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ECONOMICS OF COASTAL HAZARD PREVENTION

EcosHaz

ECONOMICS OF PREVENTION MEASURES ADRESSING COASTAL HAZARDS

GUIDELINE 2

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Chapter 1: Introduction

These Guidelines are presented to assess the benefits of conducting an oil spill management plan. Nevertheless, the design and implementation of a management plan has also associated costs. Thus, the knowledge of both, the benefits associated in comparison with the costs of the management plans allows evaluating the investment decisions.

At a worldwide level the consumption of oil has increased and with it the probability of suffering spillages (Jin and Kite-Powel, 1995). Vessel oil spills are accidents that cause a major impact on both, the environment and the economy of the affected areas. In addition, these kind of accidents affect different economic sectors, including fisheries, tourism, among others. Several studies have emphasized the amount of damages that can be caused by oil spills, for example, Grigalunas et al., (1986) studied the impact of the Amoco Cadiz spill, Carson et al. (1992) analysed the damages caused by the Exxon Valdez; Bonnieux and Rainelli, (1993) in the case of the Erika accident; Moore et al. (1998) conducted the study for the Sea Empress oil spill, Chapman and Hanemann (2001) for the American Trader an Loureiro et al. (2006) for the Prestige accident, among others.

Attending to the international organizations, the International Tanker Owners Pollution Federation Limited (ITOPF, 2010) has emphasized that the number of accidents has decreased in the last years but also the amount of oil spilled. Nevertheless, they are still frequent and relevant due to the impact that provoke in the affected area. The ITOPF (2010) offer some statistics that show as large incidents are responsible for a high percentage of the total oil spills at a global level and for example, we found that only 2 accidents were the responsible of the 35% of the oil spilt since the year 2000. Another important that is commented by this organization is that most oil spills are consequence of fails during the routine operations such as operation of loading, discharging and bunkering. Therefore, it is important to have a plan that allows to policymakers to act in an effective way in the case of an accident.

This document is focused on the case of oil spills. As a point of difference with regards to natural hazards, we should emphasize that these accidents are consequences of the human actions. Therefore, prevention and safety measures are rather relevant in order to reduce their incidence and magnitude.

1.1 Cost Benefit Analysis (CBA)

CBA is an approach to estimate the strengths and weaknesses of alternatives that satisfy transactions or requirements for activities. This technique allows determining the options that provide the best approach for the adoption of a plan in terms of benefits provided compared with the costs of implementation.

The CBA applied to oil spills prevention measures means to compare the costs that the establishment of a management plan (which contemplates different measures of prevention, risk assessment, etc.), with the benefits that these measures will provide in avoiding an oil spill or at least minimizing the risk and damages whether an accident takes place.

1.2 Economic efficiency and wealth distribution

The CBA employs the economic efficiency as the criteria that guide the decision making. Thus, the efficiency from an economic point of view is evaluated as the balance of outcomes versus inputs and the economic efficiency is reached when there is a maximum. According to this principle, a result which is not “fair” may arise, thus; it seems that the protection from oil spill effect of those with larger assets will be more efficient from an economic point of view. Nevertheless, we should take into account that in CBA the concept of fairness is not an objective (specifically), although this effect can be controlled through different ways. For example, the use of weights that increase the benefits of protecting those with lower assets or with spatial planning where more detail about the affected areas can be obtained. In this sense, previous studies as conducted by Penning-Rowsell et al. (2013) or Parker et al. (2012) consider this issue.

1.3 Dealing with data

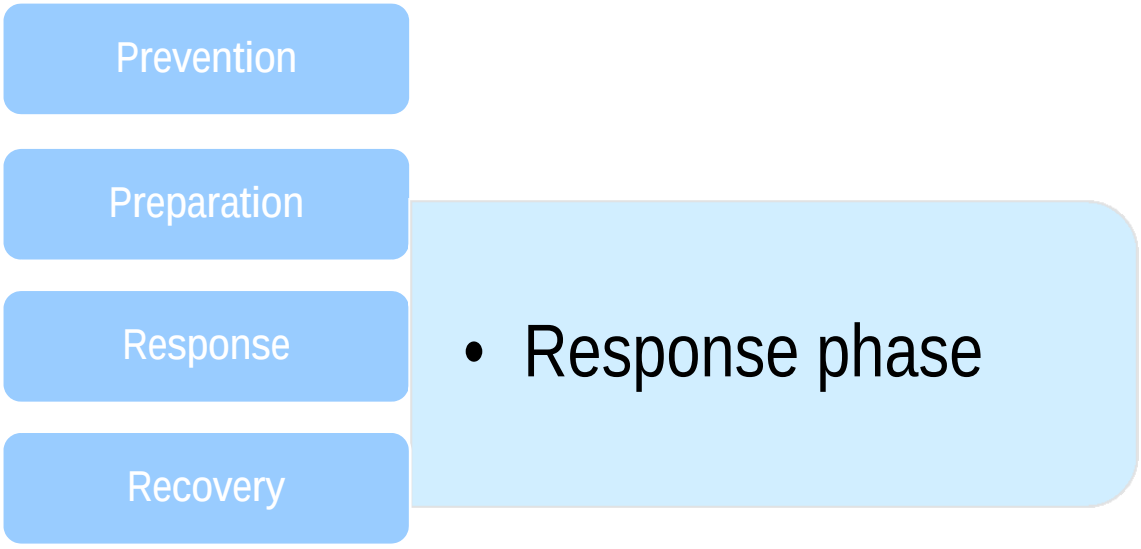
The availability, transparency and quality of data to conduct the analysis may be a difficult point for some countries or areas. In the case of lack of data this cannot be a justification for not conducting a CBA study. In this case, the use of the best available data will be employed with the necessary adjustments in quantitative and qualitative terms. At this regards, previous studies can be consulted (Grigalunas et al., 1986; Carson et al.,1992; Bonnieux and Rainelli.,1993; Moore et al., 1998; Chapman and Hanemann., 2001; Loureiro et al., 2006) but also experts’ consultations.

Chapter 2: Planning for an oil spill

2.1 The importance of a Contingency Plan

The management of a disaster like an oil spill is important. Chang et al. (2014) state that the severity of an oil spill is highly influenced by the response and other management variables. The same idea is reinforced by The International Tanker Owners Pollution Federation Limited (ITOPF, 2014). Stevens and Aurand (2008) emphasize that there are four principles that have to be addressed when any type of emergency is happening (See Figure 1):

Figure 1: Principles to address in the case of an emergency



Source: Modified from Stevens and Auran (2008)

The first principle (prevention) is the most difficult to plan, while the three other have to be incorporated into a response phase. In the response phase, a quick response matters but also the employment of the most efficient and effective technologies. Moreover, other aspects like a local response, the clean-up techniques employed, among others, also influence. In addition, the evaluation of climate and meteorological conditions should be considered. Thus, the existence of a previous planning about the response to an oil spill is decisive.

The first step in a prevention phase is the definition of the risks and, once these are analysed it is relevant to develop the response planning. In the phase of response planning, full participation of all agents is necessary. Stevens and Aurand (2008) suggest that the following parties should be involved: national government agencies, local government agencies, port authorities, coastal authorities, emergency services, other oil companies in the area, contractors, environmental organisations and local communities. They also remark the need of having resources (equipment, staff) to deal with the

disaster and the existence of additional resources, if they are needed. Moreover, they also indicate the need of a response system to provide help in case of a change in circumstances that may occur during the incident. Finally, it should exist a unity in the organizational structures and a readiness to act. Therefore, the existence of a Contingency Plan is crucial. At this respect, the International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 (OPRC Convention) also emphasizes its importance. Furthermore, the International Maritime Organization/ International Petroleum Industry Environmental Conservation Association (IMO/IPIECA, 2000) also highlights the benefits of a Contingency Plan; specifically, this tool allows for a more efficient and effective response in the case of an accident. Moreover, it also makes it easier to recognize special areas due to environmental, commercial or governmental priorities. Finally, the last benefit is that it establishes a better understanding for the different stakeholders and clarifies their roles in the emergency action.

