Financial and ecological gains of early intervention in cleaning up wrecks containing oil

A research of need and cost of cleaning up oil from the wrecks

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EXAMENSARBETE

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Handledare: Mats Enberg

Titel: Finansiell och ekologisk vinsten tidigt ingripande och rengöring av vrak som innehåller olja
En undersökning om behoven och kostnaderna för att rengöra oljan från vrak

Datum 25.2.2015 Sidantal 35 Bilagor 3

Abstrakt

Syftet med examensarbetet är att ge en bild av vrak som innehåller olja i Finland och renoveringsbehov i ekonomisk och ekologisk synvinkel. Motivet är helt okänd till många eftersom listan över potentiellt förorenade vrak är hemlig, oljeinnehållande vrak – subjekten är sällan i publicitet och materialet är svårt att hitta.

I detta arbete beskriver jag olika oljetyper och skada de kan orsaka på miljön samt vrak från andra världskriget, som har den farligaste oljetypen i sina tankar. Graden av fara ökar med korrosion, vilket jag också berättar om. Beskriver också juridiska problem och ekonomiska svårigheter som har uppstått i samband med de gamla vraken. Berättar också om olika oljeborttagnings tekniker samt de många faktorer som har inverkan på oljans borttagning från naturen, på kostnader och även på slutresultatet. Beskriver även forskning och samarbete som pågår i Östersjöområdet. I vissa sjunkna vrak finns även sprängämnen och farliga kemikalier förutom olja, men jag fokuserar på olja.

Som ett resultat, drar jag slutsatsen att oljan som finns kvar i vrak bör tas bort, om det finns en risk att tankarna är så korroderade, at oljan är på väg att hamna i havsvattnet. Detta beror på att den kontrollerade flyttkostnaden av olja är lägre än kostnaderna för avlägsnande av olja från den marina miljön. Den särskilda karaktären på Östersjön gör att naturen skulle kanske aldrig återvända till det normala efter en oljekatastrof. Även i bästa fall skulle det kunna ta lång tid. Beställare för arbetet är SYKE/ Enhet för förebyggande av förorening.

Språk: Engelska **Nyckelord:** Vrak, olja, sanering av vrak, Östersjö

OPINNÄYTETYÖ

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Suuntautumisvaihtoehto/Syventävät opinnot: Merikapteeni, YH

Ohjaajat: Mats Enberg

Nimike: Varhaisen puuttumisen taloudelliset ja ekologiset hyödyt öljyä sisältävien hylkyjen saneerauksessa
Tutkimus öljyä sisältävien hylkyjen saneeraustarpeesta ja kustannuksista

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Päivämäärä 25.2.2015 Sivumäärä 35 Liitteet 3

Tiivistelmä

Opinnäytetyöni tarkoitus on antaa kuva öljyä sisältävien hylkyjen määrästä Suomessa sekä saneeraustarpeesta taloudelliselta ja ekologiselta kannalta katsottuna. Aihe on monille täysin tuntematon siitä syystä, että vaarallisten hylkyjen luettelo on salainen, öljyä sisältävistä hylyistä puhutaan vähän julkisuudessa ja materiaalia aiheeseen liittyen on vaikea löytää.

Opinnäytetyössäni kuvailen eri öljylaatuja ja niiden ympäristölle aiheuttamaa haittaa sekä toisen maailmansodan aikaisia sotalaivoja, joiden sisältämä öljyä pidetään kaikista vaarallisimpana. Vaarallisuusastetta lisää korroosio, jota myös kuvailen. Kerron myös lainsäädännöllisistä ongelmista sekä rahoitusvaikeuksista, joita on ilmennyt vanhoihin hylkyihin liittyen. Kerron hylkyjen saneeraustekniikoista, sekä monista seikoista, jotka vaikuttavat luontoon valuneen öljyn poistoon ja poistokustannuksiin sekä myös lopputulokseen. Kuvailen myös tutkimusprojekteja ja yhteistyötä, joita Itämeren alueella on meneillään. Joissain uponneissa aluksissa on öljyn lisäksi räjähteitä ja vaarallisia kemikaaleja, mutta rajaan työni keskittymään öljyyn.

Lopputuloksena päädyn siihen, että hylyissä oleva öljy kannattaisi poistaa, jos epäillään pientäkään riskiä, että tankit ovat syöpymässä puhki ja öljy päätymäisillään mereen. Näin siksi, että hallitun öljynpoiston kustannukset ovat pienemmät, kuin luontoon valuneen öljyn poistokustannukset. Itämeren erikoislaadun huomioon ottaen, luonto ei välttämättä palautuisi ennalleen vakavan öljyvuodon jälkeen ja parhaassakin tapauksessa siihen menisi kauan aikaa. Tutkimuksen tilaajana on SYKE/ Ympäristövahinkojen torjunta-yksikkö.

Kieli: Englanti **Avainsanat:** Hylyt, öljy, öljynpoisto hylyistä, Itämeri

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Summary

The aim of this thesis is to provide a picture of the oil containing wrecks in Finland and the renovation needs in economical and ecological point of view. The subject is completely unknown to many, because the list of potentially polluting wrecks is secret, oil containing wrecks –subject is rarely in the publicity and material is hard to find.

In this thesis I describe different oil types and harm they may cause to the environment as well as wrecks from the Second World War, which do have the most dangerous oil type in their tanks. The degree of danger is increasing by corrosion, which I also describe. I also tell about legal problems and financial difficulties, which have arisen in relation to the old wrecks. I tell about different oil removal techniques as well as the many factors, which have effect on oil removal from nature, the expenses and also the end result. I do as well describe the research and co-operation which is going on at the Baltic Sea area. In some of sunken wrecks there is explosives and dangerous chemicals in addition to oil, but I limit my work focus on oil.

As a result, I conclude that the oil remaining in wrecks should be removed, if there is a risk that the tanks are so corroded, that the oil is about to end up to the sea water. This is because the controlled oil removal costs are lower than the costs of oil removal from the marine nature. The specific nature of the Baltic Sea would not necessarily ever return to normal after an oil disaster. Even in the best case, it could take a long time. This study was commissioned by SYKE/ Pollution Prevention Unit.

Language: English Key words: Wreck, oil, wreck oil removal, Baltic Sea

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1 Introduction

When discussing about the ecological influences of maritime transport and oil leakage from ships, we usually only talk about maritime accidents like Exxon Valdez or Prestige and the effects this kind of disasters have on nature. The fact that there is a huge amount of wrecks in the bottom of the seas containing oil or different kind of oil products is rarely discussed. An eternally lasting ship has not been invented, so it is just a matter of time when these wrecked ships start to leak oil. When a wreck starts to leak, it is more probably that it will leak little by little instead of leaking all the oil at the same time. These small leakages may cause confusion “Where did that oil come from?” Unnoticed may pass that the source of oil was an old wreck.

A google search of “wrecks” or “wreck oil removal”, gives only some hits which lead to newspaper in style “Oil was removed from Estonia…” A visit in the library searching books concerning wrecks, only causes a disappointment: if there are books about wrecks, they are fiction. It seems to be a totally unknown to many, that there is a lot of oil in the wrecks and the oil may leak out at any time causing a lot of different problems.

1.1 Objective

The objective of this research is to present, which financial and ecological gains can be obtained if the oil is removed from the wrecks. Intention is to show, how difficult it is to calculate the costs of wreck oil removal operation and also the price of consequences, if the oil leaks to marine nature.

1.2 Limitations

The Exxon Valdez oil spill and the number of wrecks in the whole world are given as an example, but this research concentrates only to the Baltic Sea. Many wrecks do contain even ammunition or dangerous chemicals, but the focus here is on oil.

1.3 Research method

I use personal communication as well as written material from different experts as a base for my research.

2 Potentially polluting wrecks

There are no exact numbers and positions of shipwrecks, neither to the world, nor to the Baltic Sea. However, the authorities have recently started to give attention to wrecks, not only with a view to danger to navigation but also as a source of potential pollution. (Kepplerus, 2010, p. 6).

According to the research, made by Michel et al. (2005, p. 5) there were totally 8569 known potentially polluting wrecks worldwide, wrecked between years 1890 to 2004. Tank vessels were 1583 and 6986 were non-tank vessels. 75% of the wrecks sunk during the Second World War. **Figure 1.** shows the approximate distribution of potentially polluting shipwrecks in the world.

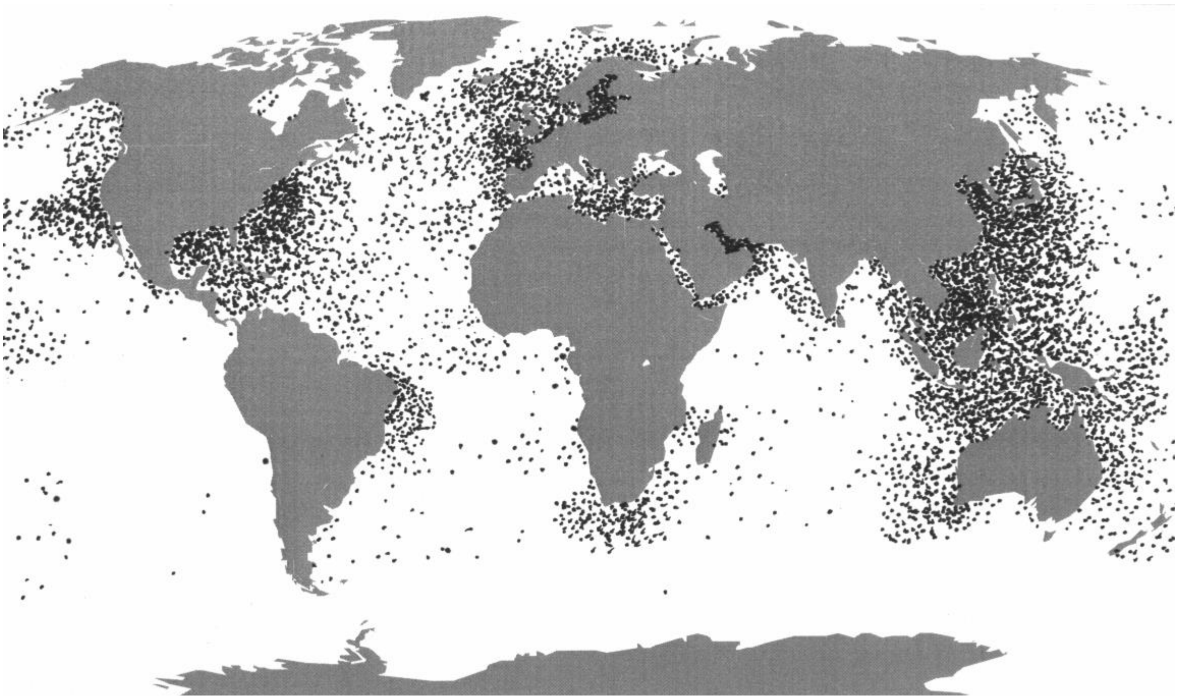


Figure 1. Approximate distribution of potentially polluting shipwrecks. (Michel et al. 2005, p. 11).

Michel et al. (2005, p.10) made two different estimates about how much oil is left in the wrecks. Estimates of between 2. 5 million and 20. 4 million tons of oil are accounted globally. Jernelöff (2011, p. 64-65) states that the 38000 tons oil spill from Exxon Valdez in 1989 killed about 250 000 birds, 2800 sea otters, 300 seals, 250 eagles and milliard grains of herring and salmon roe. The catastrophe was huge but the amount of oil leaking from Exxon Valdez was very little in comparison with the oil amount of oil which is left in the wrecks, even according the low estimate. These estimates cannot, off course be directly compared, because the Exxon Valdez oil spill happened in Alaska and the estimates are made with a view of the whole world situation. But the estimates can give an indication, how many oil spills in size and fatality of Exxon Valdez may happen if the oil from the wrecks leaks out. **(Table 1.)**

Table 1. Exxon Valdez oil leak in comparison with oil amount left in the wrecks.

