ASSESSING NATURAL RESOURCE DAMAGES FOR COMMERCIALLY AND RECREATIONALLY HARVESTED POPULATIONS

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Abstract

Resource Equivalency Analysis ("REA") is often used to "right-size" (scale) or calibrate compensatory restoration projects implemented as part of Natural Resource Damage Assessments ("NRDAs") conducted pursuant to the Oil Pollution Act of 1990 ("OPA"). The basic premise underlying REA is that, if a spill results in the loss of individual members of a population, the public can be compensated via a restoration project which creates individuals that otherwise would not exist. This is because the ecological services provided by a population are proportional to the number of individuals in the population. For example, one could compensate the public for spill-related mortality among shrimp by creating wetland terraces which, the literature suggests, would increase the number of shrimp in the population. REA answers the question, "How many wetland terraces need to be created?"

Implicit in the REA construct is the dynamic nature of the population projections. Even with density dependence, population levels fluctuate according to both biological and anthropogenic factors that combine to influence survival, reproductive and growth rates. Thus, if NRDA practitioners are to reliably identify compensatory restoration requirements using REA, it is necessary to: characterize baseline demographic rates; develop a model that uses those baseline demographic rates to project future population levels; and identify the mechanisms that cause post-spill rates to change relative to baseline expectations.

One factor that can cause post-spill demographic rates to vary is a spill-related change in human behavior. For example, if a spill-related fishing closure results in the cancelation of 15,000 recreational shrimping trips, shrimp mortality due to fishing will decrease.

In this paper we use prior OPA NRDA cases to: review the historical treatment of spill-related closures in REA models used by both DOI/USFWS and NOAA; and illustrate that the REA practitioners' approach to these spill-related changes in human behavior can (and should) change the NRDA liability construct, particularly with respect to species which are commercially and recreationally harvested.

SECTION 1: INTRODUCTION

In 2009, the M/T Athos I ("Athos I") Trustees published the Final Restoration Plan and Environmental Assessment for the November 26, 2004, M/T Athos I Oil Spill (NOAA et al. 2009). One of the public comments specifically addressed the assessment of natural resource the National Pollution Funds Center ("NPFC")[1] to seek additional information from the Trustees.

The comment leading to the NPFC's inquiry was based on three observations. First, there were two spill-related impacts that simultaneously affected waterfowl populations following the spill: (1) the oil caused bird mortality via physical fouling and/or ingestion; and (2) the response-related closure of waterfowl hunting areas decreased hunting-related mortality among those same waterfowl populations. Second, when the Trustees sought compensation for human use[2] damages, they accounted for the effect of the response-related waterfowl closure on recreational activity by asserting the loss of 4,700 waterfowl hunting trips and requesting approximately $150,000 to compensate for those lost trips. Finally, when determining the effect of the spill on waterfowl populations the Trustees estimated that as many as 2,103 waterfowl may have died as a result of physical fouling and/or oil ingestion. However, the Trustees did not factor in the many ducks and geese that were not harvested when 4,700 waterfowl hunting trips were cancelled as a result of the response-related waterfowl hunting closure

Thus, while it may be that the *Athos I* oil spill resulted in a reduction in human use services (i.e., opportunities to hunt and harvest waterfowl were lost), it appears unlikely that the spill resulted in a reduction in the level of ecosystem services (e.g., bird watching opportunities,

[1] In this case, the Athos I Trustees were not required to seek cost recovery and compensatory restoration from the Responsible Party ("RP") because the RP had met its limit of liability. Thus, pursuant to 33 C.F.R. §136.207, the Trustees presented its claims to the NPFC. Prior to allocating taxpayer money, 33 C.F.R. § 136.105 requires the Trustees to prove to the NPFC entitlement to the amount claimed. Thus, the NPFC request for additional information was issued as part of the entitlement confirmation process.

[2] Human use damages relate to a loss of recreational opportunity (often hunting or fishing) resulting from an oil spill. Trustees frequently estimate human use damages (i.e., the amount of money they will receive to compensate for changes to human use patterns) by estimating the number of trips that were lost and multiplying that by a per-trip value (i.e., value-to-cost scaling) or more recently by estimating the cost of implementing human use restoration projects (e.g., trail creation, access improvements) that generate an increase in value equivalent to the spill-related loss (i.e., the more technically appropriate value-to-value scaling).

nutrient cycling, seed dissemination) provided by waterfowl populations. As such, the approximately $9.4MM sought by the Trustees to compensate for the loss of ecological services provided by waterfowl populations appeared unjustified.

The NPFC reported that the Trustees responded to their request for additional information by stating that incorporating the effects of response-related closures would: (1) create perverse incentives for polluters; (2) contradict the legislative intent of the Oil Pollution Act of 1990 ("OPA"); (3) have no material effect on restoration requirements as closure effects were limited; and (4) generally be too uncertain to be incorporated into an assessment.

At the time, the NPFC accepted the Trustee explanation and allocated approximately $150,000 from the taxpayer-supported Oil Spill Liability Trust Fund ("OSLTF") to the Trustees to compensate for the loss of human use services provided by waterfowl and approximately $9.4MM to compensate for a hypothetical loss of ecological services provided by those very same waterfowl.

In light of (1) the increasing regularity that closures are established following oil spills as well as (2) recent observations that the net effects of the *Deepwater Horizon* incident and associated fishing closures appears to have been an increase in population levels among at least some nearshore aquatic species (Fodrie and Heck 2011, Fodrie et al. 2014), this paper reviews the technical and legal underpinnings of assessing spill-related impacts to harvested populations under OPA. The purpose of this review is to determine if REAs conducted under OPA NRDA should consider the effect of release-related hunting and fishing closures.