According to the IMO/IPIECA (2000), the three main points that should be considered in the Contingency Plan are:

- Plans have to be based in a tiered response: the reason is that spills can occur from different sources and be of different sizes, which implies that the need of resources may vary depending on the conditions of the accident
- The assessment of the risk
- The importance of cooperation

2.2 The elaboration of a Contingency Plan

In order to provide useful information to elaborate a Contingency Plan, we have reviewed the information provided by the ITOPF combined with the IMO/IPIECA (2000). Therefore, three phases can be highlighted:

1. The risk assessment phase, which is referred to the recompilation of information in order to evaluate the risk but also the environment in risk.
2. The strategy phase which contains the organization of the people involved with different functions and responsibilities and giving information to make decisions.
3. An operational phase that contains the procedures to follow in the case of an accident.

With regards to the risk assessment, the aim of this phase according to the ITOPF (2014) has to be the identification of measures that allow for reducing the risk, but also managing the risk and the feasible consequences, whether an accident happens. This is a difficult task that has to be analysed taking into account the potential sources of oil spills (pipelines, platforms, vessels) and operational risks (based on the industry best practice) (Stevens and Aurand, 2008). Nevertheless, previous literature also emphasizes other factors that can help in the prediction of oil spills. In particular, Loureiro et al. (2009) show that in areas where the application of the legislation is more flexible, the probability that an oil spill takes place is higher. In addition, Alló and Loureiro (2013) also find that areas with strict liability have suffered lower oil spill economic damages than areas with a system based on negligence. Another study that reinforces the importance of the regulation has been conducted by Chang et al. (2014). They highlight the importance of the ship safety features as a clear factor which is affected by the

implementation of different kinds of regulation; suggesting, specifically, the importance of double hulls. Extreme conditions that may also affect the probability of an accident as the ability to give a response also have to be considered.

Basically, the ITOPF (2014) suggests that the main point is to respond to the following questions:

-Which is the probability that an oil spill occurs?

-What are the probable consequences?

Following the recommendations of the IMO/IPIECA (2000) five aspects should be analysed:

1- Historical data: this is an important source of information that can help in the prediction of the likelihood of oil spills. There are areas where a higher risk can be identified and therefore they should be highlighted in the Contingency Plan.
2- The oil properties: these properties determine the physical and chemical changes that occur when an oil spill takes place, which determines the persistence on the water and its toxicity. The IMO/IPIECA (2000) recommends the preparation of a list with the properties of the different oil types, its in water and the expected effectiveness of the different clean-up measures.
3- The water current and the wind: information about tides, currents are relevant, as the information that can be provided by the local stakeholders as fishermen.
4- Sea conditions: the sea conditions (whether the sea is rough or the temperature) influence the behaviour of the oil spilled and thus the effectiveness of the response.
5- Simulations: there are tools that can be used to simulate oil spills that can help to analyse the planning of a Contingency Plan.

It is also valuable to take into account the risk to the environment. Thus, the IMO/IPIECA (2000) signals the use of sensitivity mapping to plan the process. These maps show where there are different coastal resources and the more sensitive areas from an ecological point of view. In addition, the mapping implies the collection of information about commercial, ecological and recreation resources. The application of techniques based on Geographical Information Systems (GIS) can be useful in this task. It is crucial the definition of some priorities areas, this means, areas with a high ecological value or areas which require a higher level of protection.

To sum up, it is fundamental to collect information in order to assess the risk that is faced from an oil spill. Thus, the knowledge of the areas of concern is crucial, having general information about how could be spilt, how it will behave if split, where it may go, what it might affect (considering economic, social and ecological resources). Therefore, some key points are identified, such as the identification of risk activities, highly sensitive areas, potential consequences to high sensitivity areas from risk activities, the inclusion of risk and consequences in the planning process and a broad set of strategies is discussed. The planning usually considers the modelling of the oil fate to identify which areas may be affected and the possible consequences. Table 1 sums up a list of factors that should be considered.

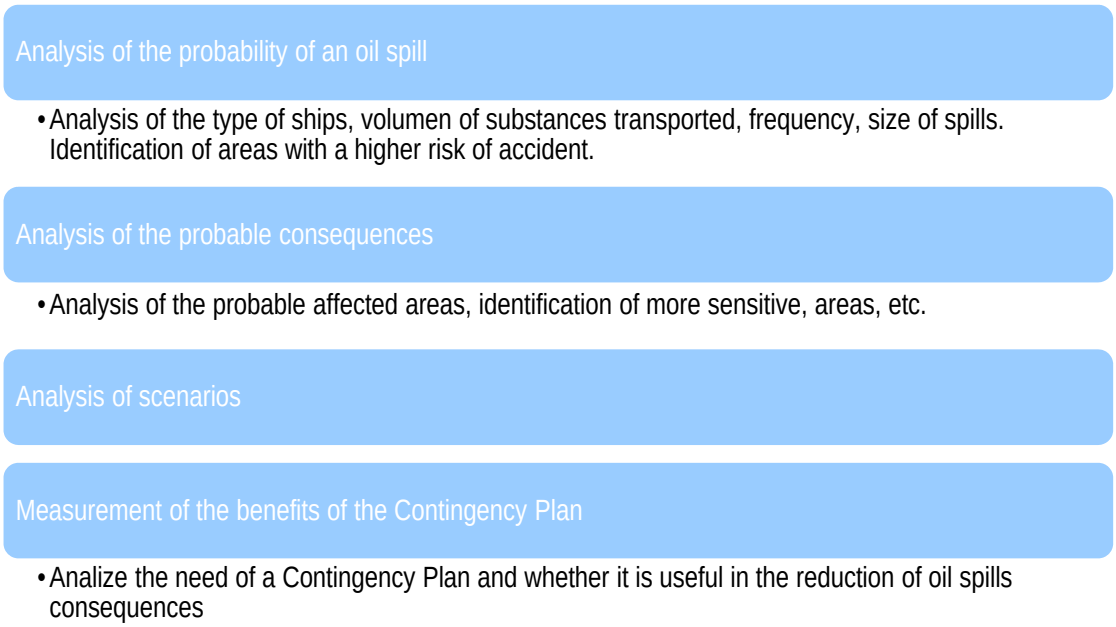
Table 1: Factors affecting oil spill risk

Oil type
Geographical location
Weather conditions
Sea conditions
Coast
Surveillance
Traffic volume
Time
Sail dangers
War
Design
Facilities conditions
Law
Quality and type of the ships
Operations type
Quantities
Frequency of operations
Training programmes

Source: IMO/IPIECA (2000)

Through the technical report published by the ITOPF (2014) we summarize this initial phase in Figure 2:

Figure 2: First phase in the Contingency Plan

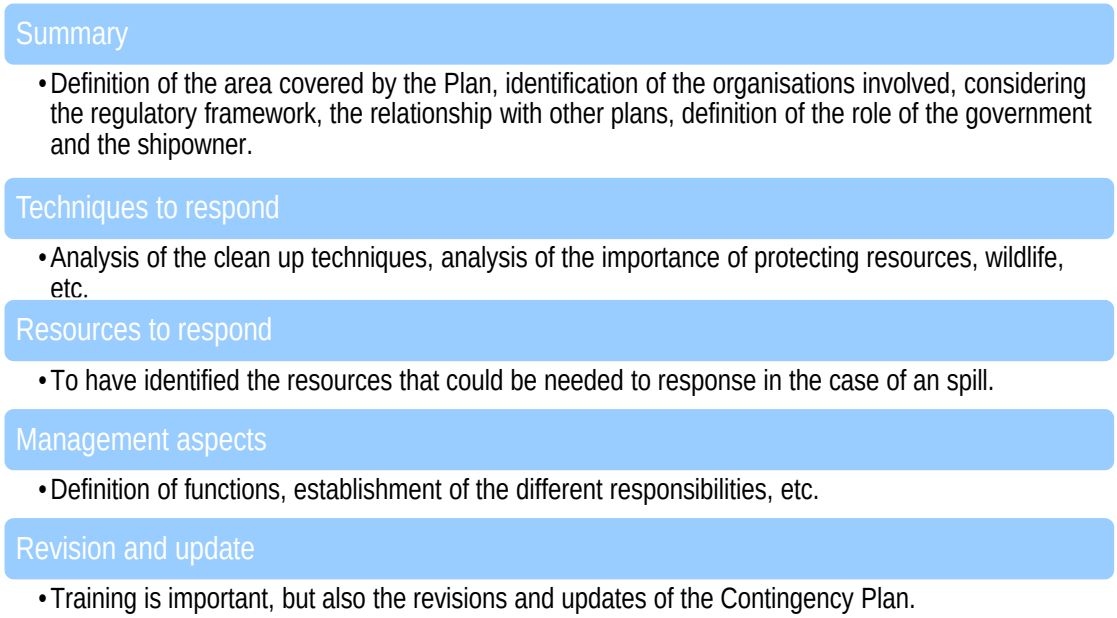


Source: Adapted from the ITOPF (2014)

A second general phase is the strategic phase, which includes the analysis and set of response priorities. A relevant phase within this is the definition of the priority sites for protection. To define these areas all or most relevant stakeholders should agree. The results should be based in the conclusions obtained from the risk assessment process and the modelling results. In this phase, it is crucial to provide an overview of the plan taking into account the geographical area covered and explaining which are the preferred protection and clean up options. Therefore, the effectiveness of each technology and the ecological risks and benefits have to be assessed. In this group of tasks, we should analyse how the different response options affect the resources, identifying the preferred option. The development of an appropriate response capacity and the evaluation of cooperation with other parties that may result affected is also necessary.

At this point, it is necessary to define the equipment needs. This is based on the definition of potential spill volumes and the equipment available for different techniques used. It is also important to define the staff needs and to ensure the equipment and staff availability. With regards to the parties/authorities involved, the determination of who are the parties involved in each task while their coordination is also essential. The communication is other point to take into account, since it is necessary to have a good communicated management structure. Moreover, there should be previous training sessions so that participants become familiar with the Contingency Plan to conduct their tasks in the case of an oil spill. The training also matters, because it helps to undertake effectively and efficiently responses. In this phase it is when the strategies are chosen. Figure 3 shows a summary of the most influential aspects following the ITOPF (2014).

Figure 3: Second phase in the Contingency Plan



Source: Elaborated from the ITOPF (2014)

Finally, the third point is related with the operational phase, which corresponds with the notification of the accident; usually, this is made through the port authorities or depending of the type of spill by the general public. Later, the ITOPF (2014) recommends that the assigned individuals have to do a checklist to evaluate the situation. Specifically, they suggest to review:

-the date and time when the spill has been observed

-the location of the accident

-the source of the spill and the cause

-the amount spilled, the type and main characteristics

-the description of the spill

-the analysis of the weather conditions and the sea conditions

-the details about the ship and salvage operations

-the action that has to be taken in order to deal with the pollution

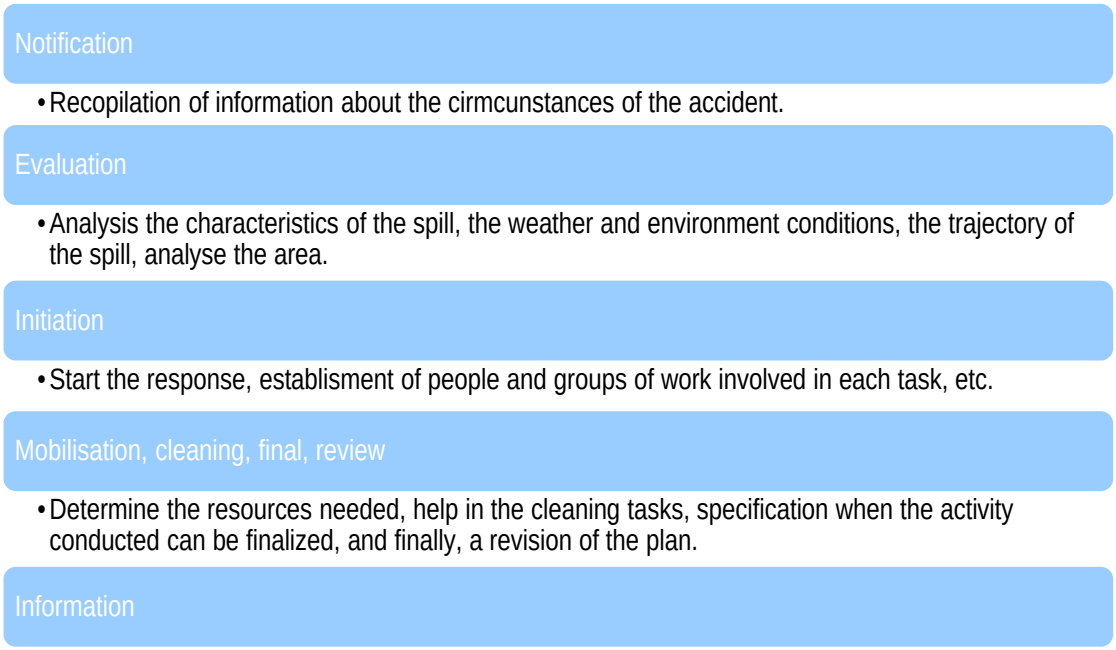
After this, it is recommended to evaluate the situation as the potential resources that may be affected. At this point, technical and expert help may be needed to determine some additional aspects. Stevens and Aurand (2008) summarize factors such as the direction of the oil spill. Basically, they refer to models that predict the primary affected areas but also the oil movement, concentrations or the weather. The knowledge about the movement of the oil can help to identify the risk areas but also which resources may result more impacted.

Once that this information has been analysed those individuals who are members of the response team should start to act. It is important to have an organized structure about the different positions and tasks of the people involved in this phase. Moreover, information about different conditions of the potential affected areas should be available in order to be checked to minimize impacts. The cleaning tasks should be evaluated and conducted by the responsible parties but also consider when the end of this activity is appropriate.

Basically, the organization and mobilisation of the people involved is fundamental, as well as the establishment of responsibilities, communications, and resources, the revision and update of the plan; this is the establishment of the procedures when an oil spill takes place.

To conclude, the availability of different databases and maps is necessary in order to support decisions that will be made to give an answer to the accident (See Figure 4).

