecosystem should have functioning food chains, nutrient cycling, energy flow, predator–prey relationships and sustainability, as well as providing goods and services to humans (Risser, 1994). Sustainable ecosystems are resilient, and can recover from natural disasters such as fires, hurricanes, or other storm events. Ecosystem management is difficult, however, because of ecosystem complexity; ecosystems have hundreds of species, several trophic levels (producers, primary and higher level consumers), complex interactions, and several levels of organization (species, populations, communities, ecosystems, and landscapes (Burger, 2006)). Evaluating (or site characterization), restoring, and protecting ecosystems is a well-established goal of environmental management (Cairns, 1980, 1994; NRC, 1986; Bartell et al., 1992; Cairns and Niederlehner, 1996; Cairns et al., 1992; Barnthouse, 1991, 1994; Suter, 1997, 2001; Burger, 1997a, b, 2007a, b; Burger et al., 2007a, b).

2. Community-based collaborative research

Although many agencies and groups are committed to involving Native Americans and Alaskan Natives, it frequently does not occur for a number of reasons, such as time or money constraints, inability to engage these communities, or inflexibility in research approaches and designs. We argue below, however, that collaboration with Aleuts not only greatly improved the research, but it led to greater acceptance of the research results and of the steps leading to closure of Amchitka.

The research approach discussed below fits into two frameworks: participatory or collaborative research, and environmental justice. Further, there are places where participatory research has been more successful, and these examples also indicate the importance of being inclusive. This approach has been particularly useful in the area of exposure and risk assessment for the Yupik people (Carpenter et al., 2005), the Inupiat (Johnston, 2007), the Mohawks (Fitzgerald et al., 1999; Schell et al., 2005)), as well as other Native Americans (DeCaprio et al., 2005). These and other projects indicate a growing trend for inclusion of Native Americans, Alaskan Natives, and other ethnic groups in environmental assessments, exposure assessments and formal risk assessments that affect their health, culture and lifestyle.

3. Background on Amchitka Island

Amchitka Island is one of over 100 sites in 34 states that comprise the Department of Energy's "Nuclear Weapons Complex" (Crowley and Ahearne, 2002). Most of these lands were appropriated in the 1940s and 1950s for the nuclear mission. DOE sites in several states include traditional Native American lands some of which were ceded to DOE. In Alaska, Native rights come from several different authorizing acts and legislation, including the Alaska Native Claims Settlement Act (ANCSA), the Alaska National Interest Lands Conservation Act (ANILCA), the Venetie Decision, and the Constitution of the State of Alaska, among others. Several of the large DOE sites were built on lands that were traditional Native American hunting and fishing grounds, including the Yakama Indian nation, the Umatilla Tribe, the Wanapum, and the Nez Perce Tribe at the Hanford site in Washington, the Shoshone-Bannock land on Idaho National Laboratory, and the San Ildefonso Pueblo, Jemez Pueblo, Santa Clara Pueblo, and Cochiti Pueblo on the Los Alamos National Laboratory (Arnon and Hill, 1979; Edelman, 1979; Lange, 1979; Sando, 1979; Schuster, 1998; Stern, 1998; Gephart, 2003; Burger et al., 2004, 2008). Similarly, Aleuts (also called the Unangan) historically inhabited many of the islands in Aleutians.

Amchitka Island (51°N lat., 179°E long.) was one of the islands traditionally inhabited by Aleuts, although they had abandoned the island before the development of the World War II military base, or the decision to test nuclear weapons. The Aleut Corporation has applied for transfer of over 120 archeological sites on Amchitka, as authorized by ANCSA. In Alaska, Native American communities are organized into corporations, and sometimes form associations, such as the Aleutian Pribilof Island Association. Amchitka was the site of three underground nuclear tests in 1965–1971, over objections from the Aleuts, the State of Alaska, the public and several other countries (Kohlhoff, 2002). Although Amchitka is 280 km from the nearest active Aleut community on Adak Island, the Aleuts consider the whole Aleutian Chain their home, partly because they travel freely among islands for employment, and to visit family and friends (Burger et al., 2007d, e).