SECTION 2: BACKGROUND

OPA, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA") and various state laws and regulations allow designated federal, state and tribal natural resource trustees ("Trustees"), acting on behalf of the public, to seek to recover NRDs to compensate the public for ecological impacts resulting from the release of oil or hazardous substances.

In a NRDA, damages are defined to include the cost of: restoring the injured natural resource to its baseline condition ("primary restoration"); (2) compensating the public for ecological and human use services lost from the time of the injury until primary restoration is complete ("interim loss compensation"); and (3) reasonable assessment costs (NOAA 1999).

There are two broad approaches to estimating interim loss compensation: traditional economic valuation and ecological restoration. Today, most NRDA practitioners rely on the ecological restoration approach (Flores and Thatcher 2002) under which the damage claim for interim losses is set equal to the cost of restoration projects that, when implemented, ensure that the public experiences no net loss in the provision of ecological services as a result of a spill (Unsworth and Bishop 1994). Zafonti and Hampton (2007) show that the service-based approach can generate a reasonable approximation of the compensating variation that would be estimated using approaches grounded in welfare economics under specific circumstances.

Resource Equivalency Analysis ("REA") is often used to identify and "right size" required restoration for the loss of ecological services. The basic premise underlying REA is that the level of ecological service provided by a wildlife population is proportional to the number of individuals in that population. Thus, if a spill results in the loss of individual members of a population, the public can be compensated for that injury via a restoration project that creates individuals that otherwise would not exist. For example, one could compensate the public for release-related mortality among common loons by deploying loon nesting rafts which increase the reproductive success of the loon pair that uses the raft and, in doing so, increases the number of loons. REA would answer the question, "How many rafts need to be deployed?"

The REA unit of observation may be the Discounted Species Year ("DSY") (Zafonti and Hampton 2005) or the Discounted Kilogram Year ("DKY") (French et al. 1996) depending upon the species being analyzed. For example, one loon living for one year is said to provide one loon year of service. Loon years occurring in the future are discounted[3] to reflect society's preference to have goods sooner rather than later, all else being equal. The resulting unit is a Discounted Loon Year. When assessing fish stocks, the unit may be a DKY where one kg of the stock existing for one-year provides one kilogram year of service. The kilogram year is likewise discounted resulting in a DKY.

Generally, the REA process can be thought of as occurring in three steps:

1. The baseline population level (i.e., the number or biomass of individuals that would have been in the population but for the spill) is projected through time using some mathematical population projection model. This projection is represented by the black dotted line in Figure 1. The shape of the black dotted line is a function of demographic rates (survival, reproduction, and individual growth) expected under baseline conditions.

[3] Discounting is a process whereby the value of services that will be received in the future is reduced. For example, if a 3 percent discount rate is assumed, a loon year occurring next year is equivalent to 0.97 loon years occurring this year. A loon year occurring two years into the future would be worth only 0.942 loon years occurring this year.

2. That same model is used to project the number or biomass of individuals through time given the effects of the spill *and* the effects of a restoration project. This is represented by the solid blue line in Figure 1 whose shape and position relative to baseline is a function of release-related mortality and future demographic rates given the spill and restoration.

3. Recalling the basic premise underlying REA (i.e., if a spill results in the loss of individuals/biomass the public can be compensated via a restoration project that creates individuals/biomass) when the "with-spill-and-restoration" population projection is below baseline, a debit, measured in DSYs or DKYs, accumulates. When the with-spill-and-restoration population projection exceeds baseline, a credit, also measured in DSYs or DKYs, accumulates. Injuries are compensated (i.e., the restoration project is "scaled") when the debit (the red area in Figure 1) is equal to the credit (the green area in Figure 1).

