DECISIONMAKING FRAMEWORK FOR INJURY ASSESSMENT CHAPTER 2

2.1 Introduction

The purpose of this chapter is to develop a decisionmaking framework to assist trustees in designing the injury assessment component of an NRDA. The framework includes five steps.

- Review information on potential injuries from the Preassessment Phase.

  Trustees review all of the information and preliminary conclusions relevant to injury developed during the Preassessment Phase.

- Construct inventory of possible injuries.

  Trustees organize and structure what is known about possible injuries resulting from the incident. A list of important types of information is provided in this chapter to suggest a way to organize information using a common framework and identify important gaps in knowledge.

  In completing this step, trustees will find it important to carefully differentiate between what is known and what is suspected.

- Evaluate injuries for strength of evidence.[1]

  Trustees evaluate possible injuries based on the strength of information for the injury, relative to what is known and what could be learned from additional injury assessment efforts.

[1] The term *evidence* refers to scientific, not legal, information.

- Establish preliminary restoration objectives.

  Trustees set forth a set of preliminary restoration objectives.

  These objectives might be based upon a number of factors including knowledge of the incident gained during the Preassessment Phase, additional information developed as part of the injury assessment design process, and the knowledge of experts.

- Evaluate injuries for relevance to restoration.

  Trustees evaluate possible injuries based on the relevance (significance and correspondence) of each injury to restoration.

Although these five steps are presented in a sequential fashion, trustees may find it useful to review the process several times as information becomes available and trustee deliberations continue.

Exhibit 2.1 presents a schematic of the decisionmaking framework and includes references to Section 2.4 of this chapter where each element is discussed in greater detail. An example application of the decisionmaking framework is provided in Section 2.5.

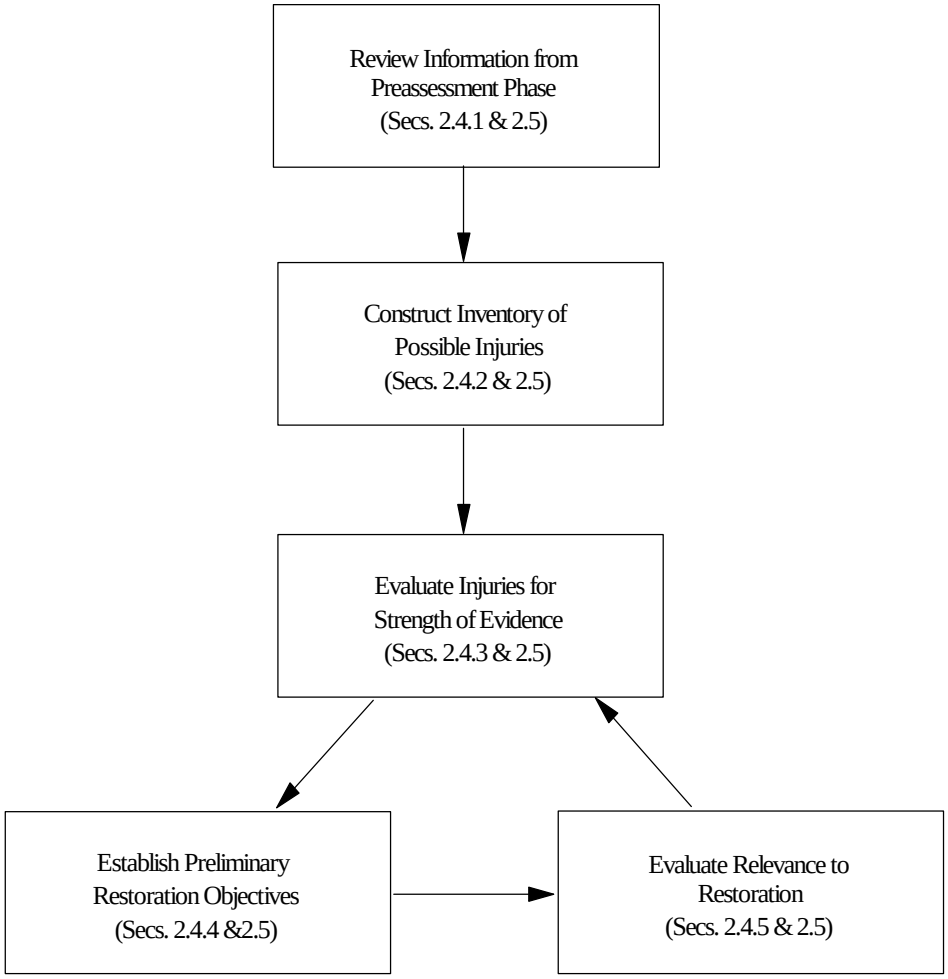
The decisionmaking framework may be more useful to trustees once the Preassessment Phase is completed. During the Preassessment Phase trustees develop initial documentation about the incident, pathways and exposures resulting from the incident, the natural resources and services affected and the specific injuries suffered, and the overall basis for the restoration actions they are contemplating.[2] This information provides the initial direction for designing the injury assessment.

Before turning to a detailed discussion of the decisionmaking framework and the example application, the next two sections explain the concepts of injury and restoration.

[2] The reader is referred to the Preassessment Phase Guidance Document, cited in Appendix B.

Exhibit 2.1

DECISIONMAKING FRAMEWORK



2.2 Concept of Injury

2.2.1 Definition of Injury

Under the OPA regulations, trustees must determine if the definition of *injury* has been met. *Injury* is defined as an observable or measurable adverse change in a natural resource or impairment of a service and is described in section 1.5.4 of Chapter 1. The list of potential adverse changes described in the OPA regulations and this document is not intended to be inclusive of all injuries that trustees may evaluate.

2.2.2 Direct and Indirect Injury

An injury can be direct or indirect. Under the OPA regulations, such a distinction is not important. However, when designing an injury study, such distinctions may be quite useful in setting priorities and selecting appropriate methodologies.

Direct injuries can occur when natural resources come into physical contact with the incident (i.e., discharged oil or response-related activities). Examples include the death of a fish exposed to the discharged oil, or restriction of boat activities for the purposes of cleanup along a waterbody affected by the discharge of oil. Indirect injuries may occur when the presence of the discharged oil interferes with a physical, chemical, or biological process important to the natural resource. An example of indirect injury would be a reduction in growth or reproduction in a population of fish-eating birds when prey (e.g., fish abundance) is reduced because of direct injury to the prey from the incident. Indirect injury also may occur from loss or reduction of services provided by a natural resource (e.g., when a fishery is closed because of the potential for oil-tainted fish).

2.2.3 Injury Causality

OPA emphasizes the need for trustees to establish that the identified injuries resulted from the incident. In the event of an actual discharge of oil, injury determination involves:

- Establishing a *pathway* from the discharge in question to the resource;
- Establishing that the resource was *exposed* to the discharge (where applicable); and
- Demonstrating that the adverse change in the resource relative to baseline was caused by exposure to the discharge.[3]

[3] OPA regulations at § 990.51(b).