At the time, the releases of radiation to the surface during the tests were not considered to pose a serious human health risks (Seymour and Nelson, 1977; Faller and Farmer, 1998) because the radioactive material was believed to have been spontaneously vitrified when the intense heat of the underground blasts melted the surrounding rock (DOE, 2002a). Amchitka Island is part of the Alaska Maritime National Wildlife Refuge, and has some of the largest and most diverse seabird colonies in North America, as well as significant marine mammals. Although the US Fish and Wildlife Service is the landowner, responsibility for the clean up of Amchitka rested with the National Nuclear Security Administration (NNSA, a division of DOE).

The controversy that continued to surround Amchitka increased dramatically when DOE announced its plans to "clean up" and close Amchitka (Greenpeace, 1996; Kohlhoff, 2002). It was possible to clean up the surface of Amchitka by traditional remediation methods; however, the Aleuts, the State of Alaska, and the public were concerned about the possibility of subsurface transport of radionuclides from the three test cavities to the marine environment. Another concern was that this region of the Aleutians is one of the most seismically active and dynamic subduction zones on earth (Eichelberger et al., 2002). However, the immediate concern was whether the subsistence foods of the Aleuts, as well as the commercial fish and shellfish from the island vicinity, were safe to eat (Burger et al., 2006b, 2007d, e). The Aleuts who live in small villages on remote islands are largely dependent upon locally-derived plants and animals; Aleuts

sometimes fish near Amchitka Island for halibut and other resources. The Aleuts are both Tribal and subsistence peoples.

The recent (and heated) controversy resulted from DOE's belief and assertion that there was no risk to people or the environment from the underground nuclear tests, based on a groundwater model, which did predict leakage at some uncertain time and a much-criticized draft human health risk assessment (DOE, 2002a, b). The Aleuts, the State of Alaska, and many stakeholders had little faith in the groundwater models, and less faith in the human health risk assessments because there were no site-specific data on either consumption patterns or radionuclide levels in subsistence foods, and ecological characterization of the marine environment was ignored or misrepresented.

The DOE, State of Alaska (ADEC), US Fish & Wildlife Service (USFWS), the Aleutian Pribilof Island Association Inc. (APIA), and other stakeholders disagreed about the path forward to DOE's closure of Amchitka Island. By closure, DOE meant that no further action (remediation, restoration, monitoring) was required. Other parties, including the Aleuts, disagreed. DOE headquarters in Washington asked the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) to develop a comprehensive Science Plan, in conjunction with ADEC, USFWS, APIA, and DOE, which would provide the science basis for closure (Higley et al., 2003; Burger et al., 2005, 2006a, 2007d; Powers et al., 2005). The mechanism was a letter of intent signed by DOE (as the responsible party), the State of Alaska, and the US Fish and Wildlife Service (as the landowner). CRESP is an independent, multi-university, consortium consisting of environmental, biological and social scientists, risk assessors, and public policy analysts that had been working together for nearly 10 years to address environmental and risk problems faced by the DOE.

This paper addresses the inclusion of the Aleuts in this process, and provides a model for collaboration with Native Americans and others dependent upon potentially contaminated biota or other resources. While the inclusion of a wide range of stakeholders has been widely recommended (PCCRARM, 1997; Pittinger et al., 1998; Goldstein et al., 2000; Burger et al., 2005, 2007d), including for DOE (Sink and Frank, 1996), involvement has usually included other state and federal governmental agencies. The actual involvement of Native Americans as collaborative members has not generally been examined, except for exposure scenarios (Fitzgerald et al., 1995; Harris and Harper, 1997, 2000; Stumpff, 2006; Harper and Harris, 2008; Donatuto and Harper, 2008). Traditional science approaches usually involved single investigators, or groups of academic and agency investigators. There are, however, a number of community-based collaborations with scientists that are not agency based (Santiago-Rivera et al., 1998; Quigley, 2001; Arquette et al., 2002, 2004). Even so, it is imperative to increase the number of published studies on community and stakeholder-drive research as models of methodology and usefulness.