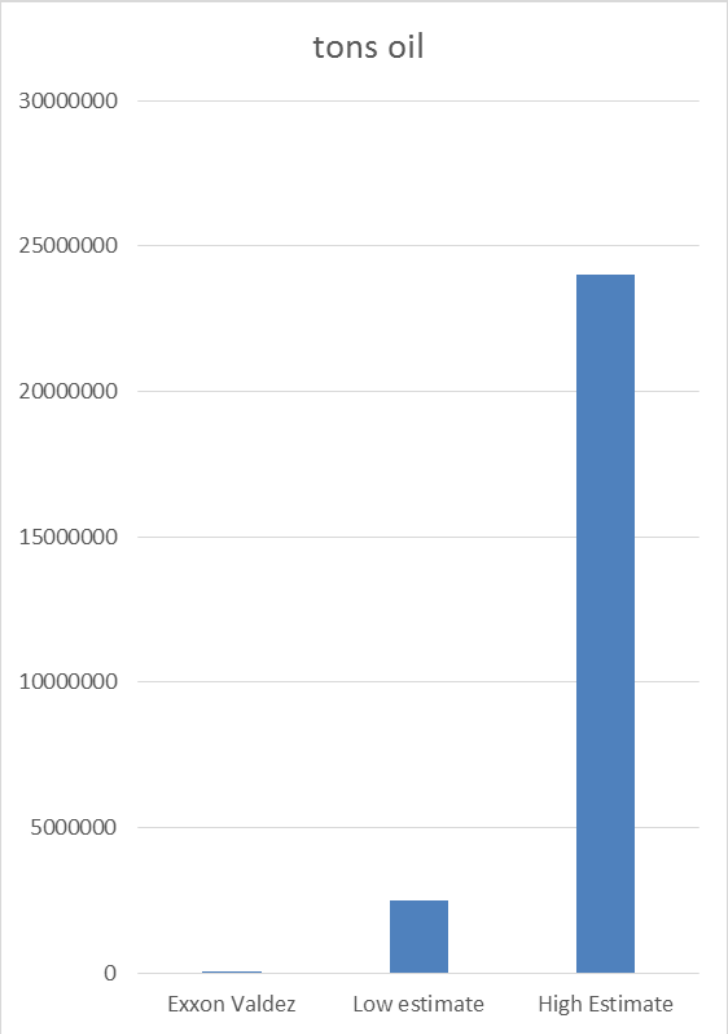


Diagram based on the facts by Michel et al. (2005, p. 5) and Jernelöff (2011, p. 64-65).

Of the potentially polluting wrecks in the world, the North Atlantic Ocean has 25%. These wrecks are estimated to contain about 38% of the total volume oil trapped in sunken vessels. The Mediterranean has 4% of all sunken vessels, containing about 5 % of the estimated oil volume. (Counsil of Europe 2012. Internet address.)

According to Sjöfartsverket (2011, p. 16) there are 40 000 – 50 000, both small and big ship wrecks in the bottom of the Baltic Sea. It is hard to get access to many of these wrecks. They may for example be located in very deep water or be covered with the sediment.

3 Wrecks from the Second World War and old, ownerless wrecks

About 75% of sunken wrecks in the bottom of the sea are from the Second World War. As their metal structures are getting corroded, the risk that the oil will leak into the sea is getting bigger each year. (Counsil of Europe 2012. Internet address.) The fact is that it is very expensive to clean up wrecks that have hazardous effects on the environment, but it is also difficult to find applicable legal basis for liability where such basis exists only partially. (Kepplerus, 2010, p. 6).

According to IMO/ GESAMP (Internet- address, 2007, p. 39), the sunken military vessels are excluded from the annual reporting through Lloyds Register of Shipping. Only a little bit information is available for some wrecked military vessels under 1939-1945, when for example 841 German vessels were lost (totally 1,040,000 tons). The assembled tonnages are a relatively small proportion of merchant shipping tonnages lost over the same period, but the tonnages are approximate, which makes the evaluation difficult. Besides the tonnages may be given as registered or displacement.

Sunken military vessels are documented to cause remarkable releases of oil into marine environment. For instance, the German naval vessel Blücher sunk in Oslofjord, Norway in 1940 and a chronic leakage of bunker fuel was noticed in the beginning of 90´s. According to assessments, 900 tons had leaked out with a speed of 50 liters a day. Blücher had totally 184 tanks and the fear was, that all the tanks would collapse at same time causing a catastrophe. An oil removal operation of 1600 tons, which was carried out to tap and drain the tanks, was completed in 1995. (Rytkönen, 1999, p. 13.)

Reliable estimates of actual and potential oil losses to the marine environment from sunken military vessel are noticed to be impossible. The smaller casualties or the bunker contents at the time of sinking are not reordered. Many military vessels were scuttled to dispose the surplus ammunition or chemical weapons or as part of disarmament programs. However, it is probable that the bunkers were in many cases emptied prior to scuttling because some of the vessels were towed to the scuttling places. (GESAMP, Internet- address, 2007, p. 40).

GESAMP recommends in para 293, 2007:

> Oil inputs from sunken vessels (e.g. war- related casualties) should be selectively monitored, given the number and location of vessels near vulnerable coastlines, and the ageing condition of the wrecks. The risks that such inputs pose to marine coastlines, living resources and ecosystems should be addressed with considerable urgency, given the aging condition of many WWII wrecks, and actions taken to reduce those risks.

The ship owner is primarily responsible and liable for discharging oil from wrecks. However, most of the wrecks that potentially may harm the environment, are as old as from the Second World War. The possibility to identify the owner or the insurance is therefore very small. (Kepplerus, 2010, p. 39). And, it is good to keep in mind as well, that under war time the specific legal exceptions to liability were prevailing. (Sjöfartsverket, 2011, p. 7).

The main issue concerning dealing with problems related to old wrecks and ownerless boats is who is responsible for the operation, which may cause significant costs. The operation will in many cases have to be financed with public funds. The problems are often solved on an *ad hoc* basis, even if there are no structures or fixed rules for responsibility. A good co-operation with different authorities, such as the Maritime Administration and the Coast Guard is important. (Kepplerus, 2010, p. 40)

In a political aspect, wrecks which have not leaked oil yet, can be a sensitive matter. Even if it is known, that a controlled oil removal operation is cheaper than an uncontrolled, sudden leakage, it is difficult to take action on foreign wrecks, which may be protected by immunity. (Sjöfartsverket, 2011, p. 24). Furthermore, wrecks which sunk over 100 years ago are classified as ancient monuments. They are protected by the law. That means that it is prohibited, without permission, to displace, remove, excavate, and cover, or, by building development, planting or in any other way, to alter or damage an ancient monument. Unlawful measures taken in respect to ancient wrecks are punishable by law. Some of the wrecks sunk with victims and are therefore burial-places. Under Finnish law it is a crime to disturb the peace of the grave. (Finnlex 80/2002).

Rytkönen (1999, p.13, 24) narrates, that the old war wrecks can be problematic in oil removal actions. The fuel system was built so, that if one or some tanks will be destroyed, the ship can still proceed its voyage, i.e. there are extremely many fuel tanks. In warship

Blücher, for example, there were 184 fuel tanks. When diving to wrecks, there may also be a possible explosive hazards, munition and warfare material covering the wreck and surrounding area.

4 Wrecks in territorial waters of Finland

In Finland, there are 3 instances which keep their own wrack registers. They are Finnish Environment Institute (SYKE), the National Board of Antiquities and the Finnish Boarder Guard.

According to Rinne (Personal communication, 25.2.2015) wreck data is received in connection of underwater inspections. Finnish Transport Agency and Meritaito Ltd. conducted survey in 2000 – 2012 within Finnish territorial waters, all survey data are stored in a CD, which includes the following data:

- All discovered objects in Excel file (more than 270 wrecks).
- All discovered objects in ESRI Shape format with geographic information.
- Reports and images of all discovered objects compiled by the observers.
- Location coordinates of all objects are in decimal format and coordinate system is EUREF-FIN.

The SYKE´s register over potentially polluting wrecks is not public information. A chart over the potentially polluting wrecks in Sweden can be seen in **Attachment 1**. (Sjöfartsverket, 2011, p. 45). It should be taken into account that pollution from a wreck does not respect state borders. As seen in **Attachment 1**, for example tank vessel Mundo Gas sunk carrying 2000 tons ammonium as cargo (bunker situation is unknown) in territorial waters of Sweden, very close to Finnish border, in 1966. In case of leakage, the Åland Island is in this vicinity. Also 1954 sunken Necati Pehlivan is close to Åland Island; her bunker situation is unknown. (Sjöfartsverket, 2011, p. 44)

Rytkönen writes in his research (1999, p. 7) that there is hundreds of wrecks in the territorial waters of Finland, according to Finland´s Environmental Ministry´s wreck register. A major part of the wrecks is identified and the oil emission hazard classified. Anyway, there is still a lot of unknown and unidentified wrecks. 50 of these registered wrecks do contain more than 100 tons of oil. In addition, there are almost 70 wrecks containing 10-100 tons of oil.

Finland´s Environmental Ministry has classified the potential risk that these wrecks could cause, based on the estimated amount of emission of oil or other harmful substance and reliability. There are 4 classes:

- Class 1, wreck contains with a high degree of certainty over 100 tons of oil or is correspondingly dangerous to the environment;
- Class 2, wreck may contain over 100 tons of oil due to the information available;
- Class 3, wreck may contain 10 – 100 tons of oil;
- Class 0, wreck contains less than 10 tons of oil.

22 wrecks are classified to belong to the 1st, also to the most dangerous group. In the 2nd class, there is 24 wrecks and in the 3rd group 68. To class 0 belongs 306 wrecks.

Oil may leak out in two different ways from the wrecks, according to Sjöfartsverket (2011, p. 20.) The whole quantity of oil may leak out at one time. This may happen after a structural collapse of the ship, but is quite unusual. The other, and the most common way is, that there happens diffuse or slow leaks over a long time. Rytkönen (1999, p. 5) states that the small, long time lasting leaks may cause confusion about the origin of the oil and cause additional work to authorities, who try to find out where the oil came from.

Kepplerus (2010, p. 16) warns that a minor, long time lasting leak is also more difficult to handle than a sudden, large oil leak from a big wreck. A sudden and large oil leak needs, of course, extensive salvage and cleaning action but is even so, easier to handle.

4.1 Special features of the Baltic Sea

IMO has named the Baltic Sea as a Particularly Sensitive Sea Area, PSSA. The Baltic Sea can be considered as second largest brackish water area in the world (after the Black Sea). New salt water is coming only via the Danish Strait, which causes that it takes 25-30 years before the complete change of water. Due to differences in salinity, the water in the Baltic Sea is divided into horizontal layers, which prevents the water from vertical mixing (Ympäristöministeriö, 1994, p. 4-5). New salt water comes only via Danish Strait after blowing several weeks from a favorable direction. This usually happens only with 10 to 20 years intervals (Sjöfartsverket, 2011, p. 10). During the last hundred years, this has occurred in years 1913, 1921, 1951, 1976, 1993, 2003 and 2014. (Salon Seudun Sanomat 17.2.2015, p. 6).

The salinity is low, only 6 per mil when it is about 35 per mil in the oceans. The Baltic Sea is also shallow, the average depth is only 54 meters. (Bock et al., 2010, p. 24–25). The brackish water is a challenging habitat to many species and therefore only quite a few species live in the Baltic Sea. The loss of one functionally important species may change the whole ecosystem. (Rousi and Kankaanpää, 2012, p. 12). Due to these special features of the Baltic Sea, even a small amount of oil may cause long-lasting, severe and unpredictable consequences.

4.2 Oil effects on marine nature

The main negative effects of oil pollution on marine nature are:

- Direct kill of organisms through coating and asphyxiation.
- Direct kill of organisms through contact poisoning.
- Direct kill of organisms through exposure to water soluble toxic components of oil at some distance from the oil spill and/or sometime after the incident.
- Destruction of food sources for animals higher in the food chain.
- Destruction of juvenile organisms that are generally more sensitive to pollution.
- Sub lethal exposure of organisms resulting in reduced resistance to infection and other stresses.
- Destruction of commercial value of food fish and shellfish by oil tainting.
- Introduction of carcinogens and cumulative toxins into the marine food chain and human food sources.
- Low-level effects that may interrupt the events necessary for the survival and reproduction of marine species

(Sea OOC, Internet address).

The most visible victims after an oil disaster are usually birds. They descend into the water because the oil film makes the sea calm-looking. A coin-sized oil slick is enough to kill a bird because it loses its thermoregulation ability and freezes to death. It may even drown or try to clean up itself and swallows oil, which can cause a slow death. (SYKE et al., Internet address.) If the oil disaster occurs during nesting season, it causes increased mortality of young birds, because the adult birds often abandon oil contaminated nesting sites. Eggs can also be lethally oiled by transfer of oil from the plumage of oiled adults. Even a very small amounts of oil can significantly reduce the hatching success. (Sea OOC, Internet address).