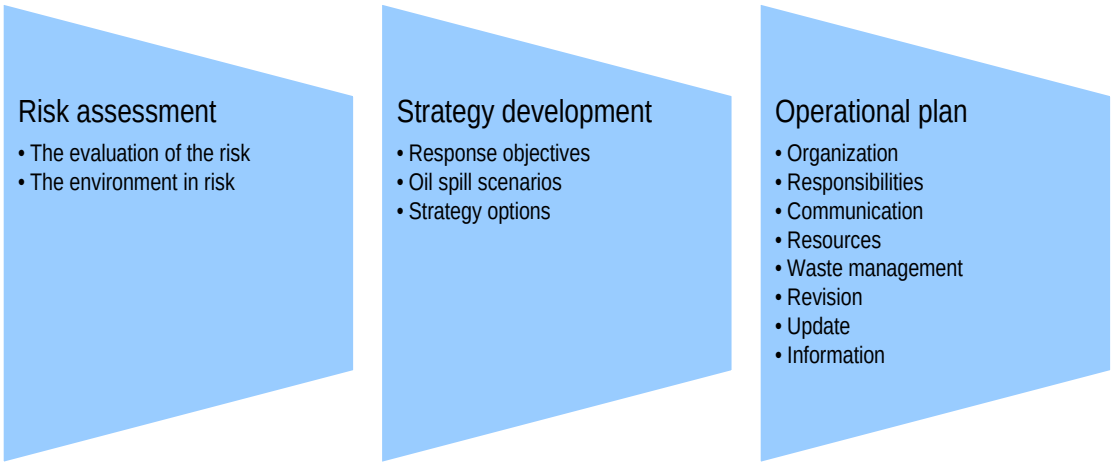
Figure 4: Third phase in the Contingency Plan



Source: Elaborated from the ITOPF (2014)

Figure 5 illustrates the planning process following the ITOPF (2014) and the IMO/IPIECA (2000):

Figure 5: Planning process



Source: Elaborated from IMO/IPIECA (2000)

2.3 Conclusions: before and after an oil spill

In a Contingency Plan there should appear clear procedures to notify, assess and initiate a response in the case of an oil spill (Stevens and Aurands, 2008). The report of an oil spill has to provide sufficient information to act in an appropriate way following the recommendations suggested previously. Stevens and Aurand (2008) indicate six crucial phases of the spill that has to be monitored (See Table 2):

Table 2: Phases of monitoring

Pre spill	A baseline monitoring
Post spill-pre impact	To collect information about pre-impact conditions
Post impact-pre clean-up	To monitor shorelines and resources impacted
Clean- up	To monitor what occurs after the clean-up operations, to know the success, among other aspects
Post clean-up Pre response termination	To monitor after the response has finished, evaluating the final state of cleaned shorelines
Post response	Analyse the short, medium and long term

Source: Elaborated from Stevens and Aurand (2008)

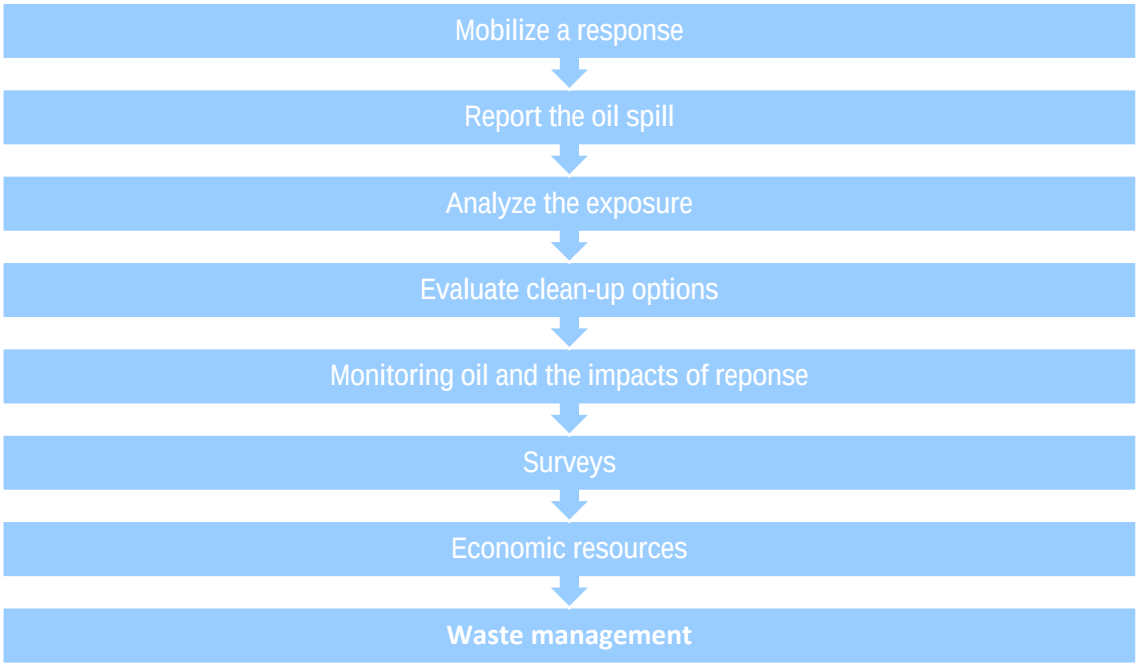
The Contingency Plan should include methods to collect data in order to analyse the size and the movement of the oil spilled, taking information about the extent and the character, identifying areas and resources that can be potentially affected, establishing protection priorities, providing response options, collecting data about the fate and the effects of the oil. Moreover, it is also necessary the inclusion of methods to collect data about the environmental conditions before the oil spill in order to compare with the conditions after the oil spill. Information about the properties of the oil that has impacted the shore,

the interactions with the environment and the geological and ecological conditions of the affected areas are other factors to be considered. Other aspect is the monitoring of water columns (the different characteristics of sea at different levels of depth). Stevens and Aurand (2008) recall the potential benefits of water analysis, which are related with a better knowledge about the dissolution and dispersion of the oil spilled. Different techniques can be used to conduct the analysis of water column, such as a fluorimeter, or analysis of discrete water samples. Furthermore, an analysis of sediments should be also conducted. Once again, the aim is to have a baseline sample of the conditions before the spill to allow the monitoring of the consequences of the contamination and the recovery.

The analysis of wildlife is also crucial. In the context of oil spill this is referred to marine mammals and birds. The goal is to have a knowledge about the pre-spill status and thus to evaluate the consequences of the accident. This kind of analysis also should be conducted with intertidal and subtidal organisms. In addition, the collection of data about the economic resources is also crucial. The importance is justified due to this information make easier the conduction of future economic evaluations and thus, future claims for compensation.

Finally, the question of the waste management is also crucial. The actions that are taken during an oil spill have to be consistent with the protocols for waste disposal established in the Contingency Plan. We should know when the oil spill response has to terminate and this has to be contemplated in the Contingency Plan (See Figure 6 for a summary).

Figure: 6 Phases after an oil spill occurs.



Source: Elaborated from Stevens and Aurand (2008)

Chapter 3: Frameworks, principles and data

This chapter shows how an oil spill risk management benefit assessment should be conducted for an oil spill CBA. Thus, it contains the theory and sources of data that will be necessary.

3.1 Types of damages and losses from oil spills

This section discusses the damages and losses that an oil spill accident can cause. Table 3 shows a classification about difference damages, considering direct and indirect losses, tangible and intangible losses.

Direct damages are a consequence of the physical contact of pollutant substances with damageable property and its contents. For example, damages to ships, or fishing tackles, among others. It is also important to emphasize that there are damages to nature and the physical environment, for example; damages to beaches. Indirect damages are those caused in an indirect way. For example, the pollution of fisheries does not allow fishermen to conduct their activity. In the case of tourism, polluted beaches may imply a less number of touristic visits and therefore reduces the expenditures in this sector (See Table 3). Furthermore, there are tangible and intangible damages. Tangible damages are those that can be quantified (for example, the number of fishermen tacks that cannot be reused). With regards to intangible damages are those which cannot be quantified directly in terms of market prices, such as the loss of marine biodiversity or reputation losses of some marine destinations. The amount of damages depends on the duration, velocity, amount of discharged oil and type of oil spilt. Thus, all these factors affect the social and economic activities of the affected area, causing also indirect losses.