4. Traditional science models versus agency-influenced and Native American/stakeholder/scientist collaboration models of science

Typically academic research has been conducted largely by individual investigators, who derived their inspiration from theory, basic science, and past research (their own or that of others), and agency research was largely conducted by individuals, and then by groups of individuals within the agency, driven by agency needs or mandates (Fig. 1). With increases in technology and the need for a range of expertise, individual investigator research expanded to include groups of investigators from different disciplines. While biomedical and toxicological

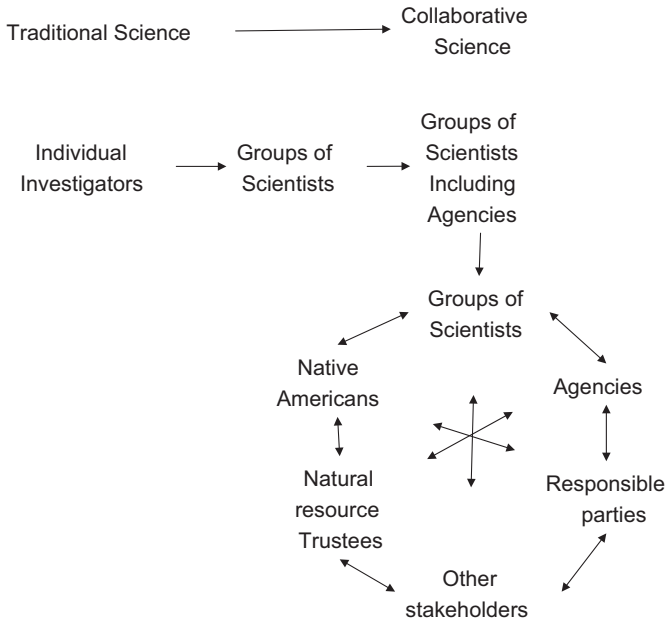

Fig. 1.

work became multi-disciplinary because of the range of techniques, species, organ systems, and diseases and maladies involved, environmental science became multi-disciplinary as managers recognized the need for a wide range of expertise (ecology, biology, geology, hydrology, toxicology, health physics, remediation, and restoration scientists) needed to deal with whole ecosystems. These changes were followed by recognition of the importance of involving a range of stakeholders (PCCRARM, 1997), which usually included people from the same or other state or federal agencies, responsible parties (governmental or private industry), and more often with time, the general public.

There is an increasing awareness of the special status Native American tribes and other indigenous communities, based in part on Treaties, which necessitate their inclusion in the solving of environmental problems that impact their rights (Nez Perce Tribe, 2003). The unique role of Tribal Nations requires a re-evaluation of the scientific process to include tribal thinking and needs. Traditional Native American lifestyles usually are not included in classical environmental planning, risk assessment methods, and long-term stewardship plans (Harris and Harper, 2000). Specific needs of Native Americans vary, but clearly include developing tribal exposure scenarios, as well as incorporation of cultural aspects that impinge upon ecosystem values (Harris and Harper, 1997, 2000; Stumpff, 2006; Harper and Harris, 2008). Harris and Harper (2000) proposed that risk assessors and managers should use Eco-cultural Dependency Webs, rather than simple exposure scenarios, and Burger et al. (2007a–i, 2008) advocated using Eco-cultural Attributes as important aspects of natural resource evaluation. While the inclusion of traditional Native American lifestyles and values is clearly complex, it is our intent in this paper to use Amchitka as a case study to illustrate how tradition Native American and subsistence lifestyles, values, and consumption behavior can be incorporated in an inclusive, collaborative model of science.

5. Amchitka Island and collaborations with Aleuts

5.1. Problem-formulation and approaches

The controversy that surrounded the DOE's proposed closure of Amchitka revolved around different perspectives of whether there

was sufficient information to "know", "be confident", or "have peace-of-mind", about the safety of subsistence and commercial foods, and about the safety of organisms living in the marine environment around Amchitka (Powers et al., 2005). DOE's assertion (DOE, 2002a, b) that there was no risk from radionuclide leakage from the underground nuclear tests was not sufficient to convince the Aleuts and the Aleutian Pribilof Island Association (APIA), the State of Alaska, US Fish and Wildlife Service, and others that there was no risk. The lack of trust in data, DOE models, and approaches made it imperative that any science plan (and its subsequent execution) developed to fill the data gaps would meet with approval of the full range of interested and affected parties.