To mammals oil often means death. If they do not die to the direct causes of oil, they may suffer of lack of nutrition and lose their habitats. Regression of the long-living species can take years. (SYKE et al., Internet pages.)

Wrecks in proximity of the coast may cause considerable difficulties to the coastal states, not only by obstructing navigation. They may also pollute the marine environment in different ways, typically by releasing oil or other dangerous substances. This can seriously harm the sources of livelihood such as fishing. (Kepplerus, 2010, p. 6). The adult fishes seem to avoid oil contaminated water so fishes do not usually die in the oil disasters. But if all the fishes do vanish, it harms, of course, the fishing industry. Even a short oil-exposure changes the smell and the taste of fish. PAH-compounds do cause mortality to offspring and may change the heredity. Crustaceans and mollusks seem to be especially sensitive to oil; they do store PAH- compounds for long periods. This results, that seashell-eating fishes, may be exposed to PAH-compounds a long time after an oil disaster. (Riista- ja Kalatalouden Tutkimuslaitos, 2012, p. 18, 29- 32) The negative economic impact caused by oil is first seen several years after an oil spill, caused by high mortality among eggs. (Sea OOC, Internet address).

The benzene in oil is carcinogenic; the cancer causing effects may occur first after a long period of time. Some of the harmful substances of the oil are oil-soluble, so they do accumulate in the organisms. The harmful substances may accrue via the food chain and move forwards, even to the human beings. (WWF, Internet pages, 2012, p 4).

The cold and oxygen-free circumstances in the Baltic Sea do retard the natural evaporation of oil and makes the oil to drift ashore. The coast is indented, which impedes the oil-collecting and results that the oil spreads to wide area to the archipelago. The ice cover in the winter makes the oil-collection even more difficult. In the summer it very challenging to clean up oil from sandy beaches and from beaches with flora. (SYKE et al., Internet pages.)

The extent of damage does not have to be proportional to the quantity of oil spilled. A small amount of oil in an environmentally sensitive area may cause considerably more damage than a lot of oil on a rocky shoreline. A combination of oil and measures taken by response personnel finally defines what happens to the environment. (Sea OOC, Internet address).

The Finnish archipelago is an important recreation ground and source of business. There is a lot of nature protection areas, fish farms, summer houses, boat harbors, hotels and beaches. All of these would suffer from a possible oil disaster. (SYKE et al., Internet pages.)

5 Fatality of oil spills

The key factors in assessing the fatality of an oil spill are: The quality and quantity spilled, weather and sea conditions and whether the oil remains at sea or is washed ashore. (Itopf, Internet address).

An oil spill in the sea normally spreads out and moves on the sea surface depending on wind and current conditions and makes a number of chemical and physical changes called weathering, which determines the fate of the oil. (Itopf, Internet address).

Some of the weathering processes, like natural dispersion of oil into the water lead to oil removal from the sea surface and facilitate its natural breakdown in the environment. If the oil forms water-oil emulsions, the oil becomes more persistent and remains in the sea or on the shoreline for a prolonged time. Finally, a long-term process called biodegradation usually eliminates the spilled oil. (Itopf, Internet address).

The hazard wrecks may pose to marine environment depends on many factors like the character of the wreck, cargo and the conditions at the location of the wreck. These factors, together with others, such as financial, political and legal factors do define, which measures can or must be taken. (Kepplerus, 2010, p. 1).

5.1 Oil spill modelling

There are many models made of different approaches, which have been developed to forecast the fate of oil spills and simulate the weathering processes. These models can be simple vector calculations or sophisticated computer models, which try to predict the movement of the oil even if the oil weathers. (Itopf, Internet address).

When modelling the oil movements, the most important information is the type and quantity of the oil spilled together with the rate of release. Key environmental input data is also the strength and direction of wind, currents and tides as well as temperature of air. Knowing the seawater temperature is also of great import; the oil may change its behavior depending on temperature. Getting actual information in real time can often be difficult. (Itopf, Internet address).

The models can be a tool for decision makers and are therefore widely used for contingency planning. By modelling a series of the most likely oil spill scenarios, decisions concerning suitable response measures and strategies can be easier to make. Oil spill models can also be useful when training simulated oil spill scenarios. (Itopf, Internet address).

In an actual emergency response, an effective use of the models can be difficult because they need a lot of input data, which may not be available at short notice. An oil leak usually occurs unexpectedly and such information as oil type and quantity are often unknown. Later, as the incident develops, more accurate data is usually received, which improves the possibilities of using different models as a tool. (Itopf, Internet address).

All the models have their limitations and are not substitute to real observations. Anyway, they can be useful when, for example, predicting whether the oil would reach the shoreline or not and in predicting the timeframe, under which the oil spill response should be made. (Itopf, Internet address).

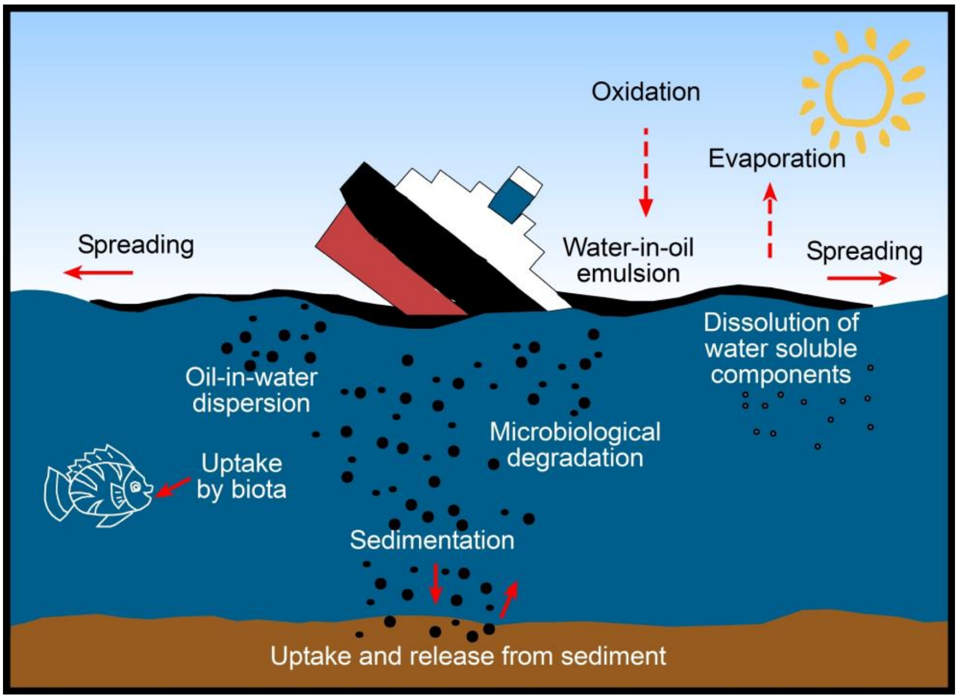
5.2 Heavy Fuel Oil

When assessing the environmental risks of different oils, the main factors are density, viscosity and the pour point. Because the major part of the wrecks in bottom of the Baltic Sea are old warships, it is based to assume that the oil type in their tanks is Heavy Fuel Oil (HFO). (Rytkönen, 1999, p. 25, 26.) Due to its features, HFO is the most dangerous oil type to marine nature. It does not evaporate, goes even under the water surface and the cleaning of HFO from the water and beaches is extremely difficult. It stains the shoreline badly and causes great damage to birds and mammals. (Merikotka, Internet address, p.4).

The HFO in the wrecks is usually firm. This is due to the fact that the pour point of HFO is usually over +10°C. That makes the oil in the tanks to be solid, it does not easily come to the surface otherwise than in the summertime. The Baltic Sea is shallow and the sea water gets warm even in the bottom usually in the end of the summer. It is not probable, what the whole amount of HFO would suddenly come to the surface, a more common way is that there will be smaller oil-leaks every now and then. (Rytkönen, 1999, p. 25, 26.) That causes that the oil-leaks caused by sunken wrecks are often classified as "mysteriously appeared oil-leaks". These "mysterious" leaks may be quite large: in 1999 about 670 tons HFO went ashore on Danish Coast, killing over 200 seabirds. The leak was evaluated to be derived from a wreck. (Rytkönen, 1999, p. 9.)

Contrary to common belief some heavy crudes and residual fuel oils are denser than the surrounding water and will sink. Also oils that are normally buoyant, may sink with time after increasing their density. These oils may sink partly and move with water or sink directly to the bottom and behave as sediment. In both cases, the oil may stay without attention and reappear as a problem in the future. The mystery oil spills, which has been reported over the years, can often be explained by resurfacing of sunken oil. It is a great challenge for tracking and recovery. (Castle et al, Internet, 1995, p. 565). **Figure 2.** below shows the main oil weathering processes.

Figure 2. The main oil weathering processes. (Seos, Internet address).



6 Risk assessment and taking action

The environmental risks and problems caused by wrecks indicate that investigations must be carried out in several steps. Data must be collected to get aware of the extent of the problem. Technical evaluation must be made to estimate the possibility of oil discharge from the wreck or eventuality to remove the entire wreck. Nowadays there are several oil removal methods available and there are only a few technical limitations. (Kepplerus, 2010, p. 16).

The environmental benefits of taking action must be weighed out against the risks and the costs. Many components may affect the risk assessment. It is often difficult to know beforehand the quantity and quality of oil the wreck contains, but this information is of great importance when thinking about the hazards to marine environment and possibility to remove the oil. A lot of information can even be found in old documents and plans. Competent persons with shipping technology and history can help in the interpretation of information. (Kepplerus, 2010, p. 17).

By removing oil from the wrecks before they start to leak, the environmental and socio-economic consequences could be avoided. An emergency oil spill response cannot be planned and managed as cost-efficiently as a proactive removal of oil. (NOAA, Internet address, 2013, p. 3).

It has been found, that it is cheaper to remove the oil from wrecks than let the oil leak to marine nature. Measures should be taken to wrecks which are not yet leaking. The expenses of a wreck oil removal cannot be evaluated in same way as cleaning up oil, which is about to beach. Anyway, the reimbursement for fishing and land users and the cost of absent tourists is up to 6o percent of the total expenses in a bigger oil disaster. (Sjöfartsverket, 2009, p. 24, 67).

Also Rytkönen (MTV3 news 2014) says that it is cheaper to remove oil at once than that the authorities would every year follow up the wreck and make small removal actions.

“Sen lisäksi koko ajan saastutetaan meriluontoa, mille ei voida laskea rahallista hintaa. Itse pitäisin järkevänä, että priorisoidaan ne hankalat tapaukset ja otetaan öljyt pois”, sanoo Jorma Rytkönen Suomen ympäristökeskuksesta.

Etkin (Internet address, 2010) states that oil spills are significantly more expensive to clean in near shore or port locations than the offshore spills.

The most environmentally friendly and cost-effective way to remove oil is to remove it from a wreck. If it is needed to collect the oil from the sea, the costs are at least 10 times higher. And when the oil is collected from ashore, it will be even more expensive. (Domus Baltica, Internet address).

In Finland, two massive oil removal operations has been made: Park Victory in 1994 – 2000 and Estonia 1996. Inventories were also made on m/s Coolaroo, which sunk in 1961 outside Helsinki and was categorized as category 1. However, after checking the tanks, it was found that there was no oil left so there was no need for an oil removal operation. (Swedish Maritime Association, 2010, p. 16). It has been the standard practice of SYKE to study one or two wrecks annually and to perform oil removal operations, if possible. There are other cases not reported, where oil has been removed during these surveying actions. (Personal communication with Rytkönen 25.2.2015).

6.1 S/S Park Victory

S/ S Park Victory sunk after the breakage of anchor chain and drifting aground southeast of Utö 25.12.1947. After observing oil leakage in several summers, 410 m^2 oil was removed from the tanks between years 1994 and 2000. The diving time was totally about 1200 hours and the costs were about 3, 6 million euros. (Hylyt.net. Internet address)

The collected oil was analyzed and it was found out that the oil in tanks was so fresh, that it could still have been used as fuel. (Rytkönen, 1999, p. 8.) Therefore can be stated, that the harmfulness of oil do remain the same, regardless of how long time has passed.