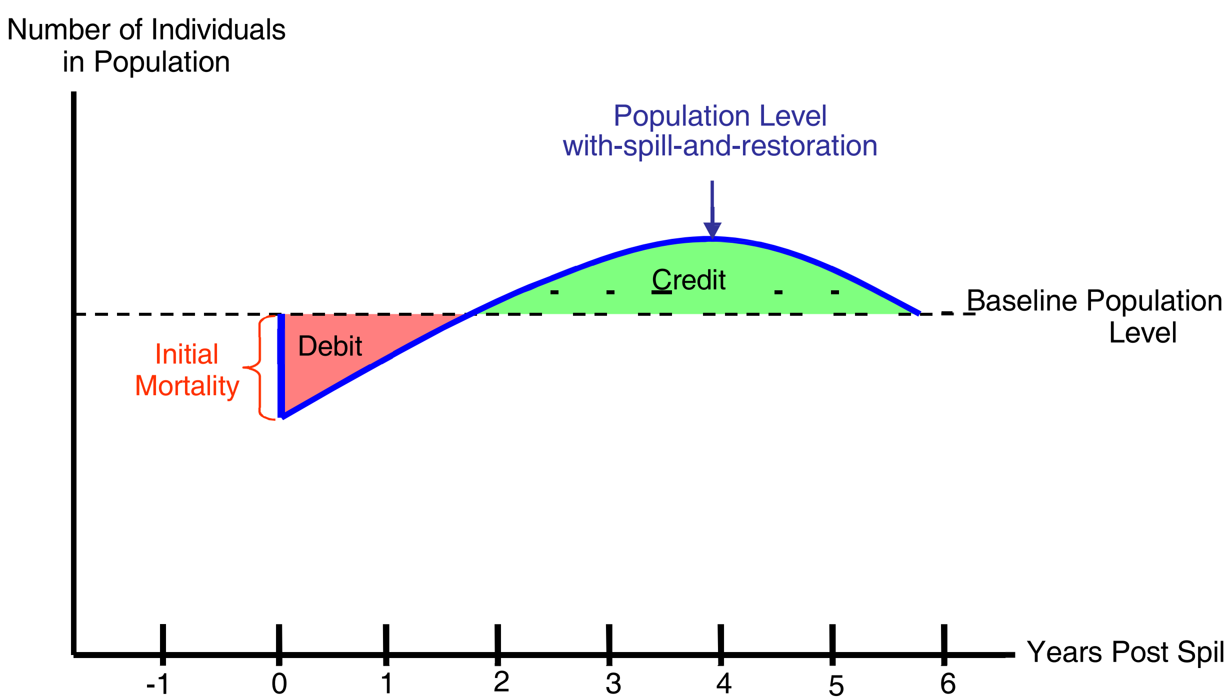

Figure 1. A graphical representation of REA.

Thus, when working within the REA construct, it is, under many circumstances, appropriate to: characterize baseline demographic rates; develop a model that uses those baseline demographic rates to project future population levels; and, as noted by Zafonti and Hampton (2005), identify the mechanisms that cause with-spill-and-restoration rates to change relative to baseline expectations.

It is universally recognized that human activities affect these demographic rates both indirectly (human activities alter habitats and habitat alterations affect population demographics) and directly (human harvest alters survival rates) (Thurman and Burton 2010, French-McCay and Jennings 2002, French et al. 1996, Primack 1993). Further, the literature includes multiple examples of methods that can be used to project future population levels (see e.g. NOAA 2010 or Akçakaya and Sjögren-Gulve 2000) amongst both un-harvested species (see, e.g., Arnold 2007) and harvested species (see, e.g., NOAA 2012 and USFWS 2011) in a manner that explicitly addresses the effect of human behavior on population demographic rates.

Given the clarity of theory, the robustness of the existing literature, and noting that many of the methodologies described therein have been developed and implemented by resource management agencies that act as NRDA Trustees, it is somewhat surprising that that *Athos I* Trustees opted not to evaluate the possibility that release-related changes to hunting behavior may itself have been a source of demographic rate changes. This is even more surprising when one realizes that, historically, the effects of release-related closures were explicitly considered in both the U.S. Department of Interior's "Type A" NRDA model, the model often used by the National Oceanic and Atmospheric Administration ("NOAA") and state Trustees to quantify oil spill related injury to aquatic organisms (e.g., SIMAP) and ENTRIX's COSIM model.

- In documenting the Type A model, French et al. (1996) write on Page I.4-49 that, when projecting aquatic losses through time, the basic equations include instantaneous total mortality (*Z) where Z is the sum of M (instantaneous natural mortality i.e. mortality due to all causes other than fishing, and* ***F (instantaneous fishing mortality).*** French et al.

further note that, when describing total injury for a spill that results in a fisheries closure, "*Some of YCL [lost harvest due to closure] would be lost due to mortality regardless of closure. As a result,* ***only that portion of losses due to a closure that exceed losses from mortality is added to total losses"*** (page I.4-55; emphasis added).

- When documenting SIMAP's approach to quantifying spill-related injury to aquatic organisms following the Chalk Point Oil spill, French-McCay and Jennings (2002) report that, when quantifying fish and invertebrate injury, *"Survival rates include accounting for* ***natural and fishing mortality****."* However, because [closure-related] impacts to each species were, in this case, thought to be small, post-spill changes in *"fishing mortality among surviving animals are* ***assumed*** *not to compensate for the killed animals"*[emphasis added].

- When documenting COSIM's approach to quantifying injury following oil spills, ENTRIX reported "Oil spills can have two distinct effects on population levels. Oil-related toxicity tends to decrease survival, growth, and reproductive rates; release-related closures tend to increase survival, growth, and reproductive rates. The actual change in population level is a function of these to potentially offsetting effects."

SECTION 3: ARE THERE VALID REASONS TO OMIT CLOSURE EFFECTS?

The *Athos I* Trustees attempted to justify their decision to ignore the effects of response-related closures by making four assertions as noted above and explained below.

3.1 Would incorporating the effects of closures create perverse incentives?

The concept of incentives (perverse or otherwise) is grounded in behavioral science and economics. A review of the basic theory related to this topic raises questions about the validity of the *Athos I* Trustee "Perverse incentive hypothesis." Figure 3 illustrates the idea of perverse incentives as it relates to environmental pollution (in this case, spilling oil).

- The marginal social benefits curve suggests that, at low pollution levels, the ability to pollute just a little more provides society considerable benefits (thank goodness we can exhale carbon dioxide). As the level of pollution increases, the marginal social benefit of pollution decreases (the social benefit of emitting carbon dioxide to run an SUV for ½ hour so the seat is warm is rather low).

- The marginal social cost curve suggests that, at very low levels, the cost of just a little more pollution is low (it's hard to imagine human breathing results in costly environmental impacts). As pollution levels increase, so too does the marginal cost of that pollution (at some level the carbon dioxide released might mean the planet overheats and society ceases to exist; the cost of that extra carbon dioxide would be high indeed).
- In an optimized world, society would pollute at the level where the marginal social benefit of polluting is equal to the marginal social cost of polluting (p^*). Any other level (more or less) leaves society worse off. Any rule or regulation that incentivizes entities to pollute at some level other than p^* is said to create a perverse incentive.