To evaluate causality, trustees may wish to consult the criteria set forth in Fox (1991). The Fox paper provides a detailed discussion of the many considerations important in establishing causality for environmental changes and sets forth seven specific criteria that should be evaluated.

These criteria are summarized briefly below.

- *Probability*: Is the relationship statistically significant? The demonstration of a statistical relationship between exposure and an adverse change is an important factor in evaluating causality, provided that the statistical power is adequate. A statistically significant correlation between exposure and an adverse change does not, in and of itself, prove causality, but a causal relationship is very unlikely without such a correlation. However, as discussed in detail in Section 3.4.3, statistical significance should not be equated with biological or environmental significance.

- *Time Order*: What is the temporal nature of the association? Does the cause precede the effect in time or was the adverse change already occurring? For example, was the population of a particular species declining prior to the incident? Although the timing of cause and effect may be obscured, the injury should occur during a reasonable time frame following the incident. For example, did the fish kill occur immediately after the discharge or two months later?

- *Strength of Association*: What is the degree to which the cause is associated with the effect (i.e., severity, frequency, extent). Is the exposed population 200 times or 2 times more likely to suffer the injury than the baseline occurrence of that effect? Are all organisms affected by the exposure or is only a fraction of the exposed population affected?

- *Specificity*: How precise is the cause and effect relationship? Does the adverse change occur only in the exposed population relative to baseline information? For example, a decline in reproductive success may be observed following an incident. If that association is limited to the exposed population, the causation argument would be strengthened. If, however, similar declines in reproductive success are consistently found elsewhere (i.e., at reference sites), the association would be weakened.

- *Consistency on Replication*: Has the association been repeatedly observed under different conditions? The occurrence of an association in more than one population or species, in different areas, by different researchers, is strong evidence of a causal relationship.

- *Predictive Performance*: Is the association strong enough to allow for prediction of consequences? Such predictions are based on hypothesis formulation and observation.

- *Coherence*: Does the cause-effect hypothesis conflict with knowledge of natural history, biology, and toxicology? Is there a plausible mechanism? Is there a dose-response relationship?

2.3 Concept of Restoration

2.3.1 Definition of Restoration

Trustees must identify a reasonable range of restoration alternatives[4] for consideration, as defined in section 1.5.8 of Chapter 1. Each alternative is composed of primary and/or compensatory restoration components that address one or more specific injuries associated with the incident. Primary restoration refers to any actions taken to return the injured natural resources and services to baseline on an accelerated time frame. Natural recovery, in which no human intervention is taken to accelerate recovery of the injured natural resource and service, is included under the primary restoration component. Compensatory restoration refers to any actions taken to compensate for the interim losses of natural resources and services, from the time of the incident until recovery is achieved.

Each alternative must be designed so that, as a package of one or more actions, the alternative would satisfy OPA's goal to make the environment and public whole for injuries resulting from an incident. Acceptable restoration alternatives include any of the actions authorized under OPA (i.e., restoration, rehabilitation, replacement, or acquisition of the equivalent) or any combination of those actions.

In general, both primary and compensatory restoration of services must be accomplished through actions to restore natural resources or to preserve or enhance the amount, quality, and/or availability of natural resources that provide the same or similar services. This may include actions to improve access to natural resources, although in selecting such actions, the trustees must carefully evaluate the direct and indirect impacts of the improved access on natural resource quality and productivity. In the natural resource damages context, a service may not be viewed as an abstract economic unit or activity that may be restored independently of the natural resources from which the service flows.

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[4] OPA regulations at § 990.53(a).

2.3.2 Primary Restoration

Trustees must consider primary restoration actions,[5] including a natural recovery alternative. Alternative primary restoration actions can range from actions that prevent interference with natural recovery (e.g., closing an area to human traffic) to more intensive actions expected to return injured natural resources and services to baseline faster or with greater certainty than natural recovery.

When identifying primary restoration actions to be considered, trustees should consider whether:

- Activities exist that would prevent or limit the effectiveness of restoration actions (e.g., residual sources of contamination);

- Any primary restoration actions are necessary to return the physical, chemical, and biological conditions necessary to allow recovery or restoration of the injured natural resources (e.g., replacement of sand or vegetation, or modifying hydrologic conditions); and

- Restoration actions focusing on certain natural resources and services would be an effective approach to achieving baseline conditions (e.g., replacing essential species, habitats, or public services that would facilitate the replacement of other, dependent natural resource and service components).

2.3.3 Compensatory Restoration

In addition to primary restoration, trustees must consider compensatory restoration actions[6] in the restoration alternatives. The extent of interim natural resource or service losses that must be addressed by a particular restoration alternative may vary depending on the level and speed of recovery generated by the primary restoration component of the restoration alternative.

To the extent practicable, when identifying the compensatory restoration components of the restoration alternatives, trustees should consider compensatory restoration actions that provide services of the same type and quality, and of comparable value as those injured. This is the preferred approach to identifying compensatory restoration actions. If such actions do not provide a reasonable range of alternatives, trustees should identify actions that, in the judgment of the trustees, will provide services of at least comparable type and quality as those injured. Where the injured and replacement natural resources and services are not of comparable value, the scaling process will involve valuation of injured and replacement services.

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[5] OPA regulations at § 990.53(b).

[6] OPA regulations at § 990.53(c).

In general, both primary and compensatory restoration of services must be accomplished through actions to restore natural resources or to preserve or enhance the amount, quality, and/or availability of natural resources that provide the same or similar services. This may include actions to improve access to natural resources, although in selecting such actions, the trustees must carefully evaluate the direct and indirect impacts of the improved access on natural resource quality and productivity. In the natural resource damages context, a service may not be viewed as an abstract economic unit or activity that may be restored independently of the natural resources from which the service flows.

2.3.4 Relationship between Primary and Compensatory Restoration

The concept of scaling compensatory restoration actions is illustrated in Exhibit 2.2. The first graph characterizes the level of services provided by an injured resource, and the second graph characterizes the level of services provided at a compensatory restoration project site. Time is represented on the horizontal axis, and the level of services is represented on the vertical axis. The baseline level of services is indicated by the horizontal line labeled "baseline."

If no primary restoration is undertaken, the combined areas A and B would represent the total services lost from the time of injury until the return of the resources to baseline through natural recovery. However, a primary restoration program would promote the recovery and reduce the interim loss of services by the amount represented in area B. In other words, the compensatory restoration project would need to compensate for the loss of A.

Trustees would compensate for the loss in services due to the injury by implementing an on-site compensatory restoration project generating additional services represented by area C. The public will be compensated when the area of C equals the area of A. Alternatively, if natural recovery were the preferred option, then area C should equal the sum of areas A and B.

It should be clear from this discussion that the selection of a metric to characterize service levels is critical.

A range of primary restoration activities may be considered by the trustees. Active primary restoration would achieve a quicker return to baseline, relative to natural recovery, and generally would reduce the interim loss of services. However, in some situations, active primary restoration may not be feasible or desirable and the trustees would develop only a compensatory restoration program in conjunction with natural recovery.