Table 3: Examples of direct, indirect, tangible and intangible oil spill losses

Measurement			
		Tangible	Intangible
Form of loss	Direct	Damage to ships	Loss of marine biodiversity
		Damage to fishermen tacks	Damage to beaches
	Indirect	Loss in fisheries or tourism sectors	Inhalation of vapors

A relevant point to consider is also the avoidance of double counted effects.

3.2 Short and medium term damages

The methodology for assessing the benefits of oil spill alleviation program considers the effects suffered immediately after the accident and also those mid-term or longer effects that remain over time. Loureiro (2014) conducted a court report for the Prestige oil spill where economic losses were computed taking

into account both time periods (immediate losses and mid-term losses). Furthermore, it is crucial to understand the ex-ante difficulty about the potential effects and duration of the oil spill damages. These aspects are crucial points that have to be considered carefully, because they matter significantly for the implementation of the CBA.

3.3 Data

3.3.1 Defining the affected area

The first task is to define the affected area, in order to assess the benefits of reducing oil spills. This is the area that is affected by the discharge, both directly and indirectly.

The affected area is usually identified as the maximum known extent of the oil spill. However, it is also necessary to extend the benefit area beyond because the indirect effects of an oil spill accident may affect several economic activities and the water transportation.

3.3.2 The vulnerability of the affected area

It is also relevant the assessment of the vulnerability of the areas in terms of the damages that could be caused. Thus, the area where the oil spill takes place is a factor that affects the amount of damages that can be suffered. Chang et al. (2014) recall that the prediction of the oil spill impact is influenced by the location. Thus, if the oil spill takes place in areas closer to shore or to human populations, it is expected that the economic impact is greater, and the cleaning costs are higher. Other related factors are the amount of oil spill and the spillage rate or type of oil spilled. Depending on the type of oil, the behaviour will be different. We have to consider the reactions of oil to environmental conditions at the time of oil spill. Thus, one again climate and weather conditions and the hydrographic modelling are decisive (Stevens and Aurand, 2008).

Furthermore, Fattal et al. (2010) indicate that in order to analyse the coastal vulnerability, several factors have to be considered, especially environmental and socioeconomic vulnerability factors. In Table 4, we show relevant indicators to be studied to know the vulnerability of the affected area.

Table 4: Factors to assess the vulnerability of the affected area

Environmental vulnerability	Socioeconomic vulnerability
Global exposure	Heritage: natural/conservation capital
Coastal morphology	Infrastructures

Biological sensitivity	Oil spill management
Intensity of pollution	Human activities
Marine weather	

Source: Fattal et al. (2010)

Thus, it is necessary to determine:

-the geo-reference of each property in the affected area

-the amount of territory affected by the oil spill

-the area of the property in square meters if the property is non-residential

To identify the affected activities in the benefit area, national and regional databases can be used as preliminary sources. Field surveys can also be used to determine damages to other type of properties not registered in databases. For example, in the Prestige oil spill (Spain), environmental damages were computed by the conduction of surveys to the population.

3.3.3 Oil spills damage data

The employment of Geographical Information Systems (GIS) and the availability of vulnerability maps may help to understand what kind of damages can be suffered due to an accident. Below a description of the main methodologies is presented. A case study will serve as an example to assess the implementation of many of the suggested methodologies.

Methodology to be employed:

Valuations for benefit-cost analysis can be achieved through different valuation methodologies:

Market prices: When markets function competitively, one can use market prices for the economic valuation of non-market goods and services. Even when markets are non-competitive (i.e. distorted), one can adjust market prices to derive shadow prices that could be used for economic valuation of non-market goods and services.

To conduct an analysis through market prices, it is important to have information about changes in prices before and after the oil spill. In addition, we need the quantity of the resource that we are valuing. With this data, we can know which is the economic value and how this value has decreased with the accident, multiplying quantities times price variations before and after the spill.

An example of oil spill short-term valuation can be found in Loureiro et al. (2006). Specifically, this study tackles the valuation of losses in different sectors as a consequence of the Prestige oil spill: commercial fisheries and shellfish, mussel farming, canning and fish processing sector, tourism sector, birds and

mammals with reposition costs, cleaning up and recovery costs. The authors also stand out the need to consider additional costs, such as costs of legal representation, and health related problems of volunteers and cleaning teams.

Travel Cost Method (TCM): Some amenities do not have a direct price associated with them, this is the case of the coastal landscape and coastal heritage environments. In order to apply a value to these types of amenities a value is often derived from a good or service which is complementary to the consumption of the free amenity.

The travel cost method involves collecting data on the costs incurred by each individual in travelling to the recreational site or amenity. This 'price' paid by visitors is unique to each individual, and is calculated by summing up the travel costs from each individuals original location to the amenity. By aggregating the observed travel costs associated with a number of individuals accessing the amenity, a demand curve can be estimated; and as such a price can be obtained for the non-price amenity.

An example of this application can be found in the expert report about the Prestige oil spills, conducted by Loureiro (2014). This study shows that TCM can be applied to evaluate the economic losses in the tourism sector as a consequence of the Prestige oil spill.

Hedonic Pricing: One of the techniques used for the monetary valuation of environmental goods and services is the Hedonic Price Model (HPM). This model relates that the price of a good or product is a function of its attributes or characteristics. Each attribute can affect the price of the good positively or negatively, depending on consumers´ preferences. A hedonic price method was employed by Dominguez and Loureiro (2013) to estimate the effect of environmental stigma in Galician pelagic fisheries after the Prestige oil spill. Specifically, they analyzed how the publication of news about the accident affected the price of fisheries.

Choice experiment: This method asks individuals to declare a preference between one group of environmental services or characteristics, with a given price/cost to the respondent , and another group of environmental characteristics at a different price or cost (Denoted each as choice set). A similar technique is the *Conjoint Analysis*, which is also called multi-attribute compositional models or stated preference analysis, which is statistical technique that originated in mathematical psychology. It is used in surveys developed in applied sciences, often on behalf of marketing, product management, and operations research. Therefore, in this methodology individuals face different scenarios with different levels for different characteristics (one of them is an economic attribute) through a survey and they have to choose the preferred option. This selection allows researchers to know their preferences and the economic valuation of them.

An example was conducted by Liu and Pan (2014) to evaluate the environmental damages from the Penglai 19-3 oil spill in China.

Contingent Valuation: The contingent valuation method (CVM) is used to estimate economic values for all kinds of ecosystem and environmental services. It can be used to estimate both market (or use) and non-use values, and it is the most widely used method for estimating non-use values.

An example of the application of this method can be found in Carson et al. (2003). In this study, a CVM study was conducted after the Exxon Valdez accident assessing the willingness to pay of US households to prevent another accident. Loureiro et al. (2009) also evaluate the environmental damages from the Prestige oil spill. More recently, Loureiro and Loomis (2013) also assessed the environmental damages of the Prestige oils spill at international level, considering the European magnitude of this spill.

This methodology is implemented through a survey, where researchers ask participants how much they are willing to pay for protecting a natural resource, for example.. Thus, through this technique we can obtain the economic value that individuals associate to the resource.

Benefit transfer: The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. Alló and Loureiro (2013) conducted a meta-regression for large accidental oil spills which allows predicting the marginal contributions to the damage function of the most relevant causing factors. Through this methodology, we can assess economic damages without the need of having to conduct an specific study for the accident side. This means, that we can take the economic values from previous studies and adjust them to the particular circumstances and characteristics of the accident.

3.3.4 Data quality

Data elements have different qualities. Usually it is difficult to have detailed local data. It is frequent to have statistics at national or regional levels; although if an oil spill affects only a local area, it is necessary to have disaggregated statistics about this affected area. In case of not having the data, we have to be aware that we can employ regional data (using weights) but that the quality of our estimations is not going to be same as with specific data for this area. Thus, the objective is to improve the quality of the data using a transparent and auditable system. Eventually, data related to both costs and benefits are difficult to find at local levels.