6.2 M/S Estonia

M/S Estonia sunk in 1994 to 60-70 meters depth causing over 800 victims. The Swedish Government made a cenotaph of it and covered the wreck with gravel and concrete. The oil removal was performed before this in challenging sea conditions in 1996. Totally 230 – 250 m^3 different oils were removed in 1996. The expenses were about 2, 5 million euros. It was impossible to remove all the oil, but the case showed that it is possible to perform oil-removal operations even from wrecks, which are located in deep sea and under challenging conditions. (Rytkönen, 1999, p. 7, 8.)

7 Oil removal

A typical oil removal operation includes the following phases:

- Initial Mobilization
- Wreck Assessment / Leak Prevention
- Removal Mobilization
- Oil Removal
- Wreck Stabilization
- Disposal and Demobilization

(Michel et al., 2005, p. 37).

7.1 Factors influencing salvage planning

7.1.1 Mobilization distance

In mobilization, the cost of unique equipment and personnel is usually a significant part of the oil removal operation. If the removal costs are going to rise because of a long mobilization, it is common to employ local marine capability in diving a support vessels providing a smaller but longer recovery, which lasts perhaps over several seasons. (Michel et al., 2005, p. 37).

7.1.2 Sea conditions

For planning and mobilization, it is important to be aware of the sea conditions and weather expected because they directly affect to the selection of work platform and the time window. Water temperature and clarity as well as currents, tides and oil viscosity do impact the selection of working platforms, methods and time needed. (Michel et al., 2005, p. 37).

Heavy work platforms and ROVs (Remotely Operated Vehicles) do increase both mobilization time and cost, even if they may extend the weather window. ROV operations as well as diving may be impeded by the poor water clarity. (Michel et al., 2005, p. 38).

Expected wind and sea conditions must be taken into consideration when planning and mooring the work platforms. To find out, which kind of mooring wire and deck gear is needed and what type and size of anchors could be used the wind, wave and mooring load analyses must be made. Dynamic positioning system has become more common, but it means increasing costs and operational complexity. (Michel et al., 2005, p. 38).

In restricted or protected waters it is possible to use smaller platforms and simpler mooring, which makes the mobilization costs smaller. However, the costs may significantly rise because of the risks to local vessel traffic, fishing and beach usage. (Michel et al., 2005, p. 38).

7.1.3 Oil type and viscosity

It is important to successful salvage planning to know the oil type in the wreck. The wrecks can contain many kind of oils. In addition to bunker oil, there may be for example engine lubrication oil, hydraulic oil or oil as cargo. Samples should be taken of the oils in the wreck, not of released oil, because it may give a false picture. Oil type, volume and location depends for example on vessel´s type, age, propulsion and route. (Michel et al., 2005, p. 38).

Oil viscosity performs a key role in oil recovery operations. Lighter oils do flow easier and are therefore easier to remove. Michel et al., (2005, p. 39). Rytkönen (1999, page 9) states that oil properties do often change to solid in the tanks of sunken wrecks. In the bottom of the sea, where the seawater temperature is lower than the pour point, oil can be pseudo plastic, solid or even fixed. It is often necessary to heat or even emulsificate the oil with warm seawater to limber up and remove the oil.

7.1.4 Oil Weathering

Oil properties in closed tanks change slowly, even if stratification due to different densities may occur resulting sludge or water-oil layers. Lighter oils can be removed quite easily, heavy oils are more challenging due to slow flow. To get a realistic estimate about the time and efforts needed, it is necessary to know the oil type, viscosity and location before selecting proper pumping, tapping and hose options. (Michel et al., 2005, p. 41).

7.1.5 Wreck condition

When planning an oil removal operation, the key questions are:

- Is there oil in the wreck or not?
- If there is, how much and what type?
- Is it safe to work in the wreck?

(Michel et al., 2005, p. 41).

There are multiple fuel tanks in cargo ship wrecks. They are located along the bottom of the ship and each tank usually has port and starboard halves. Double-hull configurations and different oil piping systems can make the oil removal complicated. It is not so common, that there is an emergency piping system which facilitates the oil removal in case of accident. (Michel et al., 2005, p. 41).

Ships do get damage from the initial event (e.g., collision or explosion) but also from hitting the sea bottom. These events can cause immediate oil leakage to the sea or internally. The wrecks orientation and hull condition are important factors when planning an oil recovery. Cargo vessels do usually land upright, while tankers are tend to land upside-down. (Michel et al., 2005, p. 42).

Wrecks location has an impact on condition. Water depth and temperature, chemical characteristics of the water, biological activity, sea and storm characteristic are factors that impact the condition. Also is the wreck in protected or unprotected waters is in interest. (Michel et al., 2005, p. 43).

The condition of the wreck depends on initial structural damage and corrosion. The hull condition often varies significantly throughout the wreck. The piping lines and the superstructure are made of thinner steel than the hull, which should be taken into consideration when evaluating the wreck condition. (Michel et al., 2005, p. 41).

7.1.6 Rate of corrosion

Sea water is corrosive for metals. Rate of the decomposition depends on several factors in addition to damage the ship in the wreckage like water temperature and chemistry, biological activity, wind and current conditions. (Hassellöv et al. 2007, p. 19.) The wrecks buried in the soft bottom sediment or in deep waters can withstand a longer time before the oil from the tanks will run out. The Baltic Sea is quite shallow, so the wrecks are going to corrode more rapidly here than in the oceans. (Sjöfartsverket, 2009, p. 59.)

The corrosion rate may increase by disturbing activities like divers, fishermen, salvage efforts and currents. Marine growth outside the tanks seem to protect the hull paint and thereby decrease the corrosion rate. (Michel et al., 2005, p. 43).

If the wreck is totally sunken to the bottom sediment, where is neither oxygen, nor bacterial activity, can the rate of corrosion be as low as 0, 01 mm/ year. On the other hand, a combination of anaerobic conditions and for example sulfate-reducing bacteria may lead to corrosion rate 0, 3 – 0, 8 mm/ year. A well-done protective painting may retard corrosion, but it may be removed after 15 years. (Swerea/ Kimab, 2011, p. 60-61.) Installing of sacrificial anodes, also so called cathodic protection, could be a solution to win time while waiting the oil removal. (Sjöfartsverket, Internet address, 2014, p. 26).

It is known, that three of four possible oil leaking wrecks sunk under the Second World War. According to the analyses about the corrosion rate of steel, there will be several oil leaks from the wrecks until year 2030. (MTV3 news 2013.)

”Sitten kun se ruostuu puhki, niin öljyä alkaa valua mereen. Lisäksi monet hylyistä ovat saman ikäisiä, eli markkinat ikään kuin kypsyvät samanaikaisesti, sanoo meripalveluyhtiö Alfons Håkansin projektijohtaja Kari Rinne. Usein pelti on ruostunut siinä vaiheessa ihan paperiksi, mikä tarkoittaa, että öljyn poistoa ei päästä enää tekemään hallitusti.”

(MTV3 news 2013).

7.2 Wreck inspection

A proper wreck assessment before making a removal plan saves time and improves the chances to success. Inspection methods like diver or ROV observations, sampling and measuring orientations of the wreck should be used. Even mapping of the location of the wreck and bottom conditions is in interest. (Michel et al., 2005, p. 44).

Ship construction drawings are useful when making a removal plan. If it is difficult to obtain them, it is possible to use drawings of a vessel of same or similar class. If photos and accounts of sinking and documents concerning cargo, voyage and bunker are available, they can be used as well as previous reports of wreck surveying. Drawings can be combined with Sonar mapping system, GPS, divers and ROVs. (Michel et al. 2005., p. 44 - 45).

It is important, but also time-consuming to locate and sample individual tanks. Growth cleaning is often needed before tanks can be located. A hammer can be used to sound bulkheads and hull frames. Tank sampling can be made with a drill and a sampling tube and can be performed by ROVs. Heavy oils may need heating. Due to stratification, several samples should be taken. (Michel et al., 2005, p. 45).

Rytkönen (personal communication 25.2.2015) points out, that the most important question before starting an oil removal operation is: Is there oil in the wreck or not and is it worth to go to the site? If there is no oil in the wreck, the mobilization with its cost will be unnecessary.

7.3 Oil removal techniques

The oil removal technique depends on wreck condition, location and oil quality. Sometimes the whole wreck can be removed. If only oil is possible to remove, many types of tapping and pumping techniques can be used, for example hot-tap cutting tools, vacuum pumping, submersible hydraulic pumps, heating equipment and ROV operated cutting and pumping tools. (Michel et al., 2005, p. 45).

Hot-tap cutting is a method where an access hole is cut into a pressurized tank or pipe to install a tap or pipe flange. Several versions of these tools can install a pipe flange and cut a hole in into tanks without spilling oil. Pipe flanges can be installed to the hull by welding by drilled bolts. There are also light-weighted cutting tools, which allows that one diver installs and operates the hot tap. To ensure mounting of pump, inserting heating coils and providing replacement of water, several hot-tap flanges and holes must be mounted. (Michel et al., 2005, p. 45-46).

Alfons Håkans Company has developed innovative Oil Removal Operation (ORO) technology operated by ROVs. It is integrated way of working and toolbox to set up Best Available Technology (BAT) case by case. Alfons Håkans ORO system is specially designed for subsea oil removal operations and including vacuum and/ or pump based offloading solutions, oil viscosity control system, integrated trace heating solution in oil transfer hoses and new, year 2014 patented Remotely Operated Underwater Hot Tapping Machine. (Lecture in Lappeenranta University of Technology, 12.2.2015).

Frank Mohn Company (FRAMO) has developed specialized ROV operated underwater tools for tapping and removing oil from wrecks: Remote Offloading System (ROLS). It was used for example in oil removal of Estonia. (Michel et al., 2005, p. 46).

Repsol has developed Hot Tapping Machine, which was used for the Prestige oil offloading. Both ROLS and Hot Tapping Machines can be used in conditions, which are impossible or unsafe for drivers. They allow working in deep water and poor weather conditions. (Michel et al., 2005, p. 46).

Different vacuum pumps, simple diaphragm pumps as well as high volume rotary vacuum pumps can be used for removing of low viscosity oil. If the oil viscosity is high, clogging of the suction hose can be a problem. (Michel et al., 2005, p. 46).

Positive displacement submersible pumps and centrifugal pumps are often used in wreck oil removal operations. The most common positive displacement pumps used in underwater operations are screw pumps, which are available in various configurations and sizes. Some larger pump types enable pumping 1600 liters per hour. (Michel et al., 2005, p. 50).

Heating tanks may be necessary before pumping. The ship´s heating coil piping tends to corrode quicker than the hull plating, so it is common that they cannot be used. Localized heating can be arranged near the pump inlet, or the whole tank can be heated. An old and often used technique is to use portable boilers, which deliver steam through hoses to the wreck. Multiple heating points may be needed to lower the viscosity. Mixing with light oil, such as diesel, reduces the oil viscosity as well as heating, but also mixing energy is needed. Mixing with light oil was used for example in the oil removal of Erika. (Michel et al., 2005, p. 50-51).

7.4 Use of divers and ROVs

Using surface supplied air or mixed gas is the most common way when diving to wrecks. Surface supplied compressed air enables diving to about 65 meters, but the working time in bottom is very short. By using gas-mixes like helium-oxygen it is possible to extend diving depth to 90 meters or extend diving time in shallower depths. When diving to 45 – 365 meters, saturation diving is a preferred method because it requires fewer diving personnel and the bottom working time is more efficient. The mobilization costs are, however, high for saturation diving, so it is best suitable for complicated and long-lasting operations. (Michel et al., 2005, p. 51).

ROVs are an obvious choice at depths beyond 300 meters. In shallower depths it is practical to use ROVs to assist divers or for surveys. ROVs are not as capable as divers, but they can be used in repetitive, simple tasks. (Michel et al., 2005, p. 51).

8 Marine oil spill cleanup cost factors

Many instances including oil transporters, insurance companies and government agencies are very interested in oil spill cleaning costs for planning purposes. Anyway, it is very difficult to evolve a universal per-unit cost factor, because it depends on the influencing factors like the oil type, location, proximity to shoreline, degree of shoreline oiling, spill size and cleanup strategy. Also socio-economic factors, cultural values and labor costs can vary a lot. Also the fact, that there are never two spills alike, makes it complicated to develop a universal cleanup cost factor. (Etkin, 2000, Internet address).

In general can be stated that near shore and in-port spills are 4-5 times as expensive to clean up as offshore spills. Spills of heavy fuels are more than ten times as expensive as spills of lighter crudes and diesel fuels. Per-unit costs of cleaning up a spill under 30 tons is more than ten times as expensive as for spills over 300 tons. (Etkin, 2000, Internet address).