Exhibit 2.2 assumes that baseline remains constant over time. This may not always be the case (refer to Exhibit 2.3). Trustees should consider whether the baseline level is changing when planning and conducting an injury assessment.[7]

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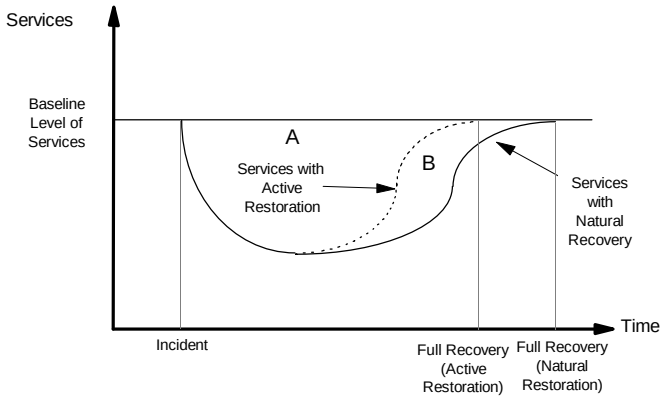
[7] The plots in Exhibit 2.3 were developed by John Cubit, NOAA, Damage Assessment Center, Long Beach, CA.

Exhibit 2.2

THE RELATIONSHIP BETWEEN PRIMARY AND COMPENSATORY RESTORATION

Level of Services Provided by Injury Site



Increment in Services at Site of Compensatory Restoration Project

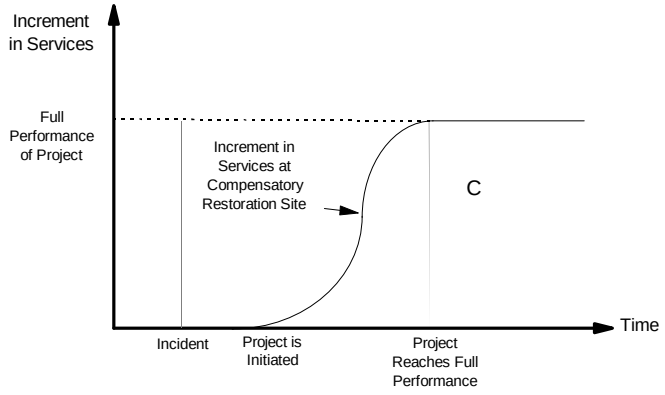
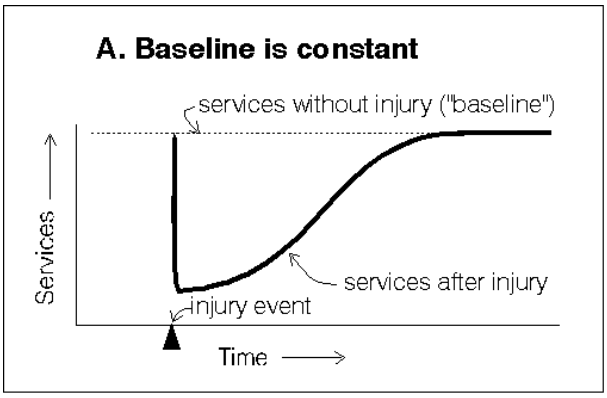
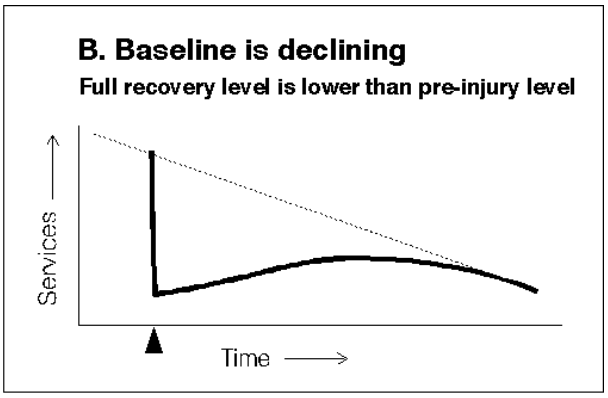
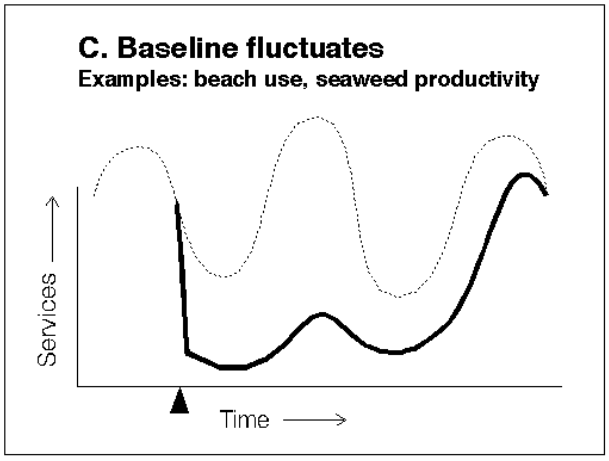


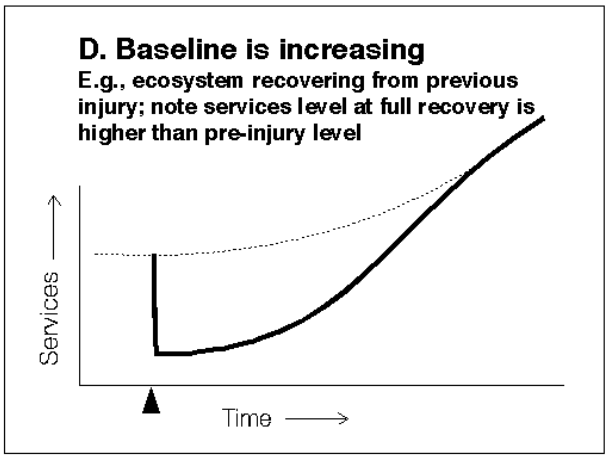
Exhibit 2.3

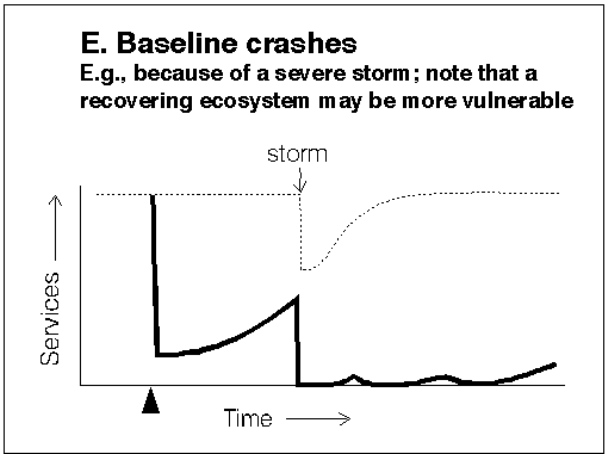
EXAMPLES OF A FEW BASELINE FORMS











2.4 The Decisionmaking Framework

The decisionmaking framework for injury assessment is structured to ensure that restoration considerations are an integral part of the injury assessment planning process. Natural resource trustees may wish to use this framework to assist in designing an integrated and cost-effective injury assessment that will support restoration.