3.4 Conclusions

To sum up, Chang et al. (2014) conclude that the main factors that influence the damage caused by oil spills are:

-Variables related to the oil spill: ship safety features (single hull vs. double hull), the location of spill, the amount of oil spilled and the rate and the type of oil.

-Variables related to the disaster management: the time of response, the governance factor, the technology used to give a response, the human capital, natural processes but the local culture and the context variables also matter.

-Variables related to the marine physical environment: connecting waterways, the influence of tides and currents, the wave exposure, the temperature and salinity of water, substrate at site exposed to oil and the weather conditions.

-Variables related to the marine biology: the exposure to toxins, the exposure quantity, the habitat/depth of species, the mobility, the feeding mode, species identity, other stressors, developmental stage and the generation time.

-Variables related to human health and society: existence of a direct skin contact with carcinogenic compounds, air pollutants, ingestion of contaminated food and water, psychological and social costs and subsistence uses.

-Variables related to economic issues: commercial fisheries and aquaculture, commercial fisheries and aquaculture value chain, tourism industry, waterway usage, other marine-based industries, oil industry, agriculture, pure economic loss, passive use and recreation, real state, financial sector, legal and research costs, municipal/regional government impacts, economies of scale, recovery boom, expensive savings, tax revenues and conservation benefits.

-Variables related with policy and decision: port closure, brand campaigns, compensation payments and the fishing moratoria.

Chapter 4: Benefits (avoided costs) and Costs

In this chapter, examples of economic losses are presented in order to emphasize the importance of damages that after an oil spill the society can suffer. These examples show a direct assessment of losses. Nevertheless, in order to conduct a CBA we know that the Net Present Value (NPV) has to be considered to obtain the present value of future cash-flows.

4.1 Benefits (avoided costs)

4.1.1Oil spill damages to fisheries and shellfisheries

When oil spill accidents take place, one of the most affected economic sectors is the fisheries. Damages to fisheries can be calculated with market prices. Specifically, it is necessary to analyse the trend of the quantities sold, and the evolution of prices. In this sector, we should consider that there may be image losses due to the fact that prices can be damaged by stigma. In order to provide an example, we employ different studies that have been published and that show the methodology employed in the case of the Prestige oil spill in Galicia (North-West of Spain). Nevertheless, at this point it is important to state that economic compensations paid by ITOPF are based on market prices. We should know that there are more damages that cannot be only measured with market prices in the case of oil spills. In addition, this organism also compensates with economic subsidies the periods of closure of the activity that are common, for example, in the case of fisheries. This means that when an oil spill affects the sector of fisheries, usually, there are some months where this activity is going to be banned. Therefore, this organism pays an economic subsidy compensating these periods of closure. Therefore, all these points have to be considered.

Loureiro et al. (2006) state that there are three factors that should be taken into account following previous studies as Cohen (1995). Thus, to analyse commercial fisheries, it is necessary to consider, first; the morbidity effects of carbon-based toxicity on species; second, the mobility of fish populations and the possibility of escaping toxicity also should be considered and, third, the effects of oil spill in the reproductive cycles of species are unknown. Loureiro et al. (2006) also highlight that the diversity of fisheries is rather significant. For the Prestige oil spill, more than 50 commercial fisheries have been evaluated. This means that depending on the area of study, we have to consider the richness of the commercial biodiversity in each area

Once these issues are clear and that commercial species have been identified, the next step is the collection of statistical data before and after the oil spill. The aim is to analyse the impact suffered to test whether there are differences that can be linked with the oil spill. Loureiro et al. (2006) remark that it is convenient to use data on stock and catching efforts. Nevertheless, in the Prestige oil spill they employed total landing and their respective economic ex-vessel values. The reason was the availability of data.

Another question to consider is that, when an oil spill takes place, the establishment of periods of fishing activities closure is highly probable. Thus, when these periods are over and fishing activities are reopened, the landing volumes may increase. At this respect, Loureiro et al. (2006) indicate that it is

important to consider that maybe this increase is not consequence of a recovery; on the contrary, it may be consequence of over-harvesting.

To evaluate losses, they compute economic losses and also take into account to net out the possible savings due to reductions of inputs usage during the extraction bans. Thus, we need to know the changes in prices due to the oil spill and multiply these changes in prices by the quantities sold in the local market. There might be additional losses that cannot be computed; for example, there are extra-market damages as the non-commercial biodiversity, this is, those losses resulting from the destruction of biota (phytoplankton, zooplankton and other multiple microorganisms) besides algae that are used to feed many fish populations. Finally, Table 5 shows an example of the economic losses computed for the Prestige oil spill by Loureiro et al. (2006). It has to be noted that these losses are analysed in a short term; however, it is interesting to study also the effect on the long-term (Loureiro, 2014).

Table 5: Fisheries losses in € million (short term-immediately after the oil spill)

	Galicia	All affected area
Commercial losses in fisheries (2000-2004)	63.08	112.66

Source: Loureiro et al. (2006)

4.1.2 Oil spill damages to mussel farming/ Aquiculture

In addition to fisheries damages, there are also other sectors that can be affected. Thus, although the mussel farming may not be directly affected by the oil spill, it also may suffer economic losses. Thus, questions such as safety, or the effect of news may influence the price of this specie. Therefore, through the use of statistical methods (econometric models), the damage on this sector (or aquiculture in general) can also be considered.

Thus, following with the Prestige oil spill, Loureiro et al. (2006) conclude that economic losses in the mussel sector sum up to €12.83 million (Table 6). To compute these losses they assumed that the changes in this selling industry were consequence of the Prestige oil spill. Therefore, they did not consider any other market condition. Thus, they accounted the reduction in kg sold and reductions in prices.

Table 6: Mussel sector losses in € million (short term-immediately after the oil spill)

	Galicia	All affected area
Commercial losses in the mussel sector	12.83	12.83

Source: Loureiro et al. (2006)

4.1.3 Oil spill damages to canning and fishing processing sector

With regards to the canning and fishing processing sector, they are heavily dependent on shellfish and fishing activities. Therefore, during periods of fishing bans, this sector suffers losses in a direct way. Depending on the degree of development of these industries, this sector can imply damages for the local activity; for example with a decrease of the number of employments. To take into account this kind of losses, it is necessary to have access to database that provides information about the composition of the industry, type of firms according to the level of income generated, employment, etc. Also it is necessary to attend whether this industry exports, as it was the case of the Galician canning and fishing processing sector. Once again, taking as reference the study of Loureiro et al. (2006), economic damages to this sector amount to more than €20 million (Table 7). To estimate economic losses, they considered the size of the firms, thus they used a detailed database about this Galician sector; taking into account the gross value added (GVA) product (value of output minus value of inputs) and compared it before and after the accident. They also considered that the evolution of exports detected a decrease that was also taken into account.

Table 7: Canning and fish processing sector losses in € million (short term-immediately after the oil spill)

	Galicia	All affected area
Commercial losses in the canning and fish processing sector (2002-2004)	22.50	26.77

Source: Loureiro et al. (2006)

4.1.4 Image losses (stigma effects)

To conclude with this chapter, it is also necessary to consider that there are losses linked to the stigma effect that fisheries markets can suffer. Dominguez and Loureiro (2013) have analysed this effect for the Prestige oil spill. Specifically, they focused on pelagic fish species and show that printed media surrounding the accident was significant in explaining the evolution of prices.

To analyse this kind of effect it is necessary to have information about prices and landings., but also detailed information about the number of news that have been published with regards to the accident. Collecting information about the kind of news that had been published, whether they were negative or positive, or neutral news that just inform about the situation. Finally, it is necessary to conduct an econometric analysis that in the case of Dominguez and Loureiro (2013) was the hedonic price model (See Chapter 3). They found an economic loss of €70.2 million at 2011 prices (Table 8).