When determining a per-unit amount cost, the most important factors are oil type, the total amount oil spilled and location. The complex relationships of these factors and the manner in which they are influenced by other factors is shown in **Figure 3**. (Etkin, 1999, Internet address). The complexity of counting oil spill response cost can also be seen in **Attachment 2.** (Etkin, 1999, Internet address).

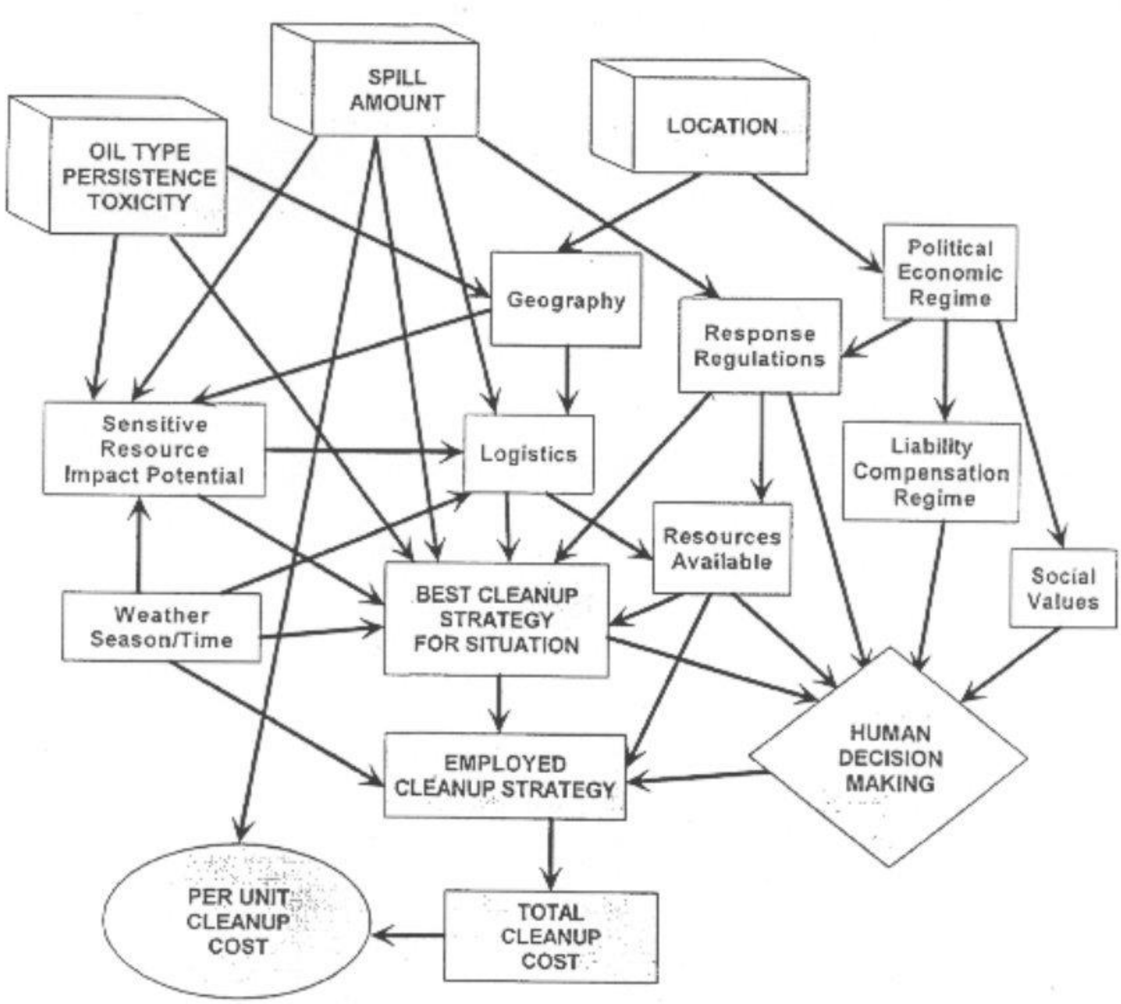


Figure 3. **Factors determining per unit oil spill cleanup costs.** (Etkin, 1999, Internet address).

8.1 Impact of oil type

Oil type together with wind and current conditions determines the direct environmental impacts of an oil spill. Heavier oils and crudes are more persistent and therefore significantly more expensive and challenging to clean up than lighter refined fuels. Mechanical containment and recovery are used to a certain degree, but there is often only a little benefit of these actions because the products begin to evaporate and dissolve very quickly in the water. Gasoline spills cannot be cleaned up; the gasoline is usually evaporated and dissolved before the cleaning-up unit arrives. (Etkin, 2000, Internet address).

Spills of more persistent products, like HFO, do require complicated cleaning up methods like mechanical and manual recovery. Dispersant application could be one method, but it is prohibited in many countries. Shoreline oil spill caused by persistent products can result in prolonged and demanding oil spill recovery operation. It is also the most expensive cleaning up process. (Etkin, 2000, Internet address).

Table 2. shows an analysis of cleanup costs of US and non-US spills by oil type in US $. It can be seen in the table that the proportion of persistent oil increases the costs. As well can be seen, that the cleanup costs for refined oils and lighter crudes are below the average spill cleanup cost. (Etkin, 2000, Internet address).

Table 2. Per Unit Oil Spill Cleanup Costs by oil type (1999 US$)

Oil Type	US Spills in $	Non-US Spills in $	All Spills in $
No. 2 diesel fuel	3.24/ liter 3,607.38/ ton	1.53/ liter 1,699.32/ ton	2.07/ liter 2,307.90/ ton
Light crude	2.86/ liter 3,131.08/ ton	4.09/ liter 4,554.06/ ton	3.83/ liter 4,265.94/ ton
No. 4 fuel	--- ---	21.47/ liter 23,893.38/ ton	21.47/ liter 23,893.38/ ton
No. 5 fuel	7.81/ liter 8,693.58/ ton	21.81/ liter 24,272.64/ ton	20.84/ liter 23,190.72/ton
Crude	13.05/ liter 14,520.66/ ton	3.56/ liter 3,963.127 ton	6.52/ liter 7,250.04/ ton
Heavy crude	18.95/ liter 21,091.567 ton	5.79/ liter 6,447.42/ ton	7.68/ liter 8,540.70/ ton
No. 6 fuel	16.247 liter 18,066.30/ ton	14.63/ liter 16,275.847 ton	15.33/ liter 16,95.04/ ton

(Etkin, 2000, Internet address).

8.2 Impact of location

When determining the oil cleanup cost, the most important factor is location, which is a complex issue involving geographical, legal and political aspects. The timing of spill may also play a role depending of season or tides. It determines, how sensitive the geographical location is. The political and legal circumstances under which the spills occurs may also play a role. As a consequence, both geographical location and timing have significant impact on the oil spill response actions. Mobilizing crew and response equipment into a re-

mote location during a winter storm can be complicated and increase greatly the cost. **Figure 4.** shows the average cleanup costs per ton spilled in 1997 U.S. $.
(Etkin, 1999, Internet address).

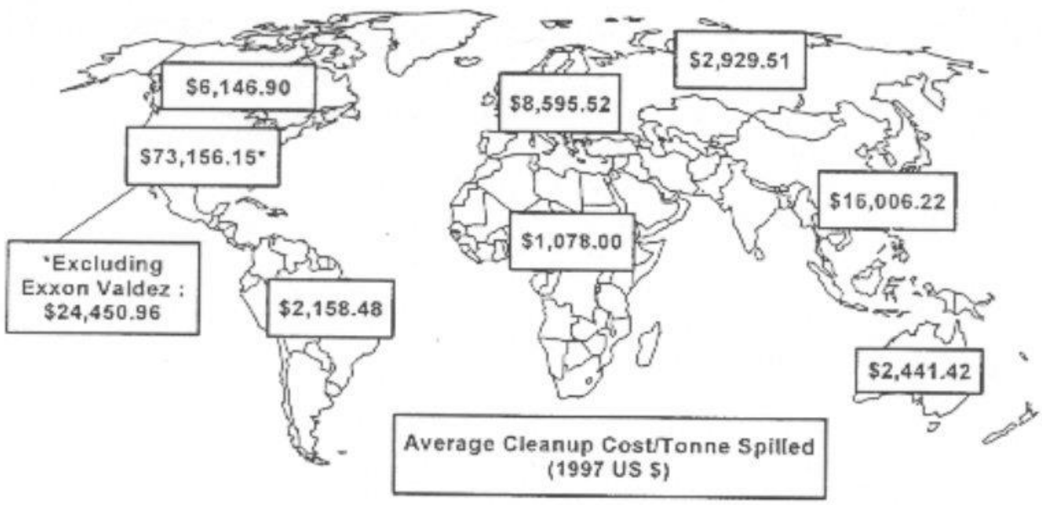


Figure 4. Average cleanup cost per ton spilled (in 1997 U.S. $), based on analysis of oil spill cost data in the OSIR International Oil Spill Database. (Etkin, 1999, Internet address).

8.3 Impact of shoreline proximity

The most expensive alternative in almost any oil spill cleanup is cleaning up the shoreline, which is very time-consuming and labor-intensive. The cheapest and easiest alternative would be "do-nothing" –method, but it works only in locations which are exposured to intensive wave action. It needs monitoring and also takes time, so often the local people and decision-makers pressure to usage of aggressive cleaning up methods, because they want to have a "clean-looking" beach. However, the aggressive shoreline cleaning up tactics such as hot-water washing and usage of heavy machinery can cause a great and prolonged damage to the environment. (Etkin, 2000, Internet address).

Consequently, the response measures can mitigate the spill effects, but have an impact on the environment anyway. Oil removal by mechanical means may cause a lot of environmental damage. The well-meaning cleanup personnel for example often tramples the plants. (Sea OOC, Internet address).

The oil type determines the degree of shoreline oiling. Before impacting the shoreline, the non-persistent oils are tend to evaporate. Also wind and currents may drive the oil towards or away from the coast. If the oil spill happens very close to the coast, more probable that the oil will go ashore. That makes the cleaning of a near shore oil spill much more expensive than the cleaning the offshore spills. (Etkin, 2000, Internet address).

Table 3. Shows the per-unit cleanup costs in relation to how long the oiled shoreline is. It is good to keep in mind that if the "do-nothing" –method is used, there will still be costs due to recovery, monitoring, and logistics. (Etkin, 2000, Internet address).

Table.3 Per-Unit Cleanup Costs By Degree of Shoreline Oiling (1999 US $)

Shoreline Length Oiled	US Spills in $	Non-US Spills in $	All Spills in $
0-1 km	2,644.11/ ton 2.37/ liter	5,530.66/ ton 4.97/ liter	5,086.00/ ton 4.57/ liter
2-5 km	5,991.33/ ton 5.38/ liter	6,150.37/ ton 5.53/ liter	5,793.00/ ton 5,21/ liter
8-15 km	10,540.42/ Ton 9.47/ liter	6,304.60/ ton 5.67/ liter	5,876.00/ ton 5.28/ liter
20-90 km	15,164.62/ ton 13.63/ liter	6,863.19/ ton 6.17/ liter	6,612.00/ ton 5,94/ liter
100 km	27,303.53/ ton 24.54/ liter	9,061.36/ ton 8.14/ liter	11,398.00/ ton 10.24/ liter
500 km	51,962.94/ ton 46.70/ liter	10,404.21/ ton 9.35/ liter	16,443.00/ ton 14.78/ liter

(Etkin, 2000, Internet address).

Table 4. shows the cleanup costs related to offshore, near shore and shoreline oiling. The "near shore" means here that the oil spill is within 5 km of the shoreline. (Etkin, 2000, Internet address).

Table 4. Per-Unit Marine Oil Spill Cleanup Costs By Location Type (1999 US $)

Location	US Spills	Non US Spills	All Spills
In Port	34,089.30/ ton 30.63/ liter	12,983.04/ ton 11.67/ liter	19,674.25/ ton 17.68/ liter
Nearshore	25,066.44/ ton 22.53/ liter	17,931.06/ ton 16.11/ liter	22,442.69/ ton 20.17/ liter
Offshore	6,873.72/ ton 6.18/ liter	8,570.10/ ton 7.70/ liter	8,292.947 ton 7.36/ liter

(Etkin, 2000, Internet address).