2.4.1 Review Information from Preassessment Phase

Trustees may wish to begin by carefully reviewing all information and preliminary conclusions generated during the Preassessment Phase, including the Notice of Intent to Conduct Restoration Planning as well as other information generated during preassessment activities. In most cases, trustees already will be very familiar with preassessment information as they begin to design the injury assessment. The purpose of this review is to ensure the trustees are familiar with all available information about the incident and environmental characteristics prior to the incident.

2.4.2 Construct Inventory of Possible Injuries

To ensure that the evaluation of possible injuries is as complete as possible, trustees should consolidate knowledge about all suspected injuries prior to evaluating the injuries for inclusion in the assessment. To compile the inventory, trustees should answer the following types of questions for each suspected injury.[8]

- What are the natural resources and services of concern?
- What are the procedures available to evaluate and quantify injury and the associated cost and time requirements?
- What is the evidence indicating exposure?
- What is the pathway from the incident to the natural resource and/or service of concern?
- What is the adverse change or impairment that constitutes injury?
- What is the evidence indicating injury?
- What is the mechanism by which injury occurred?

[8] OPA regulations at § 990.51(f).

- What is the potential degree and spatial and temporal extent of the injury?

- What is the potential natural recovery period?

- What are the kinds of primary and/or compensatory restoration actions that are feasible?

When completing the inventory, the trustees should critically examine all observations, data, and assumptions that indicate that specific injuries have occurred or will occur. Trustees should give careful consideration to contradictory evidence, alternative hypotheses, and possible confounding factors.

Constructing the inventory of possible injuries should not require an extensive research effort, but should instead be based on the knowledge of the trustees and outside experts, and the information collected during response and preassessment. It may be useful to review the relevant scientific and damage assessment literature as the inventory is constructed. To be most useful, the inventory should not be a list of possible *studies* that might be conducted in support of an injury assessment program, but rather should focus on what is known and suspected about *injuries* from the incident.

Exhibit 2.4 presents an example of a tabular format that trustees might use to consolidate this information. The columns in the exhibit are keyed to the questions listed above. This example format can be varied to meet the particular requirements of an incident. For example, an additional column could be added to summarize information about baseline trends or two columns could be used to consider pathway and exposure issues separately. A separate table could be generated for each type of natural resource (e.g., fish, birds, wetlands). The paragraphs below provide a brief discussion of each of the questions listed above and in the exhibit.

Exhibit 2.4

INVENTORY OF POTENTIAL INJURIES

Resource	Injury	Services	Evidence for Injury	Mechanism	Pathway and Exposure	Time to Natural Recovery	Possible Primary Restoration Activities	Possible Compensatory Restoration Activities

What are the natural resources and services of concern?

Trustees should identify the specific natural resources of concern using precise language to describe the area, habitat, plant, or animal at whatever level is appropriate. To complete this first step, trustees may consider the spatial and temporal extent of the incident, pathways from the incident to resources, likely exposures, and observed or suspected adverse effects. Appendix D describes a wide range of natural resources that could be injured by oil. The information in Appendix D can be used as a check on the completeness of the list of injured natural resources.

Trustees should also list the specific ecological and human services affected by the injury. The trustees should consider the important services provided by the affected natural resources, with particular attention to the role of those natural resources in the overall ecosystem (e.g., source of clean food, habitat for rearing of young).

What are the procedures available to evaluate and quantify injury, and the associated cost and time requirements?

The OPA regulations allow for a wide range of assessment procedures,[9] from field or laboratory procedures, to model- or literature-based procedures, to a combination of procedures. When practicable, injury assessment procedures should be chosen that provide information of use in determining the most appropriate alternative for restoring the injury resulting from the incident. In addition, when selecting injury assessment procedures, trustees should consider factors such as the time and cost to implement the procedure, nature, and spatial and temporal extent of injury, information needed to determine and quantify injury, possible restoration actions for expected injuries, and information needed to determine appropriate restoration. If more than one procedure providing the same type and quality of information is available, the most cost-effective procedure must be used.

Under the OPA regulations, injury assessment procedures must meet all of the following standards:

- The procedures provide assessment information of use in determining the type and scale of restoration appropriate for a particular injury;

- The additional cost of a more complex procedure is reasonably related to the expected increase in the quantity and/or quality of relevant information provided by the more complex procedure; and

- The procedures are reliable and valid for the particular incident.

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[9] OPA regulations at § 990.27.

What is the evidence indicating exposure? What is the pathway from the oil to the natural resource and/or service of concern?

For incidents involving an actual discharge, trustees should describe the specific pathway and mechanism thought responsible for exposing the resource in question to the incident. Trustees will need to evaluate whether there is a pathway from the oil to the resource in question and the natural resource in question was, in fact, exposed to the discharge.

What is the adverse change or impairment that constitutes injury?

Trustees should list the specific injury of concern. Known or suspected adverse change should be defined as precisely as possible.

What is the evidence indicating injury?

Trustees should list the basic facts and hypotheses that suggest that injury has or is likely to have occurred. Data and observations collected during response to the incident will provide information, for example, about the extent of animal and plant mortality and perhaps other injuries. There also may be data on oil concentrations in various media such as water and sediments, and information on the degree of oiling of shorelines, wetlands, etc. This information can be combined with the knowledge of experts and with information found in the published literature to provide the initial line of reasoning supporting injury.

What is the mechanism by which injury occurred?

Trustees should list the mechanism of action thought to have caused the observed or suspected injury. The trustees may wish to review the relevant toxicological literature and consult with biologists and environmental toxicologists knowledgeable about the mechanisms (e.g., suffocation, acute/chronic toxicity, tissue or cellular damage) of action that cause adverse effects in resources exposed to oil.

What is the potential degree, and spatial and temporal extent of the injury?

In order to adequately assess injury to natural resources and services, trustees must evaluate the degree (severity or magnitude) of the injury, and the spatial (geographical) and temporal (duration) extent of that injury.[10] Such information allows the trustees not only to prioritize their concerns relative to various injuries, but ultimately to define the scale of restoration possible given those prioritized injuries.

[10] OPA regulations at § 990.52(b).

Degree of injury may be expressed in terms such as percent mortality, incremental mortality, proportion of habitat affected, and extent of oiling. Spatial extent may include quantification of the total area or volume of injury. Temporal extent may be expressed as the total length of time that the natural resource and/or service is adversely affected, starting at the time of the incident and continuing until the natural resources and services return to baseline.

What is the potential natural recovery period?