Table 8: Image losses (in € million) (short term-immediately after the oil spill)

	Galicia	All affected area
Image/reputation losses	70.2€	_

Source: Dominguez and Loureiro (2013)

4.1.5 Oil spill damages to tourism

Tourism sector is one of the most affected in the case of an oil spill takes place. Loureiro et al. (2006) conducted an analysis to estimate the economic losses suffered as a consequence of the Prestige oil spill.

To evaluate tourism losses and following the paper of Loureiro et al. (2006) it is necessary to have statistics about the tourism sector in the affected area. It is important to know the number of visitors, domestic and foreigners, the average stay and the average expenditure. The motive of the travel is also relevant data whether it is available. Thus, through the analysis of the total economic expenditures before and after the oil spills, the damage can be assessed.

Besides these direct losses, Loureiro et al. (2006) also evaluate other losses in utility or expenditures related with the experience and enjoyment of the destination. Thus, these come from expenditures in souvenirs and general purchases (for example, gastronomic and typical products). However this kind of information is more difficult to obtain. Table 9 shows the losses obtained in different accidents.

Table 9: Tourism and recreation damages

	All affected area (million euro)
Tourism losses from the Prestige oil spill (2002-2003)	110.55€
Recreation losses for fishermen Erika oil spill	100

Source: Loureiro et al. (2006), Bonnieux and Rainelli (2003)

4.1.6 Environmental losses

Environmental damages are also significant losses that can be suffered after an oil spill. Loureiro et al. (2006) assess these losses in birds and mammals. For birds, they employed the reposition costs, which basically measures the amount of money needed to restore he number of birds affected. Nevertheless, they highlight that one limitation of this method is that it is based on market prices and therefore we cannot value some species that may be in danger of extinction, for example.

In the case of marine mammals, Loureiro et al. (2006) highlight that the valuation is more complicated because there are no market prices for whales, dolphins, among other species. In addition, they also note the lack of previous studies; and therefore they only valued the minke-whale following Loomis and Larson (1994).

Later, Loureiro et al. (2009) employed the contingent valuation method (CVM) (See Chapter 3) to evaluate the environmental damage, asking a representative sample of respondents whether they would pay a certain amount to avoid a similar oil spill to the one evaluated (Prestige oil spill). Specifically, they analysed the willingness to pay (WTP) per household to avoid an accident similar to the Prestige oil spill in Spain. They found that the WTP is about 40.51€ per household, concluding that the Spanish society valued the environmental losses of this oil spill by around 574€ million (Table 10).

Table 10: Environmental damages

	All affected area
Birds and mammals for the Prestige oil spill	€25.12 million
Non-use values damages in the Exxon Valdez	$4.87-7.19 billion
Environmental damages in the Prestige oil spill	€574 million

Source: Loureiro et al. (2006; 2009), Carson et al. (2003)

4.1.7 Other oil spill damages: damage to properties, cleaning and recovery costs

Damages to residential properties are also an important element to be considered. When an oil spill occurs, fishermen tacks can be affected implying an extra-expense for themselves. Therefore, this kind of damages should also be considered. In the case of the Prestige oil spill, for example, the own fishermen claimed these damages.

In addition and once again taking as example the Prestige oil spill, there are other kind of expenses that have to be taken into account. Thus, Table 11 shows the different costs that have been considered by Loureiro et al. (2006):

Table 11: Other estimated costs

		All affected area
Extraction of fuel inside tanker (to extract the fuel to the bottom of the sea)	Prestige Oil spill	€100 million
Recycling of residuals (to recline residuals collected from the taker)		€32 million
Expenditures by local communities and the autonomous governments (expenses related to additional cleaning costs and other indirect costs related with the commercial activity)		€123.5 million
Volunteers (imputed value of work of volunteers)		€4 million
Losses in other goods (other losses not contemplated before)		€2.6 million
Promotion campaigns (to promote Galician fisheries products)		€19 million
Public support to the mussel sector (economic subsidies for helping this activity)		€0.3 million
Costs of cleaning and restoration	Amoco Cadiz	€134 million
	Exxon Valdez	€3100 million
	Erika	€124 million

Source: Loureiro et al. (2006), Garza et al. (2008)

4.2 Costs

So far, the main points that a Contingency Plan should contain and the benefits associated with its existence have been presented. Nevertheless, this has associated costs. Following a report conducted in the USA (Washington State Department of Ecology, 2006) it is also necessary to analyse the different type of expected costs that are derived of the existent law. Thus, main typical costs that can be computed are:

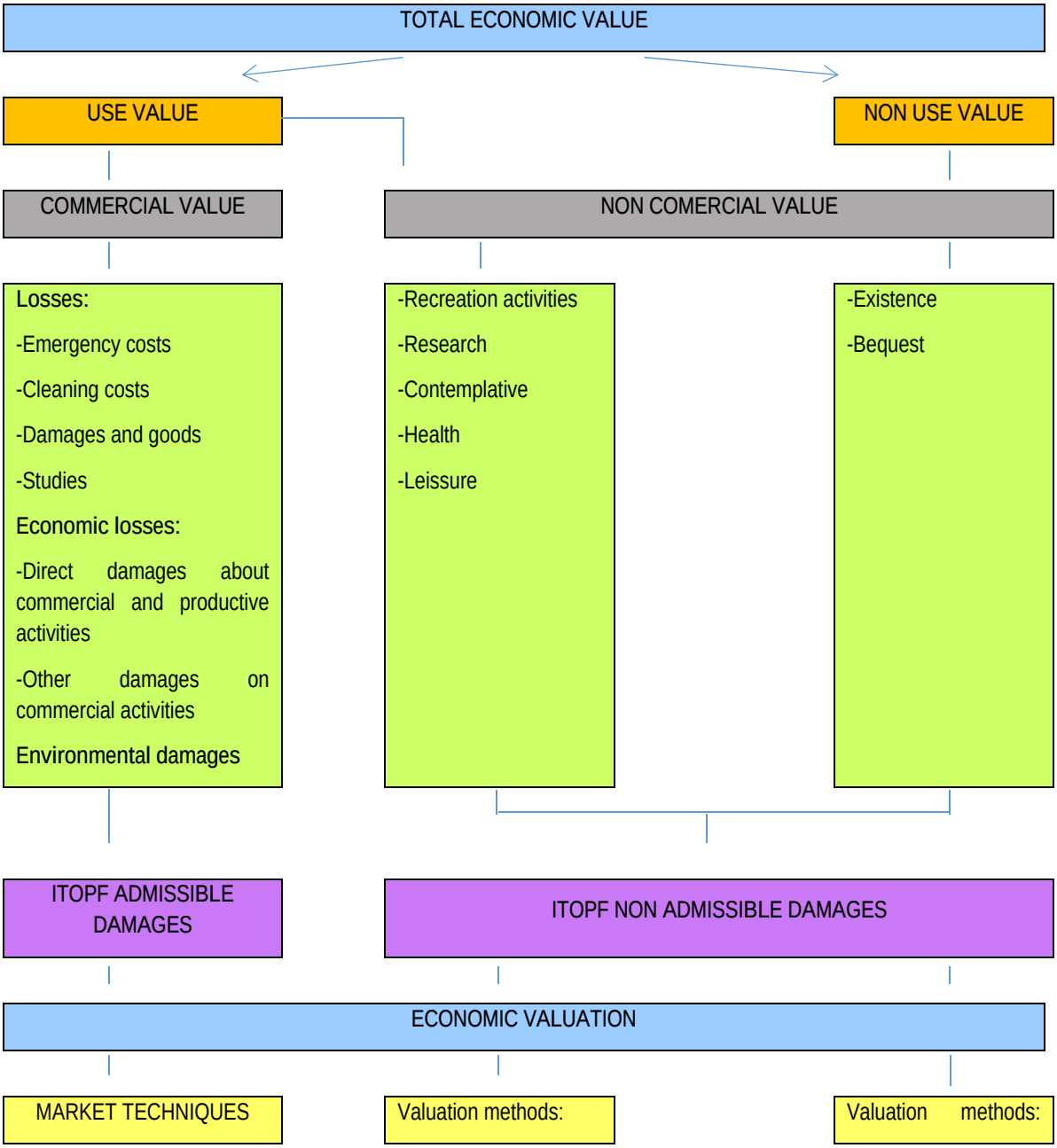
- costs in equipment
- costs in writing and maintain the contingency plan (revision, updating),
- the cost of personnel training,
- overhead