For example, if an oil transporter knows that, in the event of a release, the only costs they face are related to cleanup; all other costs would be borne by other members of society. Now the marginal cost of pollution as realized by the oil transporter (referred to as a private marginal cost) is below and to the left of society's marginal social cost curve. The transporter will not be as careful as society would prefer when transporting oil and the result will be too much oil pollution. That is, they would emit at $p_{\text{no regulation}}$ not p^*; this is a perverse incentive.

OPA is specifically designed to ensure that oil transporters face the full social cost of spilling oil. Under the "polluter pays" concepts embedded in environmental laws, oil transporters know that they will bear the full social cost of any spill. With this knowledge, they are incentivized to put forth the socially optimal level of pollution prevention effort (p*).

But what if there were some systematic error embedded into assessments which resulted in a spiller paying more than the social cost of the spill? Now the marginal cost of pollution as realized by the oil transporter would be above and to the right of society's marginal social cost curve. The transporter would be too careful and the price of petroleum products would be too high because the pollution level ($p_{over\text{-}regulation}$) would be too low.

Under OPA, NRDA assessments should identify compensation levels that ensure society experiences neither an increase nor a decrease in ecosystem services as a result of an oil spill and subsequent restoration. By extension, incorporating the positive/favorable (to the RP and the environment!) effects of release-related closures into REA would not create perverse incentives for polluters[4].

[4] Other NRDA components regularly incorporate the positive effects of response activities. For example, all shoreline injury assessments of which the authors are aware incorporate the generally positive effect of shoreline clean up on that habitat. Likewise, fish assessments incorporate the generally positive effect on-water oil removal.

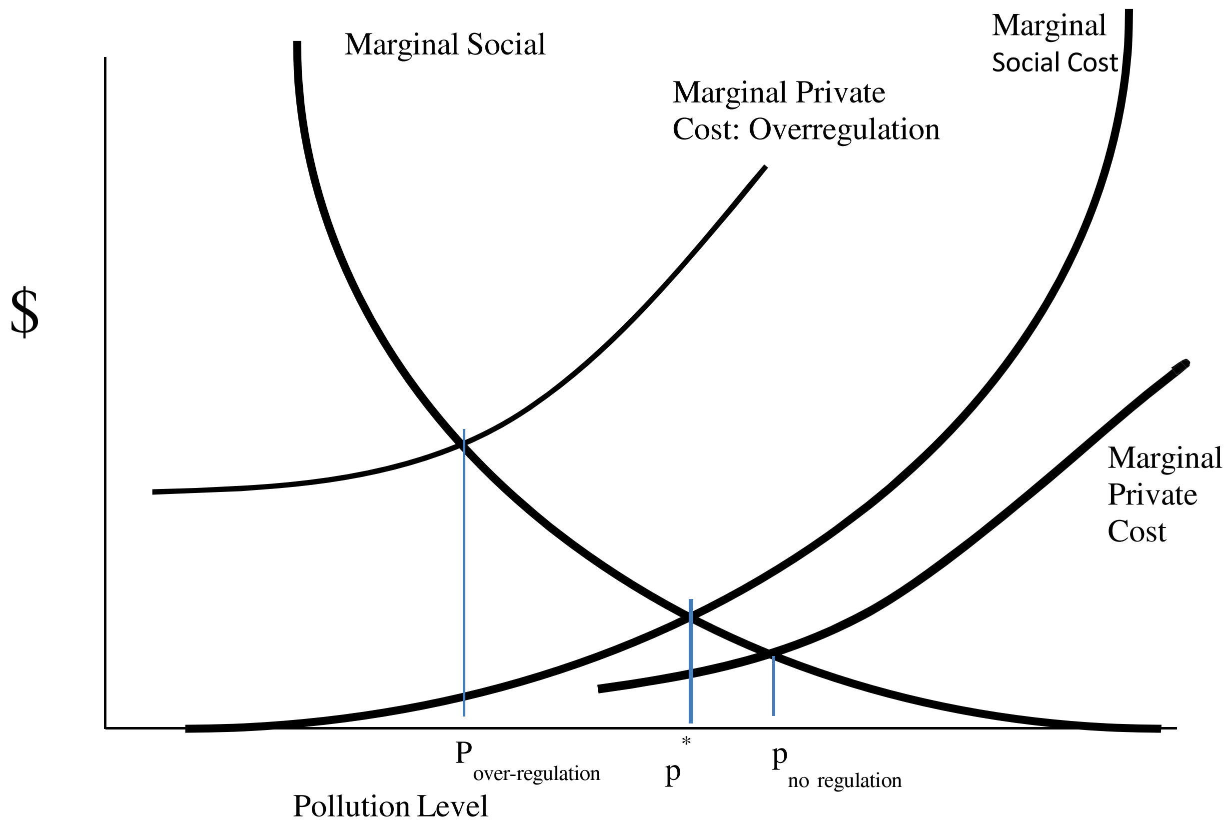

Figure 3. Incentivizing socially optimal pollution levels.

3.2 Would incorporating closures contradict the legislative intent of OPA?

The goal of OPA[5] is to make the environment and public whole for injuries to natural resources and services resulting from an incident involving a discharge or substantial threat of a discharge of oil. This goal is achieved through the return of the injured natural resources and services to baseline and compensation for interim losses of such natural resources and services from the date of the spill until recovery.[6]

To the extent that the legislative intent of OPA is to embed the "polluter pays" principle into law and, in so doing, move society toward a more optimal level of pollution, Section 3. Clearly indicates that, in direct contrast to the *Athos I* Trustee assertion, it is the failure to consider the effects of release-related closures while conducting a NRDA that contradicts the legislative intent of OPA. But are there other components to the legislation or implementing guidance that would support the *Athos I* Trustee position?