Trustees must determine not only whether natural recovery[11] is possible, but also the rate of such recovery. Analysis of recovery times may include such factors as the:

- Nature, degree, and spatial and temporal extent of injury;
- Sensitivity and vulnerability of the injured natural resource and/or service;
- Reproductive and recruitment potential;
- Resistance and resilience (stability) of the affected environment;
- Natural variability; and
- Physical/chemical processes of the affected environment.

Although it is desirable to account for these factors and produce a rigorous quantitative natural recovery estimate for a particular natural resource, this may not be practicable for many injuries. Where quantitative procedures are lacking, inadequate, or unnecessarily costly to precisely estimate natural recovery times, trustees may use appropriate qualitative procedures to develop estimates where needed.

What are the kinds of primary and/or compensatory restoration actions that are feasible?

Trustees should list actions by which primary restoration of the natural resources and services might be accomplished.[12] Trustees should also list actions that could replace services lost due to the injured natural resource. These actions might include activities such as acquisition of additional habitat, provision of food while restoration or natural recovery is ongoing, improvements to facilities to allow enhanced public uses of the resource, etc.

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[11] OPA regulations at § 990.52(c).

[12] Trustees should refer to the Restoration Guidance Document cited in Appendix B for a list of possible restoration actions.

2.4.3 Evaluate Possible Injuries for Strength of Evidence

The strength of evidence for each possible injury should be evaluated based on what is presently known about the incident and could be learned from additional work during injury assessment. Exhibit 2.5 provides four questions to guide evaluation of strength of evidence, both with current knowledge and with additional studies. The paragraphs following Exhibit 2-5 provide a brief discussion of each of the questions.

Exhibit 2.5

QUESTIONS TO EVALUATE STRENGTH OF EVIDENCE

- Can the injury be stated in terms that comply with the definition of injury in the OPA regulations.
- Can the injury be reliably documented under appropriate quality assurance procedures?
- Can the pathway of exposure be established through empirical observations, modeling, or a combination of observations and models?
- Is it reasonable to conclude that the injury was caused by the incident in question or do other plausible explanations exist?

- **Can the injury be stated in terms that comply with the definition of injury in the OPA regulations?**

Trustees should begin evaluating the strength of the information by determining whether they are able to clearly define the injury in terms consistent with the OPA regulations. That is, is there an *injury* as defined by the OPA regulations? Is the injury related to an actual discharge of oil, response actions, or a substantial threat of a discharge of oil?

- **Can the injury be reliably documented under appropriate quality assurance protocols?**

Trustees should evaluate the quality of the data that support the finding of injury and should carefully consider limitations in these data. In cases where a model-based assessment (e.g., type A model) is appropriate, field observations and literature searches may generate important corroborative information. If additional assessment effort is needed, trustees should consider the quality of the findings likely to be generated by these efforts. Chapter 3 provides information trustees should consider when designing and evaluating injury assessment studies. To be scientifically defensible, any assessment efforts undertaken by the trustees should be designed with a strong quality assurance component.[13]

- **Can the pathway of exposure be established through empirical observations, modeling, or a combination of observations and models?**

In the event of an actual discharge, trustees should evaluate the quality of the data indicating that injured natural resources have been exposed to the discharge or affected by the incident. If additional assessment efforts are needed to further document the pathway of exposure, trustees should consider the quality of the findings likely to be generated by these studies.

- **Is it reasonable to conclude that the injury was caused by the incident in question or do other plausible explanations exist?**

Trustees should evaluate the quality of the data that supports the finding that the injury was caused by the incident in question. Adverse effects can occur for a variety of reasons and natural resources sometimes are affected by other substances or perturbations.

2.4.4 Establish Preliminary Restoration Objectives

Trustees should further develop a set of preliminary restoration objectives. Because these objectives are tentative at this stage, trustees can expect to revise the objectives as the design for the injury assessment is developed and finalized. The preliminary objectives will be based on information gathered during the incident, response, and preassessment efforts, the knowledge of experts, and the results of the first three steps of the decisionmaking framework.

The restoration objectives should set forth a brief list of the restoration endpoints that the trustees seek to achieve. Trustees should consider listing restoration actions with each objective to make the objectives more tangible and useful and ordering the objectives by overall importance to the trustees.

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[13] Chapter 3 provides an overview of quality assurance procedures for injury assessments.

For example, imagine that a large discharge of oil has occurred in a coastal area, resulting in extensive oiling of the intertidal zone, including salt marshes. Bird, fish, and shellfish mortality are documented, as is tissue contamination in large areas of shellfish beds. The area was closed to beach use, fishing, shellfishing, and boating for a three-week period. Some shellfish beds are not expected to be reopened for several months and will suffer from reduced populations for approximately three years. Oiled salt marshes will be impaired for approximately five years.

In this situation, the trustees might develop the following list of preliminary objectives to guide the injury assessment process.

Objective 1. Clean up, isolate, or remediate any continuing sources of oil that would inhibit natural recovery or limit the success of further restoration efforts. Actions might include removal of buried oil in a gravel beach that continues to generate sheens.[14]

Objective 2. Restore or rehabilitate injured habitats to baseline conditions. Actions might include replanting of salt marsh vegetation and protection of oiled areas from erosion during vegetation recovery.

Objective 3. Enhance the recovery of specific injured natural resources and services that are important to the environment or public. Actions might include replacement of killed birds by encouraging recolonization of the area (e.g., nesting sites), reseeding of shellfish beds, and placement of clean sand on degraded public beaches.

Objective 4. Create or enhance habitat or human facilities to provide equivalent services as compensation for services lost from the onset of injury to full recovery to baseline. For example, such actions might include rehabilitation of additional areas of degraded salt marsh near the discharge area (but not caused by the discharge).

Compensatory restoration actions are typically considered after primary restoration actions have been developed because the scope of compensatory restoration is dependent upon the speed and effectiveness of primary restoration.

2.4.5 Evaluate Possible Injuries for Relevance to Restoration

The final part of the decisionmaking framework is the evaluation of possible injuries for relevance to restoration. Exhibit 2.6 provides a checklist to aid the evaluation of relevance of possible injuries. The paragraphs following Exhibit 2.6 provide a brief discussion of each of the questions.

[14] Often, significant sources of oil will be removed during the response action. In this example, we assume that buried oil was discovered after clean-up actions were terminated.

Exhibit 2.6

QUESTIONS TO EVALUATE RELEVANCE TO RESTORATION

(1) Relevance to Primary Restoration

- Can the injury be remedied by direct restoration of chemical, physical, or biological attributes of the environment?
- Do the trustees conclude, on a tentative basis, that active primary restoration is preferable to natural recovery?
- Can the injury be quantified in a way that allows the scale of primary restoration to be determined?

(2) Relevance to Compensatory Restoration

- Can the environment or public be compensated for lost services through compensatory restoration such as habitat construction, stocking, or other activities, to replace lost services?
- Can the injury be quantified in terms that allow the scale of compensatory restoration to be estimated?