It was apparent that two aspects needed to be carefully defined and described: (1) the steps that were essential to provide the necessary information to assess the safety of the subsistence and commercial foods from the Amchitka marine environment, and (2) the definition and recognition of the range of interested and affected parties that should collaborate in the project (Table 1). In the latter case, the four major parties were defined by agreements to include APIA, US Fish and Wildlife Service, State of Alaska, and DOE (Burger et al., 2006b). In this paper we primarily describe collaborations with Aleuts.

Table 1 indicates the differences in approaches between traditional (investigator-initiated) science, agency-directed or mandated science, and collaborative science, although clearly the inclusion of a full range of Native Americans and stakeholders can be an integral part of any science plan, and we recommend this approach. The table is intended as a model for a science process that considers Native American and stakeholder involvement as an integral part of the whole research process, including dissemination of information, public communication, and follow-through (or path forward approaches). The latter three aspects are usually considered management and communication, rather than science, but we suggest that scientists should also be involved in these processes.

Seven steps were identified as critical: problem-formulation, research plan, research design refinement, data collection, research and analysis of data, dissemination of research findings, public communication, and a path forward (Table 1). It should be noted that all seven steps are considered as science based. The problem-formulation phase, the one where a range of stakeholders and others are often included (Bartell et al., 1992; NRC, 1993; Barnthouse, 1994; Suter, 1997), is one of the most critical steps because it is where the issues are clarified, the problem is defined, uncertainties or data gaps are identified, and hypotheses are developed.

5.2. Inclusion of Aleuts as collaborators at Amchitka

The approach of DOE regarding the potential risk from radionuclides at Amchitka was to commission a groundwater model and a human health screening risk assessment (DOE, 2002a, 2002b). These did not reassure the Aleuts, or other stakeholders, that the marine organisms living around Amchitka were free from radionuclides, or that the Aleut subsistence foods were safe to eat, mainly because the assumptions of the models were suspect, the exposure scenarios were unrealistic, and there were no site-specific data on either radionuclide levels in biota or subsistence foods, or on consumption patterns of the Aleuts. Further, development of both reports did not involve the Aleuts or the state and federal agencies until the reports were presented in draft form.

The CRESP process involved both Aleut representatives (APIA) and the Aleuts themselves (in their villages) collaboratively in nearly every phase of the project, from problem-formulation to defining a path forward (Tables 1 and 2). This collaboration was critical, because, while the APIA representatives can act officially and legally, and represent the overall Aleutian and Pribilof Islanders, more specific information from the Aleuts living closest to Amchitka provided a site-specific perspective. Visiting Aleuts in small, remote villages provided an opportunity for them to share their concerns, but also to provide specific information on what subsistence foods they eat, and how they eat them.

Table 1
Comparison of different methods of inclusion of Native Americans and other stakeholders in solving environmental problems.

Parameter or phase	Traditional method of science	Inclusion of governmental agencies	Inclusion of Native Americans and non-governmental stakeholders
Problem-formulation	Designed by scientists based on theory, environmental data, or past research	Designed by scientists or by agency personnel, influenced by agency needs and grant/contract requests	Designed by scientists in collaboration with Native American tribes or entities, governmental agencies, and other stakeholders
Research plan	Designed by scientists based on the problem and past research	Designed by scientists (from either academia or agencies), using approved methods and protocols of agencies	Designed by scientists in collaboration with Native Americans and other entities (mentioned above)
Research plan refinement	Usually based on research needs and problems encountered during execution	Based on research needs of scientists	Refinement based on requests and needs of Native American entities and other interested and affected parties
Data collection	Conducted by scientists	Conducted by research scientists, often with no agency involvement	Inclusion of Aleuts on the expedition to collect, using their usual subsistence methods
Research and data analysis phase	Conducted by scientists	Conducted by research scientists, sometimes with agency personnel	Conducted with inclusion of some Native Americans of other entities
Dissemination of research findings	By scientists, usually in peer-reviewed journals	By scientists, usually as reports to governmental agencies and/or in peer-reviewed journals	By scientists and other contributors of the research, such as Native Americans, regulators or government agency personnel
Public communication	Often non-existent	Often non-existent, but sometimes in public workshops or through newspapers	Through media outlets (newspapers, newsletters), public workshops, visits to Native villages, affected towns, agency offices, and with other affected parties
Follow-through or path forward	Usually results in further grant applications	May result in further grant or contract applications, further collaborations with the agency	May result in products that contribute to solving a particular problem faced by Native Americans, or by affected or interested parties