8.4 Spill size cost correlation

The cleanup cost per ton is significantly negative correlated with the spill size. This is due to that even a smaller spill needs mobilization of crew and equipment. The logistics costs money, regardless if the rented crew and hired equipment are used or if they are just standing-by. Therefore smaller spills that do require response are more expensive. Also mobilization for something, that turns out to be a "non-event" can cost very much. In Etkin´s study on a per-unit basis, spill response for spills under 30 tons were more than ten times as expensive, as for spills of 300 tons. (Etkin, 2000, Internet address).

When thinking about wreck oil removal, the mobilization cost is would decrease if inspections of wrecks located within relatively short distances from each other could be inspected at one time at a stipulated price. (Hassellöv, 2007, p. 11.)

8.5 Different clean up strategies including dispersant usage

Dispersants are chemicals, which reduce the interfacial tension between oil and water. They weaken the cohesiveness of the oil slick so that wave action breaks up the slick into droplets. After that, the oil disperses naturally throughout the water column. Dispersants do stratify micelles which cover the oil droplets. They help to prevent the oil droplets from coalescing into other slick. (Sea OOC, Internet address).

Etkin, (1999, 2000, Internet addresses) recommended dispersant usage because it would lower labor and equipment costs and be an easy method to use, as seen in **Table 5**.

Table 5. Per-Unit Marine Non-US Oil Spill Cleanup Costs By Primary Methodology

Cleanup Methodology

Primary Method	**US $/ ton**	**US $/ liter**
Manual	23,403.45/ ton	21.03/ liter
Mechanical	9,611.97/ ton	8.64/ liter
Dispersants	5,633.78/ ton	5.06/ liter
In Situ Burning	3,127.87/ ton	2.81/ liter
Natural	1,286.007 ton	1.15/ liter

(Etkin, 2000, Internet address).

She admitted, that dispersants might be potential for environmental damage in sensitive marine areas and recommended that fisheries, tourist beaches and industrial water intakes would be taken into consideration before decision making.

According to some scientists, the dispersant usage is the worst thing to do in an oil catastrophe, even if it is a cheap solution. After a research made of Deepwater Horizon´s leakage and the dispersants used in Gulf of Mexico, Dr. Shaw wrote in The Times that there is not yet enough information about the long-term effects of dispersant-oil mixture on nature. She stated that dispersants only increase the toxicity of oil, leading to a deadly combination. According to her, the solvents in dispersants do penetrate lipid (fat) membranes and allow the oil to enter cells of the body more readily causing damage to every organ. (Shaw, 2011, Internet address).

Today, the use of dispersant is either not allowed or highly districted in many countries, particularly in the Baltic States. In countries, where the use of dispersants is permitted, they have not been used in a long time. Only UK in Europe lists the dispersant usage as a preferred method. Otherwise only Southeast Asian and Middle Eastern countries are inclined to use dispersants. (Itopf, Internet address).

9 Research and co-operation

Wrecks located in the international waters have caused a legal uncertainty and lack of transparency. All states have had their own legal framework for dealing with wreck removals only within their territorial waters. States have legal possibilities to order the removal of wrecks from their Exclusive Economic Zone (EEZ) if it is supported by applicable public international law. Conventions, like the International Convention relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 1969, as amended in 1973, or the Protocol relating to Intervention on the High Seas in Cases of pollution by Substances other than Oil (the Intervention Conventions) do empower a coastal state to intervene on the high seas even outside its territorial waters if there is a risk for marine pollution for that state. Many states have had restricted rights, depending on local legislation, to claim compensation for the costs of wreck removal within their EEZ anyway. (Gard.no, Internet address).

9.1 IOSC

The International Oil Spill Conference (IOSC) was held first time in 1969. According to IOSC website, it is a forum for professionals, the private sector, government and non-governmental organizations to highlight and discuss innovations and practices in oil spill prevention, preparedness, response and restoration. IOSC has gathered a lot of material, which is not accessible anywhere else. (IOSC, Internet address).

9.2 GESAMP

GESAMP is an abbreviation of The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. GESAMP advises the United Nations (UN) in marine environmental protection with a view to scientific aspects. It was established in 1969 and is today sponsored by nine UN organizations and is involved in collaboration and coordination. Assessments and studies are in general carried out by working groups. Most of the working group members are part of the wider GESAMP network but not sitting members. (Gesamp, Internet address)

9.3 The Nairobi International Convention

The Nairobi International Convention on the Removal of Wrecks was adapted in 2007. Since Denmark became the 10th country to ratify it in April 2014, it will enter into force a year later, in April 2015. The intention of Nairobi convention is to provide international rules for removal of wrecks, which are not located in territorial waters. The Convention can also be extended to the territorial seas. So far only three of the ten countries have extended the Convention to their territorial waters: Bulgaria, Denmark and the United Kingdom (Gard.no, Internet address). It has been obligated to remove the wrecks, which cause a danger or impediment to navigation. Nairobi Convention defines a "hazard" as: "*May reasonably be expected to result in major harmful consequences to the marine environment, or damage to the coastline or related interests of one or more States...*" (Nairobi- Convention, Internet, 2011, p. 4). The Nairobi Convention is a tool to regulate and simplify the matter with *future wrecks*. It does not provide a solution to already existing wrecks. (Sjöfartsverket, 2011, p. 24).

10 Research and co-operation in Baltic Sea area

Pollutants from the wreck do not respect international boundaries and therefore co-operation is very important for all the countries in the Baltic Sea area. (Sjöfartsverket, 2011, p. 23). At the moment, the Baltic Countries have different approaches to wreck situation. Most of them are only interested if the wreck causes danger to navigation as seen in **table 6.**

State	Registration by authorities	Reasons (1) Potentially polluting (2) Safety of navigation	Work on potential pollution risks	On-site investigations	Oil removal from old shipwrecks
Finland	Yes	1 and 2	Yes	Yes	Yes
Russia	-	-	-	-	-
Estonia	Yes	2			
Latvia	Yes	2			
Lithuania	Yes	2			
Poland	Yes	2	Yes	Yes	
Germany	Yes	2			
Denmark	Yes	2			

Table 6. Summary of work of the Baltic States. The situation in Russia is not known. (Swedish Maritime Administration, Internet address, 2010).

10.1 SYKE

In Finland, The *Finnish Environment Institute* (SYKE) and the Ministry of the Environment are responsible for the prevention of oil leakage from wrecks. SYKE has worked since 1987 with an inventory of potential environmental hazards from shipwrecks in Finnish waters and the work is conducted by SYKE´s Marine Pollution Response Unit. SYKE is the leading institution in Finland, co-operating with the Finnish navy and Border guard, which have provided assistance for on-site inventories and oil removal. (Swedish Maritime Administration, 2010, p. 13).

Sunken wreck environmental risk assessment, SWERA, is a SYKE´s project, which started in 2014 and will end in 2016. The aim of SWERA is to understand better the pollution threat of sunken ships. The new approach combines the tool VRAKA, developed at Chalmers University of Technology in Sweden, with an oil removal risk tool by SYKE and Alfons Håkans Ltd. A joint wreck register will be coordinated by Tallinn Technical University. The purpose is to develop a salvage support tool to make the work in sunken wrecks both safe and economically applicable. (SYKE, Internet address).

10.2 HELCOM

The ”Expert Group on Oil Combatting" was established 1977 under the HELCOM Interim Commission (1974-1980). Today the group consists of competent pollution response authorities of all the Baltic Sea countries and is called HELCOM Response Group. The 1983 adopted HELCOM Response manual describes how to operate in case of a major international oil or HNS accident. Also financial matters and administrative procedures related to requesting and receiving international assistance are defined in the manual. Today there is about 70 oil response vessels in the Baltic Sea area with equipment suitable for international assistance and many of them have even towing capacity. In coastal waters, additional smaller vessels are available to assistance. (HELCOM, Internet address).

The Helsinki Convention of 1992 is an international agreement ratified by the European Community, Finland, Sweden, Denmark, Estonia, Latvia, Lithuania, Poland, Germany and the Russian Federation and the cooperation in combating oil spillages and other harmful substances in the Baltic Sea area is based on it. HELCOM arranges regular operational marine pollution exercises. (HELCOM, Internet address).

HELCOM has initiated a new working group to refresh the national wreck data of the Baltic Sea. The new task group HELCOM SUBMERGED started its work in late autumn 2014 and will produce new data on national wrecks registers and risk for oil pollution in the Baltic Sea Area 2016. (HELCOM, Internet address).

10.3 Copenhagen Agreement

The Copenhagen Agreement is an agreement between Finland, Sweden, Norway, Denmark and Iceland and concerns the actions against oil and chemical discharges in the Baltic Sea and Kattegat. The purpose of the Copenhagen Agreement is to co-operate in investigations, surveillance and reporting to protect the marine environment from oil discharge and another harmful substances. The contracting parties are committed to mutual assistance in response operations and have joint exercises. (Oiledwildlife, Internet address).

11 Discussion

None of the material I found, was new. It looks like the fact that there is a large amount of oil containing wrecks in the bottom of the sea, was “in fashion” around year 2000, but not since that. It is strange, because the most wrecks are from the Second World War and year by year they are getting just older and more corroded, and the possibility for oil spills is increasing every moment. A massive oil spill may cause more severe damages to the environment than any major individual accident that has occurred in the Baltic Sea. The problem is not going to vanish by itself.

My objective was to count the exact costs of an oil removal operation versus expenses, if the oil leaks to the nature. Unfortunately, very soon I had to notice that it is impossible. The register concerning potentially polluting wrecks is not public, so I did not get access to it. Without register, it is impossible to say, which wrecks are potentially polluting. I could, of course, have invented a wreck x, which is in location y, containing z tons b fuel. Figure 2. (Per unit oil spill cleanup costs, p. 21), shows how many variables there is anyway. Additionally, the oil may, depending on wind, move to eight cardinal points or somewhere there between. The season is also a very important thing when thinking about oil removal costs; it is much more difficult and consequently much more expensive in the winter time, if there is ice. In chapter 8. I outline some oil spill cost models, divided by oil type, location and clean-up method. Still, they are from year 1999 and made in USA. Now, after 16 years, I don´t think they can be directly applied. There are not fresher ones available, anyway.

The most difficult thing is: it is impossible to count the value of nature contaminated by oil. As seen in Attachment 3, Finland´s environmental administration has defined the indicative values of protected species. According to the indicative values, for example one white-tailed eagle would cost 7400 € and a grass snake 252 €. One clutch would have the same price as an adult individual, if the young has not left the nest. If they had left the nest, they would have the same price as adult ones. Anyway, the unanswerable question is: how many individuals of every species there would be in the place of the oil disaster? And how about all the unprotected species? The loss of one functionally important species may change the whole ecosystem. It is impossible to count the value of possible long-lasting and unpredictable consequences. The harm an oil disaster might cause to fish farms, summer houses, hotels, beaches and boat harbors can no-one predict.

The wreck oil removal expenses would possibly be a bit easier to count. In Finland, two oil removal operations has been made, although none of them recently. The expenses of Estonia’s oil removal in 1996 were 2, 5 million €, also 10 000 – 10 870 €/ ton while the expenses of Park Victory´s oil removal in 2000 were 3, 6 million €, 8780 €/ ton. The price per ton was also around 10 000 €/ ton 15 years ago. Both of these wrecks were, anyway, in the open sea and the oil removal costs might have been lower in a near shore location. The oil recovery techniques and instruments do also progress all the time which may alter the price, possibly even to cheaper direction.

11.1 Financially

In all the documents, which had something to do with the oil removal from wrecks, was admitted that it is cheaper to remove the oil controlled. A sudden leak, which needs immediate actions, becomes very expensive because in an emergency situation, there is no time for good planning of the operation. The mobilization expenses may arise a lot, because it is not known, what is leaking and where, and how much people and equipment is needed to take the leakage under control. As well a situation, where a wreck leaks oil for example 5 summers consecutively and oil spill response actions are every year needed, would be very money-consuming, because the mobilization is needed 5 times. A cheaper solution in that case would be to remove the oil at once.

