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Review

Management of contaminated marine marketable resources after oil and HNS spills in Europe

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ABSTRACT

Different risk evaluation approaches have been used to face oil and hazardous and noxious substances (HNS) spills all over the world. To minimize health risks and mitigate economic losses due to a long term ban on the sale of sea products after a spill, it is essential to preemptively set risk evaluation criteria and standard methodologies based on previous experience and appropriate scientifically sound criteria. Standard methodologies are analyzed and proposed in order to improve the definition of criteria for reintegrating previously contaminated marine marketable resources into the commercialization chain in Europe. The criteria used in former spills for the closing of and lifting of bans on fisheries and harvesting are analyzed. European legislation was identified regarding food sampling, food chemical analysis and maximum levels of contaminants allowed in seafood, which ought to be incorporated in the standard methodologies for the evaluation of the decision criteria defined for oil and HNS spills in Europe. A decision flowchart is proposed that opens the current decision criteria to new material that may be incorporated in the decision process. Decision criteria are discussed and compared among countries and incidents. An *a priori* definition of risk criteria and an elaboration of action plans are proposed to speed up actions that will lead to prompt final decisions. These decisions, based on the best available scientific data and conducing to lift or ban economic activity, will tend to be better understood and respected by citizens.

1. Introduction

Assessments of potential contamination of marine marketable resources after an oil spill are generally *ad hoc* and site specific efforts, with significant differences in risk evaluation (Challenger and Mauseth, 1998). In the case of hazard and noxious substances (HNS), the assessment is even more complicated because spilled products may be very diverse regarding their physical, chemical and toxicological properties. When concerns are raised regarding potential contamination of marine marketable resources by spilled products, fishery authorities usually request assistance from health authorities in the derivation of risk criteria for closing and reopening the fishery, aquaculture or harvest grounds. These risk criteria and assessment protocols should be well defined in advance, based upon previous experience in other spills and appropriate scientific knowledge, to minimize health risks and mitigate economic losses due to a long ban on the sale of sea products.

Most countries with long experience in oil spill incidents have risk criteria and assessment protocols already established. In the

Abbreviations and definitions: ALARA, as low as reasonably achievable; B[a]P, Benzo[a]pyrene; BaPE, Benzo[a]pyrene equivalents; $BMDL_{10}$, benchmark lower limit dose for a 10% response; BMD, benchmark dose; BMR, benchmark response; bw, body weight; DoSS, dioctyl sodium sulfosuccinate; ECETOC, European Centre for Ecotoxicology and Toxicology of Chemicals; EFSA, European Food Safety Authority; EU, European Commission; GESAMP, Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection; HNS, hazardous and noxious substance; IPOC funds, International Oil Pollution Compensation Funds; JECFA, Joint FAO/WHO Expert Committee on Food Additives; LOAEL, Lowest observed adverse effect level; LOC, Levels of concern; MLs, maximum levels; MOE, margins of exposure; NOAEL, non observable adverse effect level; NOOA, National Oceanic and Atmospheric Administration; PAH, Polycyclic Aromatic Hydrocarbon; PCB, Polychlorinated Biphenyls; P&I Clubs, International Maritime Insurance Clubs; SCF, Scientific Commission on Food; TEF, toxic equivalent factor; TEQ, total equivalent exposure; U.S.EPA, United States Environmental Protection Agency; U.S.FDA, United States Food and Drugs Administration.

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case of HNS, these protocols are more unlikely to exist. In some cases, seafood harvests have been temporarily closed while health risks are assessed and reopening criteria developed (Gilroy, 2000). While temporary fishery bans (i.e., fishing bans for capture fisheries and marketing bans for culture fisheries) are easily imposed on the basis of evidence of the presence of oil, scientific information is needed for decisions to extend them, lift them or destroy cultivated stocks. Regarding food safety concerns, contamination risk is in general higher for sessile, slow moving or caged organisms because pelagic fish can move to uncontaminated areas, while the others are definitely contaminated. Also, whole ungutted fish is more prone to contain contaminants or their metabolites, as compared to gutted, sliced or filleted fish, since fish tends to metabolize rapidly PAHs on muscle meat. Gutted or filleted fish may probably enter the market sooner.

Regarding economic concerns, protocols ought to be harmonized with the International Oil Pollution Compensation (IPOC) Fund and the International Maritime Insurance Clubs (P&I Clubs) because at the time of claiming compensations, criteria should match. Bans are not automatically recognized by the compensation Fund or I&P Clubs even if mandated by the Government or local authority. For instance, according to IPOC Fund guidelines, "if the Fund thinks that is reasonable that fishery should start again, it may pay compensations only up to that point in time, even if there is still a ban on fishing". Decisions have to be taken concerning public health, but actions taken by operators have to be reasonable and should be aimed at keeping damage at a minimum. The Fund will find it difficult to pay full compensation if business is stopped completely when there are other ways of operating (IPOC Fund, 1992).