(1) Relevance to Primary Restoration

- **Can the injury be remedied by direct restoration of chemical, physical, or biological attributes of the environment?**

Trustees should list possible primary restoration actions considered in the Preassessment Phase and further evaluate whether these actions are technically feasible and likely to be cost-effective. While a variety of actions may appear possible at first consideration, experts should carefully evaluate the likely effectiveness of these actions.

- **Do the trustees conclude, on a tentative basis, that active primary restoration is preferable to natural recovery?**

Trustees should evaluate whether primary restoration actions will result in a more rapid return to baseline. The time needed to return the injured natural resource to baseline depends not only on the speed with which the restoration action affects the environment, but also on the time required to initiate the restoration action given the status of the overall assessment of injury, the need for detailed planning and environmental permitting, and other factors. The total time required to plan, gain regulatory and public approval, and then implement a primary restoration action can be significant.

- **Can the injury be quantified in a way that allows the scale of primary restoration to be determined?**

Trustees should consider how the degree and spatial/temporal extent of primary restoration might be determined and how the trustees might demonstrate that the primary restoration under consideration will accelerate the recovery of the injured natural resources. Trustees should be able to link the primary restoration to the baseline condition of the natural resource developed in the injury assessment.

(2) Relevance to Compensatory Restoration

- **Can the environment or public be compensated for lost services through compensatory restoration, such as habitat construction, stocking, or other activities, to replace lost services?**

Trustees should list possible compensatory restoration actions and consider the feasibility, costs, and ecological and human services to be gained from each possible compensation action. Compensatory restoration actions should generate services that are as similar as practicable to the services lost as a result of the incident.

- **Can the injury be quantified in terms that allow the scale of compensatory restoration to be estimated?**

Trustees should consider how the appropriate amount or scale of compensatory restoration will be determined and how this will be shown to be commensurate with the natural resources and services lost. In the case of compensation actions, duration as well as degree of replacement services is important.

2.4.6 Consider the Strength of Evidence on Injury and its Relevance to Restoration

Evaluation of strength of evidence and relevance to restoration for each possible injury can assist trustees in selecting injuries to include in the injury assessment and identifying additional injury assessment efforts to pursue, if any. Trustees may decide not to include injuries with low relevance regardless of the strength of evidence on injury. Injuries with high relevance and strong evidence are obvious candidates for inclusion in the injury assessment. Injuries with high relevance, but weaker information will need to be carefully considered by the trustees.

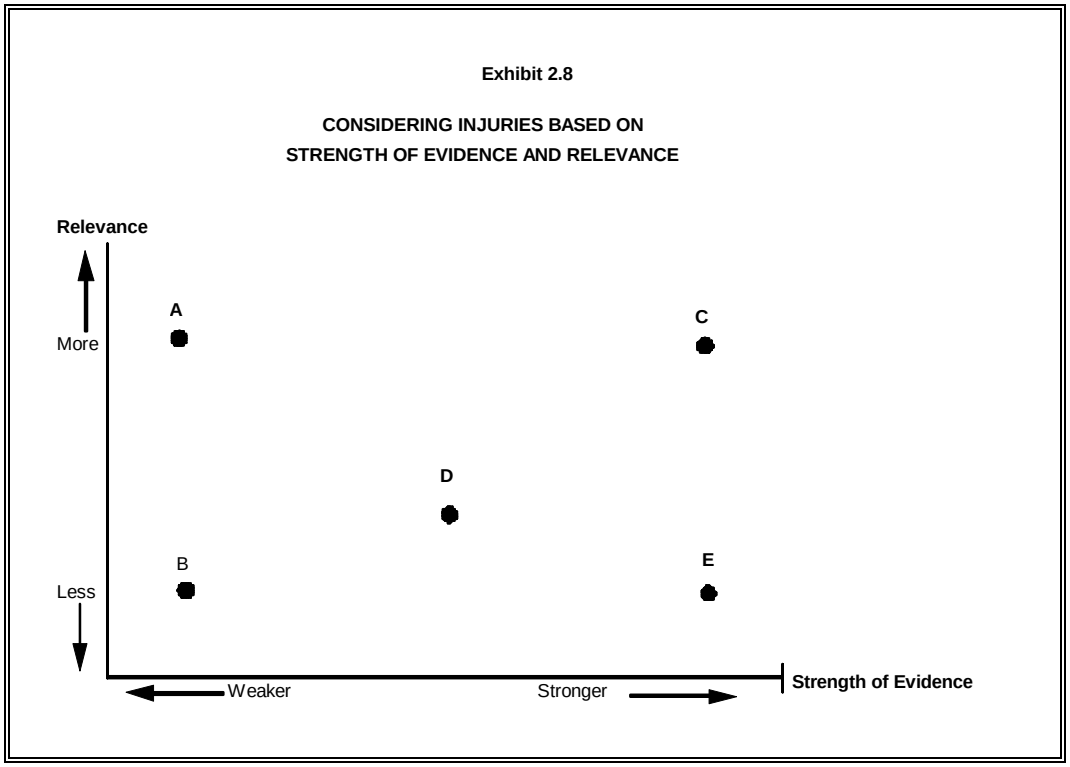
The primary value of the strength of evidence on injury and relevance concepts and of the overall decisionmaking framework is to provide a structure for discussions and deliberations among trustees and other interested persons. Trustees may find it helpful during these deliberations to use some simple tables or graphs to visualize the relationship between strength of evidence and relevance to restoration for each possible injury. Trustees could use a simple table to summarize strength of evidence and relevance, as shown in Exhibit 2.7, using either terms such as "high" and "low" or numerical rankings. When trustees use such subjective terms such as "high" and "low," they should define the parameters of these terms so that there is a common understanding of their use.

Exhibit 2.7

CONSIDERING INJURIES BASED ON THE STRENGTH OF EVIDENCE ON INJURY AND RELEVANCE TO RESTORATION

	Strength of Evidence		
Injury	**Now**	**With More Study**	**Relevance**
A	Weak	Moderate	High
B	Weak	Weak	Low
C	Strong	Very Strong	High
D	Moderate	Moderate	Medium
E	Strong	Strong	Low

Exhibit 2.8 provides one possible graphical technique. Strength of evidence for each injury under consideration is plotted along the horizontal axis, with injuries with greater strength of evidence to the right and injuries with weaker evidence on the left. The relevance of each possible injury is



plotted on the vertical axis, with more relevant injuries found above less relevant injuries.

Exhibits 2.7 and 2.8 include five example injuries labeled A through E. Injuries A and C both are judged highly relevant, and Injury C is judged to have strong evidence. Trustees might elect to include both A and C in the injury assessment. Limited additional studies might be needed to finalize the evidence for C, while significant additional assessment effort appears needed for A given the relatively weak evidence at present. Trustees would need to carefully consider the cost and time requirements of possible additional efforts for injury A.

Injury D is judged to fall in the middle of both the relevance and strength of evidence scales. Trustees will often find possible injuries in this middle area. Decisions to include these types of injuries in the assessment may depend on whether additional assessment effort can be completed within a reasonable time period and budget.