It was also stated that a controlled wreck oil removal is many times cheaper than trying to rule over an unexpected leakage close to the shoreline. If the oil is going ashore, the cleaning will be very expensive and there is no guarantee, that the consequences are satisfying. According to Etkin´s table 4 on page 26, oil recovery costs in non-US spills are about 8600 €/ ton in offshore oil spills and 18 000 €/ ton in near shore oil spills. As mentioned before, the oil removal costs in cases Estonia and Park Victory were around 10 000 €/ ton. It may be concluded that the oil removal from a wreck in offshore location would cost as much as an oil spill, if all the oil would leak to the nature at once. But as mentioned, it rarely happens and the mobilization costs would be much higher, if the leakage needs repetitive oil recovery operations. According to the same Etkin´s table, a near shore oil spill recovery would cost 18 000 €/ ton. The price can therefore be assumed to cost twice as much as a controlled oil removal from a wreck.

Rytkönen (personal communication 25.2.2015) estimates, that the costs for a wreck oil recovery operation would be around 50 000 €/ day at this moment. How many days it would take, depends on the capacity of equipment.

Because the oil removal from wrecks is very money-consuming, funding was recommended as a solution in many documents. Nothing has happened with a view to funding anyway. I can only note the same thing as the writers in the ´90s: there is no law about who finances the oil removal from old wrecks, in cases where the owner is unknown.

In most of the documents I used as references, was a mention that “something” should be done. Many document writers were in hope, that the Nairobi Convention would solve the problems. Unfortunately, the matter is not so, because the Nairobi Convention can only be applied on future wrecks, not on the most dangerous, old ones. And when thinking about Finland, the Nairobi Convention is not even ratified here, neither outside our territorial waters, nor inside.

11.2 Ecologically

IMO has named the Baltic Sea as a Particularly Sensitive Sea Area, PSSA. It takes 25-30 years before the complete change of water because new salt water is coming only via the Danish Strait, if it blows several weeks from a favorable direction. Brackish water together with low salinity and shallow depth makes the Baltic Sea a challenging habitat to many species; therefore only quite a few species can live there. An oil disaster in the Baltic Sea would therefore have especially disastrous consequences. The loss of one functionally important species might change the whole ecosystem and even a small amount of oil could cause long-lasting, severe and unpredictable consequences. That is to say, the nature would maybe never normalize again after an oil disaster.

12 Conclusion

Because the controlled oil removal is cheaper than an unexpected oil leakage, which needs immediate actions, the potentially polluting wrecks should be carefully monitored and the oil should be removed if there is a risk that the oil starts to leak to marine nature. This needs, of course, a lot of money, but the fact that a sudden leak will be even more expensive, should be kept in mind. As well should be taken into consideration, that the nature in the Baltic Sea area is especially sensitive and would maybe never normalize again after an oil disaster. A developed co-operation between all the Baltic Sea countries would be a good thing, because the pollution does not respect the state borders.

If the “oil in the wrecks” –topic would get more publicity and the list over potentially polluting wrecks would be public, the decision makers might be forced to do something to this problem. People would certainly not be clad about the knowledge, that no-one is going to pay them compensation if there would be oil in the beaches and they cannot use their summerhouses. Or about the information, that the value of their summerhouses is collapsing due to the potentially polluting wreck in vicinity.

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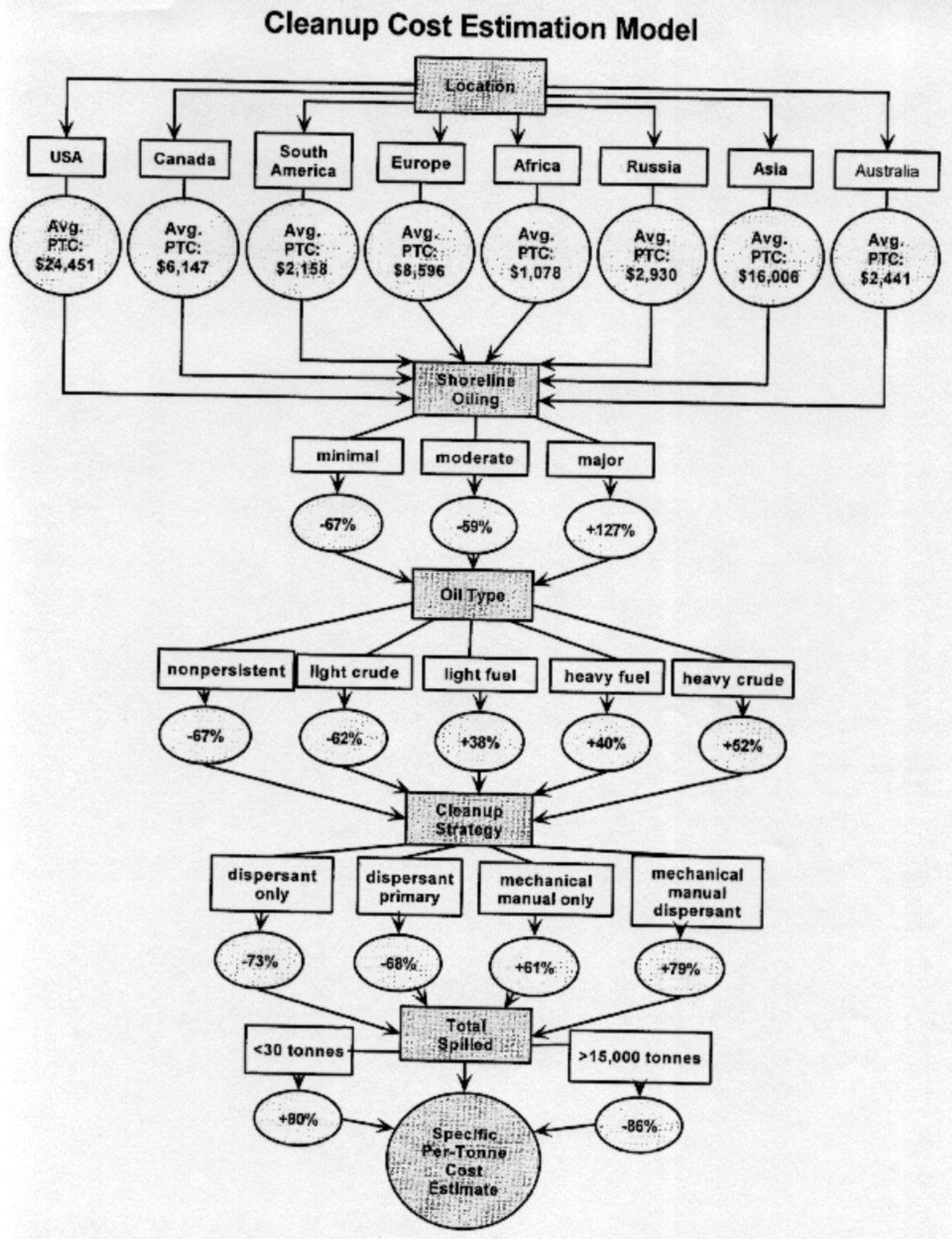
Attachment 1.

Attachment 2.

Figure 8: Per-Ton Cost Estimation Model (based on data from the OSIR International Oil Spill Database). The per ton costs (PTC) shown are based on 1997 U.S. dollars and can be adjusted with annual consumer price indices as needed. The figures can be converted into a per-gallon cost estimate by dividing the resulting figures by a factor of 294. (Etkin, 1999, Internet address).



Attachment 3.

Rauhoitettujen eläinten ja kasvien ohjeelliset arvot Ympäristöministeriö vahvistaa luonnonsuojelulain (1096/1996) 59 §:n nojalla ohjeelliset arvot rauhoitetuille lajeille. Ympäristöministeriön asetus rauhoitettujen eläinten ja kasvien ohjeellisista arvoista (9/2002) annettiin 3.1.2002. Ohjeelliset arvot auttavat tuomioistuimia rauhoitusmääräysten rikkomusten käsittelyssä ja korvausten määrittämisessä.