Table 2
Collaboration with the Aleuts in conducting research on potential radionuclide risk from leakage from underground nuclear tests on Amchitka Island, Aleutians, Alaska.

Parameter or phase	Collaboration with Aleuts
Problem-formulation	Initial workshop was held in Fairbanks to listen to the concerns of Aleuts and others. Aleut representatives presented their concerns and perceptions about Amchitka and the risks it might pose. Aleuts contributed to joint meetings with other legally-mandated parties (State of Alaska, DOE) to solving the Amchitka problem.
Research plan	Findings from the initial workshop, and discussions with Aleut representatives (APIA) led to development of a research plan by CRESP scientists (Burger et al., 2005).
Research plan refinement	Research plan was approved by representatives of Aleuts (APIA). The plan was then presented to four of the five Aleut communities visited in their Aleutian villages, and significant refinements were made according to their suggestions (Burger et al., 2007d).
Research and data analysis	Based on comments made by Aleuts in their villages, four members of the Aleut community were members of the scientific expedition to collect specimens for analysis. They collected subsistence foods in their traditional manner (Burger et al., 2006c, 2007e).
Dissemination of research findings	Project resulted in over 15 papers in the peer-reviewed literature, many with Aleuts as co-authors (Burger et al., 2006c, 2007c, e, g, h, in press). Research findings also reported in newspapers in the Aleutians and in Alaska generally; public meetings held in Anchorage, APIA, and in Aleut villages.
Follow-through or path forward	Research findings led to request by Aleuts and others that CRESP write a biomonitoring plan to ensure early warning of future problems in the biota (and subsistence foods) around Amchitka (Burger, 2007c; Burger et al., 2007i).

This table deals only with Aleuts, and others were included in various research phases (see Burger et al., 2007d).

The problem-formulation phase included Aleuts (and the state and federal parties) as presenters and participants in an open workshop to explain their perspectives and concerns, describe their traditional lifestyle and exposure pathways (what and how they collect food), and to define the problem. The workshop was followed by meetings with APIA to further refine the problem, and by the development of a Science Plan by CRESP that integrated their concerns. The objective of the Science Plan was to design a research to gather the necessary information to assess the potential risk (currently and in the future) of radionuclide exposure to the marine environment around Amchitka, and included both a geophysical and biological component (Burger et al., 2005). The Science Plan called for an expedition to Amchitka and Kiska (the reference site) to collect biota for radionuclide analysis. Prior to the expedition itself, work on Adak was to be conducted to test protocols and the efficacy of collecting particular species. Biota to be collected included three types: subsistence foods, commercial fish, and biota aimed at understanding the food chain.

The critical phase from the perspective of the Aleuts, however, was Science Plan refinement, which not only involved collaboration with Aleut representatives (APIA), but the Aleuts themselves. This collaboration was truly unusual, since when scientists receive the funding to conduct a research project, they usually do so without further input from others. In this case, after funding was secured, significant modifications were made as a result of discussion with APIA and with Aleuts in their villages (Burger et al., 2007d). Meetings in villages held individually and in groups, included environmental officers, elders and other adults, teachers, and children and teenagers. The latter group was particularly interested, provided extensive information about hunting/fishing, and comprised the next group of people who will become pregnant in the years to come (and thus represent potential future exposure). Further, some of the 14–18 year olds were the primary fishermen and hunters for the village, were being trained by elders, and some kept notes on the species they hunted or fished. At most villages, nearly the entire population of the village attended the meetings.