Injuries B and E both are judged to have low relevance. Injury B also is judged to have weak evidence and would likely be dropped from further consideration by the trustees. Injury E is judged to have relatively strong evidence and might be included in the injury assessment if little or no further study of the injury were required.

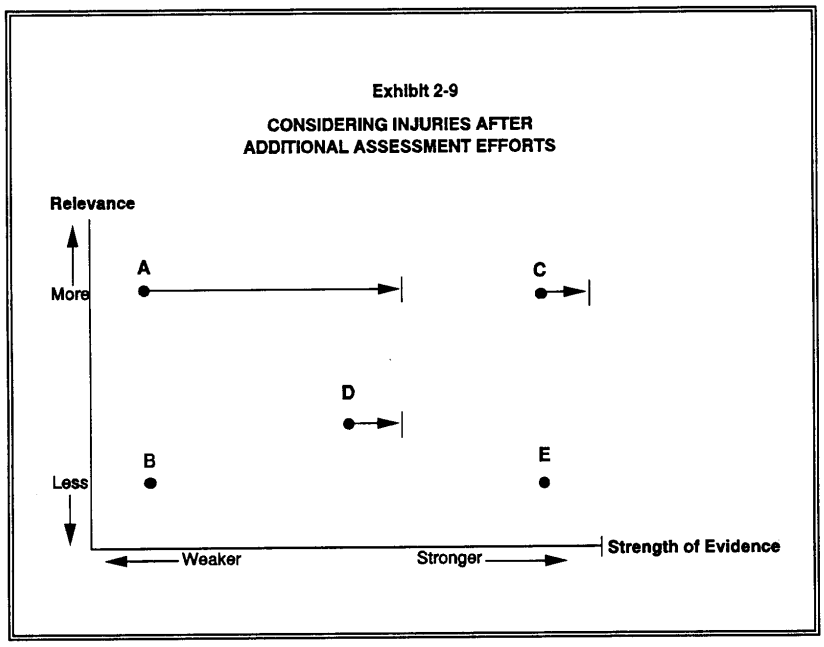
As trustees consider the strength of evidence of possible injuries they will need to carefully review additional studies needed to evaluate injuries. Trustees may wish to clearly set forth information about each additional study by developing brief answers to the following questions.

- What questions regarding injury and its relevance to restoration will the study answer?
- How will the study be conducted?
- Who will perform the study and what are the qualifications of the investigators?
- How much time and funding will be required?
- Is the study likely to generate valid data and conclusions?

If useful, trustees can include information about the expected change in strength of evidence shown in Exhibit 2.7 or can plot this information shown in Exhibit 2-9. The horizontal arrows in Exhibit 2.9 associated with each injury represent the trustees' estimate of how the strength of evidence for an injury might change after further study.

Continuing the example used above, Exhibit 2.9 indicates the trustees' judgment that additional assessment effort would significantly strengthen evidence for injury A but would have little effect on the evidence for injury D. Additional effort was not considered for injuries B and E in view of their low relevance. Little additional effort is judged necessary for injury C.

The example table or graphs described above are methods that trustees might use to facilitate discussion and decisionmaking about the interaction of relevance and strength of evidence. It is important for trustees to understand that the selection and evaluation of injuries will be an iterative rather than sequential process. As new information becomes available and trustee deliberations continue, restoration objectives may evolve and the evaluation of some injuries may change.



2.5 Example Application of the Decisionmaking Framework

The following example of a hypothetical incident and the accompanying evaluation of potential injuries using the decisionmaking framework are intended to illustrate the type of process trustees might use during the development of an injury assessment program. The list of injuries for the example is not meant to be exhaustive, rather, it is intended to include a range of natural resource injuries and service losses. Similarly, the evaluation of injuries is illustrative only and is not intended to indicate any preferred approach to injury assessment.

On June 1, an oil tanker lodged onto a submerged rock ledge while approaching a harbor in a coastal area. Tank measurements and reconnaissance flights indicated at least 1,000,000 gallons of crude oil had been discharged. Initial reports indicated that salt marshes, recreational beaches, boating, fish and shellfish, birds, and commercial and recreational fishing were most likely to suffer adverse effects from the discharge.

Nearby beaches were threatened with oiling. The beaches provide sunbathing, picnicking, hiking, surfing, fishing, and shellfishing as recreational activities, along with boat ramps for launching small vessels. The beaches also provide nesting habitat for several shorebirds.

The oil also threatened extensive salt marshes that provide habitat for birds as well as a rearing area for fish and shellfish. These wetlands also provided flood control and erosion protection to the area. Bird watchers frequently visit the salt marsh.

The wind and currents carried the oil onshore and oiled large sections of the beaches, intertidal zone, and salt marshes. Beaches were closed for three weeks immediately after the discharge. Additionally, small sections of beach were closed throughout the summer to allow for beach cleaning operations. Several boat launching areas also were closed to public use during the response action phase of the incident. The launching areas were not oiled, but the closure was necessary to provide staging areas for clean-up contractors.

The State Department of Health issued a closure for all recreational and commercial harvests of fish and shellfish for one week. The closure was then partially lifted to allow for finfishing, but remained in effect for the harvest of clams, mussels, oysters, and crabs for an additional two weeks. Some heavily oiled shellfish beds were not reopened for several months and experienced significant mortality. Shellfish populations in these beds were expected to require three years to recover.

Recreational and commercial boating activity was restricted by the safety zone established by the U.S. Coast Guard (USCG) around the damaged tanker, but no further area closures were implemented. Continued clean-up activity caused a reduction in boating activity for three weeks after the discharge.

The natural resource trustees determined to conduct a NRDA based upon information collected during the Preassessment Phase. Within the first two days of the discharge, trustees formed a working trustee council to coordinate early sampling and develop a plan for identifying, documenting, and quantifying the effects of the discharge.

To develop an injury assessment program, the trustees decided to use the decisionmaking framework described in this chapter. The trustees have summarized their knowledge and judgment about the effects of the discharge into an inventory of possible injuries. Exhibit 2.10 includes a portion of the inventory developed by the trustees.