Rauhoitetut nisäkkäät

harmaakuvemyyrä (Clethrionomys rufocanus) 17 €

idänpäästäinen (Sorex caecutiens) 17 €

isoviiksisiippa (Myotis brandti) 101 €

koivuhiiri (Sicista betulina) 50 €

korpipäästäinen (Sorex isodon) 50 €

korvayökkö (Plecotus auritus) 101 €

kääpiöpäästäinen (Sorex minutissimus) 50 €

liito-orava (Pteromys volans) 1009 €

lumikko (Mustela nivalis) 34 €

maamyyrä (Talpa europaea) 17 €

metsäpäästäinen (Sorex araneus) 17 €

metsäsopuli (Myopus schisticolor) 34 €

naali (Alopex lagopus) (tunturikanta) 7400 €

peltohiiri (Apodemus agrarius) 67 €

pohjanlepakko (Eptesicus nilssoni) 118 €

punamyyrä (Clethrionomys rutilus) 34 €

ripsisiippa (Myotis nattereri) 1177 €

saimaannorppa (Pusa hispida saimensis) 9755 €

siili (Erinaceus europaeus) 101 €

tammihiiri (Eliomys quercinus) 2355 €

tunturisopuli (Lemmus lemmus) 67 €

vaivaishiiri (Micromys minutus) 17 €

vaivaispäästäinen (Sorex minutus) 17 €

vesikko (Mustela lutreola) 5382 €

vesipäästäinen (Neomys fodiens) 17 €

vesisiippa (Myotis daubentoni) 118 €

viiksisiippa (Myotis mystacinus) 84 €

Rauhoitetut linnut

ampuhaukka (Falco columbarius) 841 €

etelänkiisla (Uria aalge) 841 €

etelänsuosirri (Calidris alpina schinzii) 2355 €

haarahaukka (Milvus migrans) 1514 €

haarapääsky (Hirundo rustica) 34 €

harmaahaikara (Ardea cinerea) 841 €

harmaapäätikka (Picus canus) 841 €

harmaasieppo (Muscicapa striata) 17 €

harmaasorsa (Anas strepera) 252 €

heinäkurppa (Gallinago media) 4373 €

helmipöllö (Aegolius funereus) 420 €

hemppo (Carduelis cannabina) 50 €

hernekerttu (Sylvia curruca) 17 €

hiirihaukka (Buteo buteo) 757 €

hiiripöllö (Surnia ulula) 1009 €

hippiäinen (Regulus regulus) 17 €

huuhkaja (Bubo bubo) 841 €

härkälintu (Podiceps grisegena) 420 €

hömötiainen (Parus montanus) 17 €

idänuunilintu (Phylloscopus trochiloides) 420 €

isokäpylintu (Loxia pytyopsittacus) 67 €

isolepinkäinen (Lanius excubitor) 252 €

jänkäkurppa (Lymnocryptes minimus) 589 €

jänkäsirriäinen (Limicola falcinellus) 505 €

järripeippo (Fringilla montifringilla) 17 €

kaakkuri (Gavia stellata) 1682 €

kalalokki (Larus canus) 101 €

kalatiira (Sterna hirundo) 84 €

kanahaukka (Accipiter gentilis) 757 €

kangaskiuru (Lullula arborea) 1009 €

kapustarinta (Pluvialis apricaria) 252 €

karikukko (Arenaria interpres) 336 €

kaulushaikara (Botaurus stellaris) 589 €

kehrääjä (Caprimulgus europaeus) 505 €

keltahemppo (Serinus serinus) 118 €

keltasirkku (Emberiza citrinella) 17 €

keltavästäräkki (Motacilla flava) 34 €

keräkurmitsa (Charadrius morinellus) 505 €

kiljuhanhi (Anser erythropus) 6391 €

kiljukotka (Aquila clanga) 6728 €

kirjokerttu (Sylvia nisoria) 84 €

kirjosieppo (Ficedula hypoleuca) 17 €

kirjosiipikäpylintu (Loxia leucoptera) 505 €

kiuru (Alauda arvensis) 34 €

kivitasku (Oenanthe oenanthe) 34 €

koskikara (Cinclus sinclus) 589 € kotka

(Aquila chrysaetos) 4877 € kottarainen

(Sturnus vulgaris) 84 €

kuhankeittäjä (Oriolus oriolus) 252 €

kuikka (Gavia arctica) 841 €

kulorastas (Turdus viscivorus) 84 €

kultarinta (Hippolais icterina) 50 €

kultasirkku (Emberiza aureola) 1346 €

kuningaskalastaja (Alcedo atthis) 841 €

kuovi (Numenius arquata) 118 €

kurki (Grus grus) 1009 €

kuukkeli (Perisoreus infaustus) 757 €

kuusitiainen (Parus ater) 34 €

kyhmyjoutsen (Cygnus olor) 589 €

käenpiika (Jynx torquilla) 202 €

käki (Cuculus canorus) 420 €

käpytikka (Dendrocopos major) 34 €

lampiviklo (Tringa stagnatilis) 1009 €

lapasotka (Aythya marila) 2018 €

lapinkirvinen (Anthus cervinus) 336 €

lapinpöllö (Strix nebulosa) 1682 €

lapinsirkku (Calcarius lapponicus) 168 €

lapinsirri (Calidris temminckii) 336 €

lapintiainen (Parus cinctus) 252 €

lapintiira (Sterna paradisaea) 84 €

lapinuunilintu (Phylloscopus borealis) 505 €

laulujoutsen (Cygnus cygnus) 2018 €

laulurastas (Turdus philomelos) 34 €

lehtokerttu (Sylvia borin) 34 €

lehtopöllö (Strix aluco) 673 €

leppälintu (Phoenicurus phoenicurus) 17 €

liejukana (Gallinula chloropus) 252 €

liro (Tringa glareola) 101 €

luhtahuitti (Porzana porzana) 252 €

luhtakana (Rallus aquaticus) 420 €

luhtakerttunen (Acrocephalus palustris) 50 €

lumihanhi (Anser caerulescens) 336 €

luotokirvinen (Anthus petrosus) 252 €

mehiläishaukka (Pernis apivorus) 757 €

meriharakka (Haematopus ostralegus) 135 €

merikihu (Stercorarius parasiticus) 505 €

merikotka (Haliaeetus albicilla) 7400 €

merimetso (Phalacrocorax carbo) 235 €

merisirri (Calidris maritima) 1009 €

metsäkirvinen (Anthus trivialis) 17 €

metsäviklo (Tringa ochropus) 84 €

mustakurkku-uikku (Podiceps auritus) 420 €

mustaleppälintu (Phoenicurus ochruros) 118 €

mustalintu (Melanitta nigra) 757 €

mustapyrstökuiri (Limosa limosa) 757 €

mustapääkerttu (Sylvia atricapilla) 50 €

mustapäätasku (Saxicola torquata) 118 €

mustarastas (Turdus merula) 34 €

mustatiira (Chlidonias niger) 185 €

mustavaris (Corvus frugilegus) 135 €

mustaviklo (Tringa erythropus) 420 €

muuttohaukka (Falco peregrinus) 4037 €

naakka (Corvus monedula) 101 €

naurulokki (Larus ridibundus) 101 €

niittykirvinen (Anthus pratensis) 34 €

niittysuohaukka (Circus pygarcus) 2018 €

nokkavarpunen (Coccothraustes coccothraustes) 118 €

nummikirvinen (Anthus campestris) 135 €

nuolihaukka (Falco subbuteo) 1009 €

närhi (Garrulus glandarius) 50 €

pajulintu (Phylloscopus trochilus) 17 €

pajusirkku (Emberiza schoeniclus) 34 €

palokärki (Dryocopus martius) 841 €

peippo (Fringilla coelebs) 17 €

peltosirkku (Emberiza hortulana) 34 €

pensaskerttu (Sylvia communis) 17 €

pensassirkkalintu (Locustella naevia) 50 €

pensastasku (Saxicola rubetra) 17 €

peukaloinen (Troglodytes troglodytes) 34 €

piekana (Buteo lagopus) 757 €

pikkuhuitti (Porzana parva) 505 €

pikkukuovi (Numenius phaeopus) 336 €

pikkukäpylintu (Loxia curvirostra) 34 €

pikkulepinkäinen (Lanius collurio) 67 €

pikkulokki (Larus minutus) 505 €

pikkusieppo (Ficedula parva) 252 €

pikkusirkku (Emberiza pusilla) 589 €

pikkusirri (Calidris minuta) 673 €

pikkutiira (Sterna albifrons) 1850 €

pikkutikka (Dendrocopos minor) 336 €

pikkutylli (Charadrius dubius) 84 €

pikku-uikku (Tachybaptus ruficollis) 252 €

pikkuvarpunen (Passer montanus) 67 €

pilkkasiipi (Melanitta fusca) 673 €

pohjansirkku (Emberiza rustica) 84 €

pohjantikka (Picoides tridactylus) 589 €

pulmunen (Plectrophenax nivalis) 420 €

punajalkaviklo (Tringa totanus) 101 €

punakuiri (Limosa lapponica) 1346 €

punakylkirastas (Turdus iliacus) 17 €

punarinta (Erithacus rubecula) 17 €

punatulkku (Pyrrhula pyrrhula) 34 €

punavarpunen (Carpodacus erythrinus) 34 €

pussitiainen (Remiz pendulinus) 101 €

puukiipijä (Certhia familiaris) 34 €

pyrstötiainen (Aegithalos caudatus) 252 €

pähkinähakki (Nucifraga caryocatactes) 336 €

pähkinänakkeli (Sitta europaea) 135 €

rantakurvi (Xenus cinereus) 3868 €

rantasipi (Actitis hypoleucos) 34 €

rastaskerttunen (Acrocephalus arundinaceus) 151 €

rautiainen (Prunella modularis) 34 €

riskilä (Cepphus grylle) 101 €

ristisorsa (Tadorna tadorna) 589 €

ruisrääkkä (Crex crex) 1514 €

ruokki (Alca torda) 420 €

ruokokerttunen (Acrocephalus schoenobaenus) 17 €

ruokosirkkalintu (Locustella luscinioides) 118 €

ruskosuohaukka (Circus aeruginosus) 1009 €

rytikerttunen (Acrocephalus scirpaceus) 50 €

räyskä (Sterna caspia) 1850 €

räystäspääsky (Delichon urbica) 17 €

sarvipöllö (Asio otus) 673 €

satakieli (Luscinia luscinia) 252 €

selkälokki (Larus fuscus) 757 €

sepelrastas (Turdus torquatus) 420 €

silkkiuikku (Podiceps cristatus) 118 €

sinipyrstö (Tarsiger cyanurus) 1177 €

sinirinta (Luscinia svecica) 135 €

sinisuohaukka (Circus cyanus) 673 €

sinitiainen (Parus caeruleus) 17 €

sirittäjä (Phylloscopus sibilatrix) 17 €

sitruunavästäräkki (Motacilla citreola) 673 €

suokukko (Philomachus pugnax) 420 €

suopöllö (Asio flammeus) 673 €

suosirri (Calidris alpina alpina) 118 €

sääksi (Pandion haliaetus) 1682 €

taivaanvuohi (Gallinago gallinago) 34 €

talitiainen (Parus major) 34 €

taviokuurna (Pinicola enucleator) 336 €

tervapääsky (Apus apus) 67 €

tikli (Carduelis carduelis) 67 €

tilhi (Bombycilla garrulus) 336 €

tiltaltti (Phylloscopus collybita) 17 €

tundraurpiainen (Carduelis hornemanni) 252 €

tunturihaukka (Falco rusticolus) 6391 €

tunturikihu (Stercorarius longicaudus) 841 €

tunturikiuru (Eremophila alpestris) 3196 €

tunturipöllö (Nyctea scandiaca) 3369 €

turkinkyyhky (Streptopelia decaocto) 252 €

turturikyyhky (Streptopelia turtur) 252 €

tuulihaukka (Falco tinnunculus) 1009 €

tylli (Charadrius hiaticula) 420 €

törmäpääsky (Riparia riparia) 50 €

töyhtöhyyppä (Vanellus vanellus) 101 €

töyhtötiainen (Parus cristatus) 17 €

uivelo (Mergus albellus) 673 €

urpiainen (Carduelis flammea) 17 €

uuttukyyhky (Columba oenas) 589 €

valkoposkihanhi (Branta leucopsis) 336 €

valkopäätiainen (Parus cyanus) 336 €

valkoselkätikka (Dendrocopos leucotos) 4037 €

valkoviklo (Tringa nebularia) 505 €

varpunen (Passer domesticus) 34 €

varpushaukka (Accipiter nisus) 505 €

varpuspöllö (Glaucidium passerinum) 420 € v

vesipääsky (Phalaropus lobatus) 505 €

viherpeippo (Carduelis chloris) 34 €

vihervarpunen (Carduelis spinus) 17 €

viiksitimali (Panurus biarmicus) 84 €

viiriäinen (Coturnix coturnix) 4205 €

viirupöllö (Strix uralensis) 757 €

viitakerttunen (Acrocephalus dumentorum) 252 €

viitasirkkalintu (Locustella fluviatilis) 252 €

virtavästäräkki (Motacilla cinerea) 135 €

vuorihemppo (Carduelis flavirostris) 336 €

västäräkki (Motacilla alba) 34 €

Muut nisäkkäät ja linnut Muiden kuin 1 ja 2 §:ssä mainitun ja metsästyslain (615/1993) 5 §:ssä lueteltuihin riistaeläimiin tai rauhoittamattomiin eläimiin kuulumattoman nisäkkään ja linnun ohjeellinen arvo määräytyy sen luettelossa mainitun sukulaislajin korkeimman arvon perusteella. Arvosta tulee pyytää alueellisen ympäristökeskuksen lausunto.

Rauhoitetut matelijat

kangaskäärme (Coronella austriaca) 2523 €

rantakäärme (Natrix natrix) 252 €

sisilisko (Lacerta vivipara) 17 €

vaskitsa (Anguis fragilis) 202 €

Rauhoitetut sammakkoeläimet

rupikonna (Bufo bufo) 34 €

rupilisko (Triturus cristatus) 420 €

sammakko (Rana temporaria) 17 €

vesilisko (Triturus vulgaris) 34 €

viitasammakko (Rana arvalis) 34 €

Rauhoitetut nilviäiset

jokihelmisimpukka (Margaritifera margaritifera) 589 €

vuollejokisimpukka (Unio crassus) 50 €

Rauhoitetut perhoset

etelänpurohopeatäplä (Clossiana thore thore) 219 €

harjusinisiipi (Pseudophilotes baton) 1682 €

hierakkalehtimittari (Scopula corrivalaria) 673 €

isoapollo (Parnassius apollo) 841 €

isokultasiipi (Lycaena dispar) 1682 €

juovapunatäpläperhonen (Zygaena osterodensis) 1682 €

juurilasisiipi (Bembecia scopigera) 151 €

kalliosinisiipi (Scolitantides orion) 420 €

kirjopapurikko (Lopinga achine) 420 €

kirjoverkkoperhonen (Hypodryas maturna) 50 €

lehtohopeatäplä (Clossiana titania) 420 €

lehtovähämittari (Chloroclystis vata) 1261 €

muurahaissinisiipi (Maculinea arion) 1177 €

neidonkielikoisa (Cynaeda dentalis) 1682 €

pikkuapollo (Parnassius mnemosyne) 336 €

pohjanvalkotäpläpaksupää (Hesperia comma catena) 420 €

punakeltaverkkoperhonen (Euphydryas aurinia) 151 €

raunikkikoi (Caryocolum petryi) 1682 €

sinilehtimittari (Scopula decorata) 1682 €

tummaverkkoperhonen (Melitaea diamina) 1261 €

tundrasinisiipi (Agriades glandon) 673 €

tyräkkikääriäinen (Lobesia occidentalis) 151 €

varjotäpläkoi (Ethmia terminella) 1261 €

Rauhoitetut kovakuoriaiset

erakkokuoriainen (Osmoderma eremita) 1682 €

isolampisukeltaja (Graphoderus bilineatus) 17 €

jättisukeltaja (Dytiscus latissimus) 17 €

punahärö (Cucujus cinnaberinus) 1682 €

Rauhoitetut korennot

kievanakorento (Aeshna viridis) 420 €

lummelampikorento (Leucorrhinia caudalis) 17 €

sirolampikorento (Leucorrhinia albifrons) 17 €

täplälampikorento (Leucorrhinia pectoralis) 17 €

Rauhoitetut kasvit ja sammalet

Rauhoitettujen kasvien ja sammalien ohjeellisen arvon määräytymisestä tulee pyytää ELY-keskuksen lausunto.

Rauhoitettujen lajien poikaset, munat, munaryhmät, toukat, toukkaryhmät ja kotelot

Pesästä lähtenyt poikanen vastaa arvoltaan aikuisen yksilön ohjeellista arvoa. Muutoin aikuista yksilöä vastaa nisäkkäillä pesäpoikue tai sen osa, linnuilla munapesye, pesäpoikue tai sen osa sekä muilla eläimillä munaryhmä tai munaryhmän osa, toukka, toukkaryhmä tai kotelo. Tunturihaukalla ja muuttohaukalla myös yksittäisen munan tai pesäpoikasen arvo on sama kuin aikuisen yksilön ohjeellinen arvo.