Refinements in the Science Plan as a result of Aleut collaborations included: (1) adding target species that were unique to village consumption patterns of Aleuts living near Amchitka (such as octopus, particular fish species, and fish eggs), (2) prioritizing the importance of the target species in terms of their importance to their subsistence lifestyle (which provided direction for the expedition itself in terms of determining sampling schedules, and later to the plan for radionuclide analysis), and (3) adding extensive intertidal collection, including locations regularly used by subsistence Aleuts. Finally, while the initial plan called for collecting species that are key subsistence foods, and perhaps some collection by Aleuts in their home villages, it did not include having Aleuts on the expedition itself. As a result of discussions in the Aleut villages of Nikolski, Unalaska, and Atka, the 13-person expedition team included an APIA team leader and three people from those villages (Burger et al., 2007d).

The expedition itself (in June and July 2004) was greatly enhanced by the presence of the villagers on board because they provided local knowledge of species and their habitats, knowledge of what parts, sizes, ages and stages of each organism that they ate, and wisdom about logistical questions and safety, including tidal and storm conditions (Table 3). More importantly, while the western scientists on board collected intertidal samples using a grid pattern, the villagers collected specimens in a manner they would for everyday subsistence use and as they would if they had been stranded on each beach. Once on the expedition, other subsistence foods were added because they were ones the Aleuts would collect if stranded. This enhanced the science, both by providing biota collected in the traditional subsistence manner, and by enhancing acceptance of the data by the greater Aleut community because their own people collected some of the

Table 3
Specific examples of how Aleut input improved the science.

Stage or phase	APIA and Aleut input
Developing the science plan	Inserted species that were of interest to Aleuts for the hunting and gathering of biota
Refining the target species	Aleuts in the villages suggested adding a number of species, including algae they consumed, as well as Octopus (*Octopus dofleini*) and Dolly Varden (*Salvelinus malma*) because they live mainly in the sea but return to freshwater streams to spawn.
Prioritizing species for collection	Aleuts in the villages wanted to add species at similar trophic levels so that if target species were not present, we would collect species of particular interest to them.
Conducting the expedition	Aleut villagers suggested that the team include Aleut hunters/gatherers to insure samples were also collected in the traditional manner. Aleuts were on the expedition.
Sample collection	Once on the expedition, Aleuts suggested the collection of additional species they would collect if stranded on an island. This included Chinese Hat limpets (*Tectura scutum*) and Gumboot Chitons (*Katharina tunicata*).
Sample collection methodology	Once on the expedition, scientists and researchers collaborated to collect samples both in the usual scientific way and in the traditional Aleut way.
Data analysis and presentation	APIA suggested some analyses to perform, and once in the Aleut villages, they suggested additional chemical analyses of interest (e.g. mercury).

samples. Further, as scientists, we were able to compare the characteristics (i.e. size of fish) and radionuclide levels of the samples collected by Aleuts with those collected by the scientists (Burger et al., 2006c, d; unpubl. data).

CRESP scientists (at Vanderbilt) and the Idaho National Laboratory analyzed radionuclide levels in biota, although the species selected for analysis were determined with the use of information gathered from APIA representatives, the Aleuts on the expedition, and Aleuts in the villages. The one improvement we could have made in the project was inclusion of Aleut interns during the sample preparation phase at Rutgers University, but budgetary constraints precluded this. However, future projects should incorporate Native Americans during the laboratory phases as well; such capacity building would contribute to overall scientific techniques of villagers, as well as enhancing data credibility on the local level.

Most scientists deal with the dissemination phase by publishing papers in scientific journals, and rarely, the findings are carried in newspapers. The other approach, taken by the CRESP Amchitka project, was to make dissemination an integral part of the process, not just the ending of the project. The Aleuts on the expedition were full members of the scientific team, and thus they were co-authors on papers in the scientific literature, the usual method of communication (Burger et al., 2006c, 2007c, e, g, h, 2008). Dissemination included providing information on the web and to newspapers, making the report available to anyone (in hard copy and CDs), and holding public meetings in Anchorage, in the APIA offices, in Homer (site of US Fish & Wildlife Service), and in Aleut villages. Partly the goal of these meetings was to solicit further input about perspectives on the data, including other analyses, and to consider the path forward. One concern that came from the meetings was the potential risk from mercury in their subsistence foods, and subsequently mercury was examined (Burger et al., 2007c, g, h). Translational approaches to science are just reaching the fore in many federal funding agencies, and the Amchitka project illustrates this approach, although it goes far beyond the usual definition of translational (which does not usually involve participation by Native Americans or stakeholders).