Exhibit 2.10

EXAMPLE INVENTORY OF POTENTIAL INJURIES

Resource	Injury	Services	Evidence for Injury	Mechanism	Pathway and Exposure	Time to Natural Recovery	Primary Restoration Alternatives	Compensatory Restoration Alternatives
Shorebirds (A)	mortality, reproductive impairment	bird watching, passive use	dead shorebirds, oiled and broken eggs, destroyed nests	direct contact with oil, habitat destruction by oil and response crews	oil washed ashore	unknown	attraction of replacement nesting pairs to the area, improve nesting sites and foraging.	Provide additional bird refuges at nearby beaches.
Shellfish (B)	mortality, tainting resulting in closure	recreational and commercial fishery, clean food	dead shellfish, samples of shellfish tissue contain oil	ingestion of oil-contaminated water, direct contact with oil	oil floats ashore, dissolves in the water column	3 years	Remediate sediments to provide new clean habitat, monitor water quality data.	Provide additional shellfishing opportunities at alternate nearby sites.
Salt marsh (C)	loss of vegetation, loss of productivity	habitat, clean food, erosion control	large oiled and devegetated areas	uptake of oil by plants and/or smothering	oil entered salt marsh and oiled the vegetation	10 years	Remove heavy contamination, replace with clean-fill and replant.	Purchase and rehabilitate degraded wetland nearby.
Fish (D)	mortality, behavioral abnormalities, closure	food, contributes to standing stock of fishery	dead fish, lower populations of juvenile fish	ingestion of oil	oil entered salt marsh	4 years	stocking of juvenile fish, enhance habitat	Provide additional recreational fishing opportunities.
Beaches (E)	oiling of beaches	human use, shorebird habitat	closure	direct contact with oil, *spill* response	oil washed ashore	1 year	additional cleanup, replacement of sand	provide additional beach habitat or access

Using the information summarized in Exhibit 2.10, the trustees first evaluate the strength of evidence for each possible injury. Existing evidence for the shorebird and beach injuries is judged to be very strong. Evidence for immediate adverse effects on shellfish and salt marshes also is strong, but evidence for continuing effects and time to natural recovery for these resources is less conclusive. Evidence for the possible injury to fish is judged to be weak.

Next, the trustees set forth preliminary restoration objectives for the injured natural resources. These objectives are described in section 2.4.4.

The trustees then consider the relevance to restoration for each possible injury. They conclude that the possible injuries to shorebirds and shellfish are most relevant to the tentative restoration objectives, followed closely by the salt marsh injury. The trustees judge the relevance to restoration of the possible injuries to fish and beaches to be substantially lower than the first three injuries.

The trustees summarize their evaluation of the strength of evidence and relevance to restoration by means of the plot shown in Exhibit 2.11.

The trustees also consider the additional assessment effort that might be conducted to strengthen evidence for the shellfish and salt marsh injuries and prepare final documentation of the shorebird and beach injuries. The possible injury to fish is dropped from further consideration by the trustees in view of the weak evidence and low relevance to restoration for this injury.

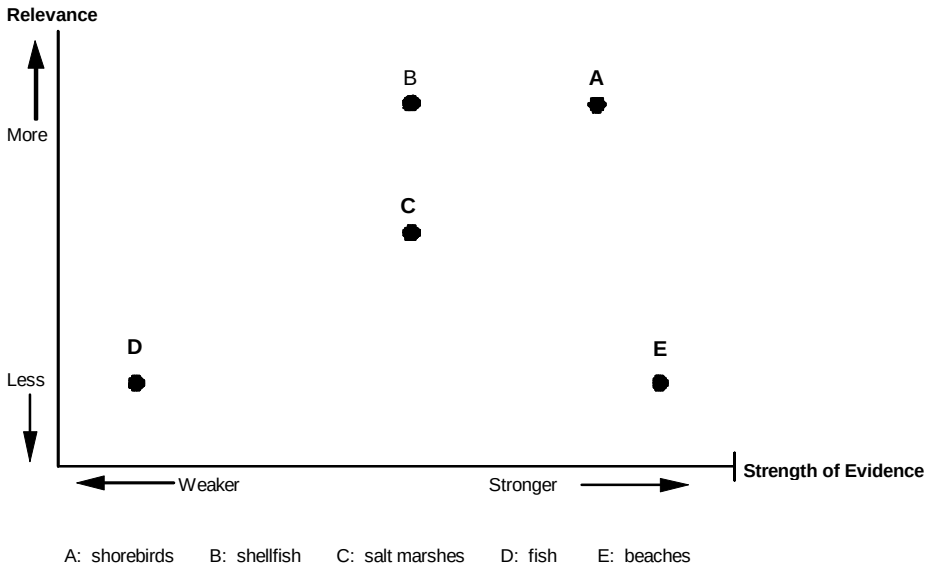
After considering a variety of assessment approaches and specific studies, the trustees reach a consensus concerning the best approach for additional study of the four injuries remaining for consideration. During these discussions, the trustees assess the likely change in the strength of evidence for each injury if additional studies are conducted and plot this information on Exhibit 2.12.

As Exhibit 2.12 indicates, the trustees judge that additional injury studies would significantly improve the evidence for salt marsh injury, but would have less effect on the evidence for shellfish injury. The evidence for shorebird injury already is strong, but would be further strengthened by modest additional work.

On the basis of the considerations outlined above as well as a variety of other factors, the trustees decide to pursue injury to shorebirds, shellfish, salt marshes, and beaches. To support this claim the trustees elect to rely on existing documentation plus additional injury assessment effort for shorebirds and salt marshes. Shellfish injury will be included based on existing documentation of closures and mortality, but no additional research on long term effects will be pursued. Beach injury will be included based on lost services documented during response.

Exhibit 2.11

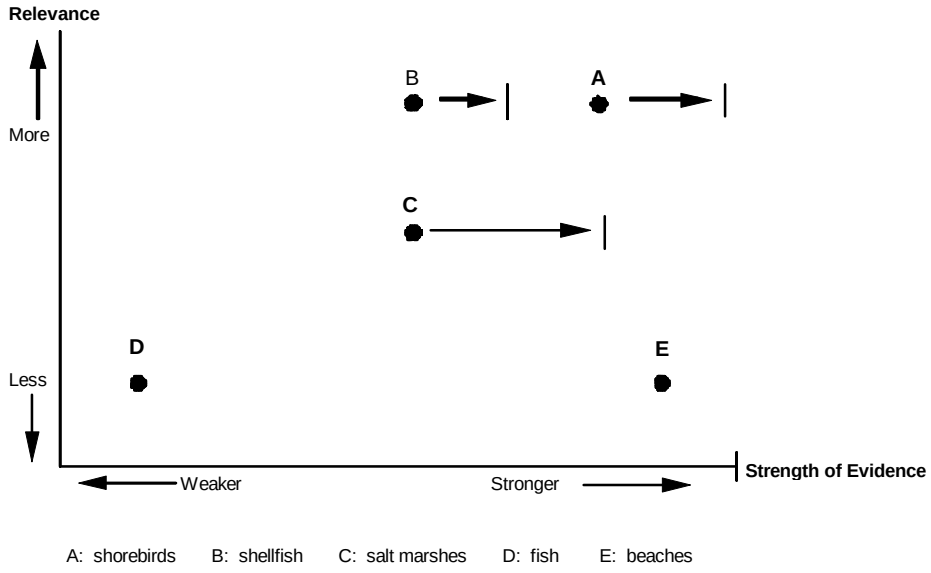
EXAMPLE OIL SPILL INJURIES



A: shorebirds B: shellfish C: salt marshes D: fish E: beaches

Exhibit 2.12

EXAMPLE OIL SPILL INJURIES AFTER ADDITIONAL ASSESSMENT EFFORT



A: shorebirds B: shellfish C: salt marshes D: fish E: beaches

2.6 References

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