In the wake of the 1989 *Exxon Valdez* oil spill in Alaska, Congress enacted OPA.[6] Among other notable features, OPA imposes strict liability for a comprehensive list of damages, including NRDs, arising from an oil spill. As noted above, under OPA, designated federal, state, foreign and Indian Trustees are directed to assess NRDs after a spill and to determine the scale of restoration to be paid or conducted by the responsible party ("RP") for injuries to natural resources under their respective jurisdictions.[7]

Notwithstanding the Trustees' power to direct an NRDA and to seek payment or performance from the RP, OPA explicitly provides that there "shall be no double recovery under this Act for natural resource damages, including with respect to the costs of damage assessment or restoration, rehabilitation, replacement, or acquisition for the same incident and natural

[5] 33 U.S.C. § 2701 et seq.
[6] See 15 C.F.R. § 990.10.
[7] Pub. L. 101-380, 104 Stat. 484 (Aug. 18, 1990).

resource."[8] This prohibition on double-recovery, at least in theory, affords an RP some modicum of protection from over-paying for an NRD. It also raises interesting questions about the assessment of NRDs related to commercially or recreationally harvested species.

There is clear overlap between compensation for (1) lost human/recreational use (hunting or fishing opportunities) (2) lost ecological services; and (3) lost earnings/profits among commercial fishermen or guides all of which may be associated with the same individual members of a wildlife population, may very well violate the prohibition on double recovery under OPA. Unfortunately, there is no legislative guidance in OPA to indicate whether the net effects of a spill should be considered in assessing NRDs.

Common sense would dictate that, instead of evaluating select components of an event that may lead to NRDs in a vacuum, Trustees should evaluate the final, overall result of the spill in determining compensatory requirements. In other words, it is reasonable to expect that the Trustees would not solely examine toxicity or smothering related to a spill, but would evaluate the damage in light of the actual resulting change in services which would include the unintended, often positive (yes, for the RP, but also, importantly, for the environment/species at issue), consequences of the spill to determine what the RP must do or pay to compensate for spill-related changes. The 2003 Buzzards Bay Bouchard B 120 and the 1996 North Cape oil spills illustrate the complexities of, and the reasoning behind, the importance of evaluating the net effects of a spill.

Bouchard Barge B-120

On April 27, 2003, under tow by the tug Evening Tide, the B 120 tank barge struck a shoal while entering the western end of Buzzards Bay, Massachusetts. The barge released an estimated 93,000 gallons of No. 6 oil, which eventually affected approximately 98 miles of coastline in Massachusetts and Rhode.

[8] 33 U.S.C. §2706(d)(3) and 15 C.F.R. §990.2

The 2003 spill affected various forms of marine life, including shellfish beds in and around Buzzards Bay. As a result, the Massachusetts Executive Office of Energy and Environmental Affairs ("EOEEA")[9] demanded the closure of those shellfish beds that were affected by the spill. By the end of April 2003, approximately 177,000 acres of shellfish beds had been closed.[10] However, at the time the EOEEA closed the shellfish beds due to oil from the B 120 spill, many of those same beds had already been closed for years due to bacterial contamination.[11] Thus, when the EOEEA lifted the B 120-related shellfish closures in 2004, many of the shellfish beds nevertheless remained closed because of the same bacterial contamination that had closed them in the first place.[12]

In determining the ultimate effect of the spill on the shellfish beds, the B120 RP argued that those beds already closed due to bacterial contamination at the time of the spill (and which remained closed after the oil-related closure was lifted) should not be included in the Trustees' ultimate determination of the spill's effect on shellfishing. Indeed, the Trustees did agree to a NRD compensation package which took into account those shellfish beds that had initially been closed due to a non-oil spill related issue, and remained closed after the oil spill ban was lifted. While there had been a spill-related shellfish closure, that closure had no actual effect on the level of ecological services provided by some of those shellfish beds and so no NRDs were calculated for those shellfish beds.

While this example is somewhat different than that of *Athos I* waterfowl, it stands for the same proposition: both sides of the equation --injury and benefits created by a spill -- should be factored into the overall injury determination.

Tank Barge North Cape

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[9] The B120 trustees included NOAA, the U.S. Fish and Wildlife Service ("USFWS") of the Department of the Interior ("DOI"), the EOEEA, and the Rhode Island Department of Environmental Management.
[10] See Final Aquatic Exposure and Injury Report, B-120 Oil Spill, October 24, 2008, available at: https://casedocuments.darrp.noaa.gov/northeast/buzzard/admin.html.
[11] Id., at 16.
[12] See Buzzards Bay National Estuary Program website, available at: http://buzzardsbay.org/shellfishimpacts.htm.

On January 19, 1996, the tug Scandia (with the tank barge North Cape in tow) caught fire, spilling approximately 828,000 gallons of No. 2 home heating oil off of Rhode Island. High winds dispersed the oil over a wide area, resulting in the temporary closure of several coastal ponds and of an approximately 250-square-mile area of Block Island Sound to fishing (including lobstering). Technical reports subsequent to the spill revealed losses sustained by multiple varieties of marine life, including an estimated 9 million lobsters.