Furthermore, as our interest is to conduct a CBA, it is crucial to have identified costs by year in order to be able to annualize costs and conduct a CBA. At this point, we should note that most of the investments are multipurpose (for example: a ship of the coastguard service can be used to rescue tasks but also to fight against pollution. In this case, we only have to impute as a cost the proportional part). Moreover, another issue that we have to consider is the importance of the discount (see Annex for a more detailed description).

Chapter 5: Admissible and non-admissible damages

An important aspect in the total economic valuation of oil spill damages is that The International Oil Pollution Compensation Funds (IOPC) only admits claims for losses with a commercial value. Specifically, The IOPC (2016) highlights "…*to be entitled to compensation, the pollution damage must result in an actual and quantifiable economic loss. The claimant must be able to show the amount of his loss or damage by producing accounting records or other appropriate evidence*[1]." Therefore, those damages that are assessed by different environmental valuation methods are not considered by this organization, and in order to recover them, a court sentence may be needed. Figure 7 shows a summary of the total economic value that can be assessed after an oil spill according to González Laxe (2004).

Figure 7: Total Economic Value



[1] Information available at: http://www.iopcfunds.org/compensation/

	Revealed and stated preferences	stated preferences

Source: González Laxe (2004).

Chapter 6: Conclusions

This document contains the main points that a Contingency Plan should consider in order to manage an oil spill accident (Figure 8 shows the main questions that have to be answered with the Contingency Plan). It also describes the benefits derived from the existence of this management tool. Furthermore, different damages that can be suffered after an oil spill also are presented through examples that have been published in earlier literature.

The main aim is to provide information to stakeholders about the importance of the existence of this kind of plans; but overall on the importance of CBA. With regards to CBA, it has been highlight that it is necessary to compare the costs derived, related to the existence of the management plan (writing, updating, equipment, material, etc), with the potential benefits that can be obtained from its existence (calculated through the avoided damages). At times, the lack of data will preclude the completion of a full CBA exercise, although the relevance of economic aspects should be emphasize in first response actions.

We have to note that in the application of a CBA, we have to compare costs and benefits in a future time. Therefore, and as it is explained more in detail in the Annex, we need to have clear the concepts of discount rate and the timing. This last question is difficult in the case of avoided costs, because we do not know in advance the timing of an oil spill.

Difficulties of measuring costs and benefits

In the assessment of a CBA for a Contingency Plan, we have to remark some difficulties that emerge regarding the need of having very detailed data. In terms of benefits or avoided damages, we should emphasize that depending on the circumstances of each accident, these may vary in a significant way. In the case of oil spills, the amount of oil, the type of oil, the characteristics of the affected area, among others factors, are very important because they determine the amount of damages.

In terms of costs, it is necessary to consider the need of databases where this information is made public and available, considering the means, equipment, staff, etc. Moreover, an additional difficulty related to measuring the costs associated with coastal protection, and in particular oil spills prevention, is related to the fact that some of the equipment is bought as a multipurpose investment. Therefore, all this information has to be contemplated in order to conduct a CBA in an efficient way.

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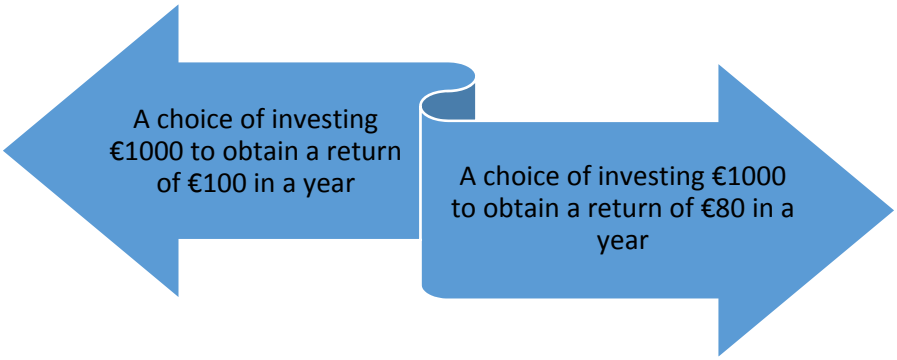
Acronyms

CBA	Cost Benefit Analysis
ITOPF	The International Tanker Owners Pollution Federation Limited
IOPC	The International Oil Pollution Compensation Funds
IMO	International Maritime Organization
IPIECA	International Petroleum Industry Environmental Conservation Association
OPRC	Oil Pollution Preparedness, Response and Cooperation
TCM	Travel Cost Method
HPM	Hedonic Price Model
CVM	Contingent Valuation Method
GVA	Gross Value Added
WTP	Willingness to Pay
NPV	Net Present Value

Annex

One relevant issue that hast to be considered in assessing coastal hazard management plans is that we may take into consideration effects that may occur in an unknown future time period. Penning-Rowsell et al. (2013) following the HM Treasury (2003) recommends considering one hundred years as a reasonable time to make predictions. In addition, to the analysis of the weight to give to a gain also matters. It is necessary to express costs and benefits over time in a common base; therefore, we need to discount future costs and benefits to a common base date.

Following Penning-Rowsell et al. (2013), we have to emphasize two reasons that explain the importance of discounting the future costs and benefits. Basically, we have to make a decision about whether we prefer an amount of money now or we prefer to invest this money and increase our return inthe future. The following figure serves as an example. :



The preferred option is the first, because we earn more money. A relevant concept to understand is the "opportunity cost of capital". Thus, when we invest our capital in the first option, we cannot invest it in the second option; therefore, we have to make an investment decision where we have to choose that option that provides us a higher return. There is an implicit issue under this; specifically, we are assuming that we are willing to invest an amount of money now rather than spending this money on consumption. At this point, we have to expect that individuals and societies may have different preferences about the distribution over time of the money, thus, they have a rate of preference to sacrifice consumption now for consumption in the future, which is known as "time preference".

To calculate the present value of future costs or benefits we use the discount rate,so that:

$$\text{Present value}=\sum_{t=1}^{t=T}\frac{X_t}{(1+r)t}$$

Where, *present value* represents the value of the cost or benefit that happens in a future year but represented in current monetary value, *r* is the discount rate used to transfer monetary values from the future to the present; *t* is the number of years into the future, X_t is the cost or benefit in the year *t* and *T* is the life of the program.

Example:

Consider the following data:

$$X_{t=}\text{€}100 \quad ; \quad r=0.05 \quad ; \quad t=5 years$$

$$\text{Present value} = \frac{100}{(1+0.05)^5} = 78.37$$

This result tell us that for an interest rate of 5%, an individual would be indifferent between having €100 in 5 years or €78.37 now.

Reference:

Penning-Rowsell, E. C., Priest, S., Parker, D.J., Morris, J., Tunstall, S., Viavattene, C and Owen, D. (2013) Flood and coastal erosion risk management: A manual for economic appraisal. Routledge, London.