Finally, determining the path forward included discussions with APIA and Aleuts in their villages, along with a range of stakeholders. Even the earliest discussions with Aleuts suggested that some form of long-term monitoring of the marine environment around Amchitka was essential to provide peace of mind that radionuclides in the subsistence foods did not pose a risk. The data on radionuclides, which showed that levels were well below any human health guidelines (Burger et al., 2006b, 2007e), could form the basis for a biomonitoring plan, and CRESP developed such a plan (Burger, 2007c; Burger et al., 2007i). This biomonitoring plan provided the basis for the long-term monitoring plan ultimately developed by DOE for Amchitka (DOE, 2008).

6. Lessons learned and conclusions

Increasingly government officials, public policy makers, managers, and the public are facing difficult and complex environmental problems, many dealing with contaminated sites. Although science clearly forms the basis for many of the decisions about remediation and restoration of contaminated sites, many aspects are clearly social and cultural (Norgaard, 1992; Meffe and Viederman, 1995; Leslie et al., 1996), and we argue, involve traditional Native American cultures and values (Harris and Harper, 1997, 2000; Stumpff, 2006; Burger et al., 2008). Inclusion of Native Americans (and other interested and affected parties) should be more than just public meetings (Kaminstein, 1996; McComas, 2003).

It should be stressed that the federal and state agencies involved with the design and execution of the Science Plan (at least at the level of signing off on the plan and project) were supportive of including Native Alaskans as much as possible. While they could provide little direct support for the inclusion of Native Alaskans in the process, personnel from federal and state agencies were impressed with the decree of inclusion, the level of expertise provided by the Aleuts, and the collaborations that developed.

The results of this study indicate that true collaboration involves inclusion in a range of activities that meaningfully affect the formulation of the problem, research design, research execution, and final outcome. In the case of Amchitka, merely identifying what organisms (kelp, shellfish, fish, birds, marine, and mammals) Aleuts collected, hunted, and fished was not sufficient. Actually having villagers collecting these organisms in their traditional manner, from the Amchitka marine environment, resulted in data reflective of their traditional culture, as well as assuring them that their traditional and cultural values were included. Collaboration with Aleuts required not only that scientists listen to them, but that Aleut ideas were incorporated into the research design and execution, markedly changing the process, data collected, and final results. Because the Aleuts participated throughout the process, they, along with other stakeholders involved, had confidence in the final results, and all parties agreed on the path forward (design of a biomonitoring plan using the radionuclide data on biota as the baseline).

We learned the following lessons from the process:

1. Aleuts (or other Native Americans) must be included early and often.
2. Aleuts (Native Americans or others of concern) must be included throughout the process, at every possible stage.
3. True collaboration is required, not just communication at the beginning and end, including the publication of scientific results.
4. Researchers must consider the Native Americans full partners, which means altering research plans and protocols to reflect their cultural and social values, as well as their scientific ones.
5. The affected public must be involved, as well as their representatives (in this case, both APIA representatives and Aleuts in their villages).
6. Agreement or consensus on the issues during the science process leads to both acceptance of the final results, and agreement on any necessary path forward (in this case, design of a biomonitoring plan to assure continued safety of the foods from the marine environment around Amchitka).
7. It is not always possible to predict the aspects of the problem-formulation, research design and execution that Native Americans (or other groups) will modify.
8. While the process of full collaboration adds time (and money) to the process, the end result is consensus, rather than continued controversy.

We suggest that this approach to defining and solving environmental problems can be applied to other complex situations, particularly those involving Native Americans or others with subsistence lifestyles or who depend heavily upon habitats or resources on contaminated sites. By carefully delineating both the overall process (Table 1), and the possible interactions with the interested parties (Table 2), full involvement and collaboration can occur.

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