As part of the restoration process, the RP began a multi-year[13] lobster restoration program in 2000. The restoration involved cutting a v-shaped notch in the tail of 1.248 million female lobsters and restocking them into Rhode Island and southeastern Massachusetts coastal waters. The "notched" lobsters were then protected from harvest by law for an additional one to two years while the v-notch remained visible. Protecting the lobsters from being harvested provided the lobsters more opportunity to reproduce, resulting in increased reproduction to compensate for the injury.[14]

In addition to (and much prior to initiation of) the lobster restoration program, the RP paid the lost profits of the lobstermen who were affected by the spill due to significant closures of the lobster fishery immediately after the spill.

The RP's funding and implementation of the lobster restoration program as part of the NRDA in addition to the RP's payment of lost profits to the affected lobstermen during the closure of the lobster fishery seems to, at least in part, violate the prohibition on double recovery under OPA. Further: the lobstermen who received "lost profit" compensation from the RP conceivably later caught and earned profit from the very same lobsters for which they were compensated to not catch during the lobster fishery closure. In addition, some of those female lobsters that would have been caught were allowed to remain in their habitat for an additional

[13] See United States, et al. v. EW Holding Corp., Consent Decree, noticed at 65 Fed. Reg. 44808 (July 19, 2000); 2000 EPA Consent LEXIS 202 (July 6, 2000).

[14] See North Cape Lobster Restoration Project, available at: https://casedocuments.darrp.noaa.gov/northeast/north_cape/admin.html.

five months, thereby providing ample opportunity for those same lobsters to reproduce (time they would not have had if the lobster fishery had remained open because, hypothetically, they would have been caught prior to reproducing). Thus, arguably: (1) the RP overpaid the lobstermen for "*lost* profits," when the compensation should have focused on the delay in collecting the profits -- "*delayed* profits"[15] -- they would have made but for the spill and temporary closure; *and* (2) the lobster restoration aspect of the NRDA should have factored in increased reproduction during the spill-related closure, which likely resulted in an increase in the lobster population after the spill and lessened the overall injury determination.

Thus, a spill's net effects is still often overlooked, as it was in the *North Cape* spill, resulting in exaggerated liability for RPs (for NRDs and lost profits, particularly for species that are both recreationally and commercially harvested), all of which appears to violate the prohibition on double-recovery under OPA.

3.3 Are the effects of release-related closures limited in magnitude?

The effect of release-related closures on population levels is, of course, dependent upon the nature and duration of the closure and the harvesting activity that closure effects. However, the *Athos I* Trustee response to the NPFC appeared to suggest that, as a general matter, the effects of closures would be *de minimis*. We evaluated this inference for several recent cases.

The *Athos I* analysis is straight forward. First, the final report of the *Athos I* Bird and Wildlife Technical Working Group reveals a Trustee belief that the combined effect of physical fouling and oil ingestion resulted in 605 dabbling duck mortalities, 82 diving duck mortalities and 1,416 goose mortalities. Second, the Trustees' lost use valuation report states that 4,700 waterfowl hunting trips did not occur as a result of the spill-related hunting closures and the migratory bird harvest data from U.S. Fish and Wildlife Service (2005) reports the proportion of

[15] "Delayed profits" is not a concept that is explicitly contemplated by OPA but, as demonstrated by the North Cape lobster restoration project, should be considered in NRDAs, including those involving commercially-relevant/harvested species.

waterfowl trips that target dabbling ducks, diving ducks, and geese in the states bordering the spill site (58 percent, 2 percent, and 40 percent, respectively) as well as the average harvest per trip (1.46, 1.65 and 1.30, respectively). Finally, comparing the number of birds thought to have died as the result of physical fouling and oil ingestion to the number of birds that did not die as a result of the release-related hunting closure, the actual effect of the spill and associated hunting closures was to increase populations of dabbling ducks, diving ducks, and geese relative to baseline. Thus, once the public was compensated for lost human use (hunting) and, working within the REA framework, there was no loss in ecological service provided by waterfowl.

We have also used published mortality estimates, fishery closure data, and harvest data collected by NOAA to evaluate several recent spills that included smothering and toxicity-related mortality among aquatic organisms as well as commercial and/or recreational fisheries closures. These spills include the *Deepwater Horizon*, *Bouchard B.-120*, and *Chalk Point*. In each case our preliminary assessment suggests that the net effect of these spills was to increase population levels of at least some species of aquatic organisms. As was the case with the *Athos I* hunting closure, the effect of the release-related fishing closures appears to have been the largest single factor affecting the harvested population.[16][16]

Thus, we conclude that the effects of release-related closures are not generally limited in magnitude.

3.4 Are the effects of closures so uncertain they cannot be incorporated into NRDA?

Estimating the short-term reduction in mortality resulting from a release-related closure is

[16] For a detailed discussion of the Deepwater Horizon see Fodrie et al. (2014). For the Bouchard B.-120 oil spill note that the Trustees and RP concluded no injury to aquatic organisms seaward of the surf zone (Bouchard B-120 Aquatic Technical Working Group (2008)) whereas the human use team estimated nearly 1,000 lost boating trips many of which would have resulted in fishing related mortality to aquatic organisms. For the Chalk Point incident note that total fish injury was estimated to be 1,485 kg (French McCay and Jennings (2002) whereas Byrd et al. (2001) estimate that 12,704 recreational trips were lost (about ½ of which were fishing trips); further, total catch per recreational trip in Maryland exceeds a kg (Personal communication from the National Marine Fisheries Service, Fisheries Statistics Division. (2016)

no more (and perhaps less) uncertain than estimating toxicity and smothering related effects. The basic approach is characterized in three steps.