Many key technical issues are consistent throughout incidents, so much valuable information can be obtained from former incidents. A systematized comparison of the parameters required for reopening fisheries in various oil spills occurring in the USA (Mauseth and Challenger, 2001) pinpointed the following aspects: the variability of acceptable benzo[a]pyrene (B[a]P) equivalents (BaPE) with each spill; a slow re-opening process because of continuous lack of national standards and criteria; the desire of each state to develop their own criteria which may or may not be based on previous experience from other spills; an expanded scope of sampling programs in space, magnitude and duration despite lack of findings of spill related health risks from seafood consumption in previous spills; continuous scrutiny of non-hydrocarbon chemical contaminants in the spilled material (metals, PCBs); and non-oil spill related failures of either health or marketability criteria that often do not result in the continued closure of the fishery. More recently the use of B[a]P as a biomarker of exposure to polycyclic aromatic hydrocarbons (PAHs) was eliminated from the European Regulations, as well as was the use of TEFs – Toxic Equivalent factors (EU, 2011a; EFSA, 2008) – contrary to risk assessments performed by the U.S. Food and Drug Administration (U.S.FDA) (U.S.FDA, 2010). In comparison to oil spills, the information available on HNS spills is scarce, and the risks are much less recognized and understood.

In this study, we first analyze the criteria that were used in former spills for the closing of and lifting of bans in fisheries and harvesting. Second, we identify and discuss European legislation regarding food sampling, food chemical analysis and maximum levels of contaminants allowed in seafood that ought to be incorporated in the standard methodologies for the evaluation of decision criteria defined for oil and HNS spills in Europe. We then propose a decision flowchart to help the decision and give hints related to other criteria that may be incorporated on that flowchart to expedite the decision process and make it more cost-effective. Finally, we discuss the *a priori* elaboration of action plans to create conditions under which to implement the criteria defined.

2. Seafood safety decision criteria after a spill

The analysis of the criteria considered for lifting bans on fishing and harvesting after recent spills involving formal closures highlights that they fall in three main categories: visual observation, sensory testing and chemical analysis.

2.1. Visual observation

The definition of closure areas is based on monitoring for oil in harvest areas and predicted drift pathways. Modeling, including variables such as meteorological conditions, sea conditions, oil properties and fate, has been recently taking more importance and falls in this category. The presence/lack of oiling on solid surfaces and benthic organisms, and the surface sheen on the water, has been used in many incidents to define the closures and reopenings of fisheries (Mauseth and Challenger, 2001). In the case of the Prestige incident, it is mentioned in an official technical report from the Spanish Agency for Food Security (AESA) that one of the criteria used for the closure and reopening of harvesting zones was the visual examination of oiling on the external tissues (skin, shell, cuticle, seaweeds) of seafood or at the water's surface (AESA, 2003). Any contamination detected visually excluded capture or harvesting from the zone.

Regarding HNS, although some floating or sinker immiscible compounds may be detected visually, many compounds which are colorless and miscible may not be visually detected. Hence, visual observation may be of limited interest to a large number of compounds.

Sensory assessment of a flavor or odor foreign to the sea product analyzed. Hydrocarbon taint in fish arises primarily from the presence of low molecular weight PAHs, in particular 2-ring compounds such as naphthalene and substituted naphthalenes (Craig et al., 2006). Water-soluble substances are readily absorbed into organisms, and when they reach a concentration at which they can be detected sensorially, they are said to be tainted (Davis et al., 2002). Tainting is in general more dramatic for sessile, slow moving or caged organisms because pelagic fish can move to uncontaminated areas. Organoleptic analysis is a low-cost and rapid method of analyzing a large number of samples. A highly trained panel on sensory analytic techniques can produce consistent data that can be readily used to select samples for more detailed chemical analysis.

Some guidelines and reports on analysis of fish taint have been produced in Europe, particularly in the UK (Craig et al., 2006; Millar et al., 2010) but also in other countries (ECETOC, 1987; U.S.FDA, 2010; Yender et al., 2002). Sensory testing based on the smell and tasting of seafood was conducted during the Braer and Sea Empress incidents in the UK. Sensory testing, based on the smell of raw and cooked seafood samples, was conducted by a panel of 10 experts using the protocol outlined in a NOAA Technical Memorandum (Reilly and York, 2001) during Deepwater Horizon. A protocol for the interpretation and use of sensory testing and analytical chemistry results for re-opening oil-impacted areas closed to seafood harvesting due to the Deepwater Horizon oil spill were produced by the U.S.FDA (2010). The EC does not have specific regulation regarding this matter.

Sensory analysis is to be taken with care regarding contaminants that produce acute toxicity because smelling or tasting by the trained panel may not be possible on those samples. Protocols need to be developed due to the intrinsic characteristics of the products in question, some of them quite toxic.

2.2. Chemical analysis

In the particular case of oil spills, PAH levels in the edible tissues are the criteria that provide quantitative data for risk assessment