1. As a normal course of events, Trustees estimate the number of recreational trips lost due to a release. Data describing the average recreational harvest per trip is often readily available from NOAA, U.S. Fish and Wildlife Service ("USFWS"), and/or state agencies (see, e.g., U.S. Fish and Wildlife Service 2005). Estimating the number of organisms that did not die as a result of a recreational closure is as simple as multiplying the two together.
2. On the commercial side, commercial fishermen often submit claims to an RP seeking compensation for revenue lost as the result of release-related closures. Dividing those claims by dock side values (see, e.g., NOAA 2016) generates an estimate of the number of organisms that did not die as a result of a commercial closure. The number of mortalities avoided among bycatch species is then calculated using ratios of catch to bycatch (see, e.g., National Marine Fisheries Service 2016).
3. The short-term effect of the spill on a population level is the difference between smothering or toxicity-related increases in mortality and closure-related decreases in mortality.

In the longer term there is always uncertainty related to future population levels relative to a baseline expectation. Predicting that difference often requires the practitioner to incorporate not only the effect of future compensatory restoration (which may be specifically designed to increase the number of commercial and recreational trips), but also regulations that effect if and how humans will respond when areas are reopened; theses future events are a challenge to predict. However, those challenges exist regardless of the methods used to estimate the effect of a spill and resulting closures on short-term population levels.

Thus, we conclude that the effects of release-related closures are not so uncertain that they cannot be incorporated into NRDA.

SECTION 4: CONCLUSION

Under OPA, Trustees are entitled to recover money (and/or require RPs to undertake restoration projects) to compensate the public for ecological impacts resulting from an oil spill. Today, the necessary level of compensation is generally estimated under an ecological restoration paradigm where damages are set equal to the cost of restoration projects that, when implemented, ensure that the public experiences no net loss in the provision of ecological services as a result of a spill and restoration (Unsworth and Bishop 1994).

One method often used to identify and "right size" compensatory restoration projects under the ecological paradigm (i.e., the service-based approach) is REA. The basic premise underlying REA is that, the level of ecological service provided by a wildlife population is proportional to the number of individuals in that population. Thus, if a spill results in the loss of individual members of a population, the public can be compensated for that injury via a restoration project that replaces those lost or injured resources. That is, the public can be compensated for a release-related decrease in a population level with a restoration-related increase in the population level.

The REA process involves predicting population levels under baseline conditions and comparing the baseline population level prediction to population level predictions that incorporate the effects of the release and any associated compensatory restoration. The scale of restoration is adjusted until the public experiences no net loss (or gain) of present value species years. At that point, compensation is said to have been achieved.

At issue is whether with-spill-and-restoration population projections should incorporate the favorable (to the RP and the environment) effects of response-related hunting and fishing closures. While the effect of these closures had been incorporated into past REA models prepared for and used by Trustees, the *Athos I* Trustees expressed the opinion that such effects should not be incorporated into the NRDA. Their opinion was based on the assumption that doing so would create perverse incentives for polluters and/or contradict the legislative intent of OPA. Further, they expressed the opinion that such effects would be too “limited in magnitude” and or “uncertain” to materially alter compensatory restoration estimates.

After carefully reviewing the theoretical and legal underpinning of OPA as well as the scientific models and methods used to implement the legislation, we find no evidence to support the *Athos I* Trustees’ view that the effects of release-related closures should not be incorporated into REAs. To the contrary it appears that, in many circumstances, response- related closures are likely to be the single largest determinant of population levels in the weeks following an oil spill and that failure to incorporate those effects into an assessment conflicts with the legislative intent of OPA, violates the prohibition on double recovery, and itself introduces perverse incentives into the system.

References

Akçakaya H.R. and P. Sjögren-Gulve. 2000. Population viability analysis in conservation planning: an overview. Ecological Bulletins 48:9-21.

Anderson, L.G., and J.C. Seijo. 2009. Bioeconomics of Fisheries Management. Wiley and Sons.

Arnold, J.M. 2007. Population viability for the roseate tern nesting in the Northwest Atlantic. Appendix 3.6-J. Cape Wind Energy Project Final.

Bouchard B-120 Aquatic Techcnial Working Group. 2008. Aquatic exposure and injury report Bouchard B-120 Oil spill. Available online at https://casedocuments.darrp.noaa.gov/northeast/buzzard/admin.html

Bouchard B-120 Oil Spill Lost Use Technical Working Group. 2009. Bouchard B-120 Oil Spill Buzzards Bay, Massachusetts Lost Use Valuation Report. Available online at https://casedocuments.darrp.noaa.gov/northeast/buzzard/admin.html

Byrd. H., English, E., Lipton, D., Meade, N., and T. Tomasi. 2001. Chalk Point oIl spill: Lost recreational use valuation report. Available online at https://casedocuments.darrp.noaa.gov/northeast/chalk_point/pdf/cpar1970.pdf

California Department of Fish and Game (CDFG) and the U.S. Fish and Wildlife Service (USFWS). 2008. Kure/Humboldt Bay Oil Spill Final Damage Assessment and Restoration Plan/Environmental Assessment. Available online at http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=15525&inline=true.

Davis, Andrew N. and Austin P. Olney, Cooperative Natural Resource Damage Assessments: Lessons Learned from the Oil Pollution Act of 1990, Harris Martin's Natural Resource Damages & Envtl. Claims Report 1, 4-9 (Sept. 2006).

Deepwater Horizon Natural Resource Damage Assessment Trustees. (2016). Deepwater Horizon oil spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Retrieved from http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan.

Flores, NE, Thacher J (2002) Money, who needs it? Natural resource damage assessment. Contemporary Econ Pol 20: 171-178

Fodrie, F.J., and K.L. Heck Jr. 2011. Response of coastal fishes to the Gulf of Mexico oil disaster. PLoS ONE 6: e21609.

Fodrie, J. Able, W, Lopez-Duarte, P., Galvez, F. Heck, K., Jenson, O., Martin, C., and A. Whitehead. 2014. Integrating Organismal and Population Responses of Estuarine Fishes in Macondo Spill Research. BioScience 64 (9): 778-788.

French, D., M. Reed, K. Joyko, S. Feng, H. Rines, S. Pavignano, T. Isaji, S. Puckett, A. Keller, F. French III, D. Gifford, J. McCue, G. Brown, E. MacDonald, J. Quirk, S. Natzke, R Bishop, M. Welsh, M. Phillips and B.S. Ingram. 1996. The CERCLA type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Vol. I-Model Description. Final report, submitted to the Office of Environmental Policy and Compliance, U.S. Department of the Interior, Washington, D.C. April. 1996, Contract No. 14-0001-91-C-11.

French McCay, D.P., C.H. Peterson, J.T. DeAlteris, and J. Catena, 2003. Restoration that targets function as opposed to structure: replacing lost bivalve production and filtration. Mar Ecol Prog Ser 264: 197-212.

French McCay, D. and J. Jennings. 2002. Final Report Chalk Point Oil Spill of April 7, 2000 in Patuxent River, MD: Modeling of the Fates and Acute Biological Effects of the Spilled Oil on the Water Column. Available online at http://www.darrp.noaa.gov/northeast/chalk_point/admin.html. Accessed 6-23-2015.

Kubitz, J.A., M. Fichera, R. Markarian, and J. Slocomb. 2011. Use of Chemical/Oil Spill Impact Module (COSIM) to assess the toxicity of petroleum to estuarine organisms. International Oil Spill Conference Proceedings: March 2011, Vol. 2011, No. 1, pp. abs180.

National Atmospheric and Oceanic Administration (NOAA). 1999. Discounting and the Treatment of Uncertainty in Natural Resource Damage Assessment. Technical Paper 99-1. Damage Assessment and Restoration Program.

National Oceanic and Atmospheric Administration (NOAA), United States Fish and Wildlife Service, New Jersey Department of Environmental Protection, Delaware Department of Natural Resources and Environmental Control, Pennsylvania Department of

Natural Resources. 2009. Draft Damage Assessment and Restoration Plan and Environmental Assessment for the November 26, 2004 M/T/ Athos I oil spill on the Delaware River near the CITGO refinery in Paulsboro New Jersey. Available at: http://www.darrp.noaa.gov/northeast/athos/pdf/DraftAthosDARP_Final_2.pdf

National Atmospheric and Oceanic Administration (NOAA). 2010. Stock Assessment Program. Available online at http://www.st.nmfs.noaa.gov/StockAssessment/StockAssessment.html.

National Atmospheric and Oceanic Administration (NOAA). 2012. North Pacific Groundfish Stock Assessments. Available online at http://www.afsc.noaa.gov/REFM/Stocks/assessments.htm.

National Atmospheric and Oceanic Administration (NOAA). 2015. NOAA Fisheries Toolbox. Available online at http://nft.nefsc.noaa.gov/index.html.

National Atmospheric and Oceanic Administration (NOAA). 2016. Commercial Fisheries Statistics: Fishery Market News. Available online at https://www.st.nmfs.noaa.gov/commercial-fisheries/market-news/index.

National Atmospheric and Oceanic Administration (NOAA), U.S. Fish and Wildlife Service (USFWS), and Rhode Island Department of Environmental Management (RIDEM). 2006. North Cape oil spill trustees and industry successfully complete North Cape lobster restoration program. Available online at http://archive.orr.noaa.gov/book_shelf/1270_NorthCapeAug10-1.pdf.

National Marine Fisheries Service. 2016. U.S. National Bycatch Report First Edition Update 2 [L. R. Benaka, D. Bullock, J. Davis, E. E. Seney, and H. Winarsoo, Editors]. U.S. Dep. Commer., 90 p.

Primack, R.B., 1993. Essentials of Conservation Biology. Sinauer, Sunderland, MA. Thurman, H.V. and E. A. Burton. 2010. Introductory Oceanography. Pearson Prentice Hall Saddle River, New Jersey.

United States Fish and Wildlife Service (USFWS) 2011. Adaptive Harvest Management: 2011 Hunting Season. Available online at http://www.fws.gov/migratorybirds/NewReportsPublications/AHM/Year2011/AHMReport2011.pdf.

United States Fish and Wildlife Service. 2005. Migratory Bird Harvest Information, 2004: Preliminary Estimates. U.S. Department of the Interior, Washington D.C. USA.

Unsworth, R.E., Bishop, R. 1994. Assessing natural resource damages using environmental annuities. Ecological Economics 11, 35-41.

Wakefield and McNutt. 2008. An ecological Framework for REA. Proceedings of the 2008 International Oil Spill Conference. Savanna Georgia.

Zafonti M. and S. Hampton. 2005. Lost Bird Years: Quantifying bird injuries in natural resource damage assessments for oil spills. Proceedings of the 2005 International Oil Spill Conference. Global Engineering Documents #I4718A.

Zafonti, M. and S. Hampton. 2007. Exploring welfare implications of resource equivalency analysis in natural resource damage assessments. Ecological Economics 61: 134-145.