Outline of PAJ Study Program on Self-cleanup mechanism of Ocean for Spilt Oil

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1. Introduction

The oil spilt in ocean is evaporated, dissolved and emulsified in sea water and lead to mousse as it spreads and drifts on sea surface at the early stage of oil spill. A part of these spilt oil is recovered by skimming operation, but the remainder is dispersed in ocean or is drifted ashore. The remaining oil in ocean is supposed to be cleaned up from ocean in a long time by biotic and abiotic degradation with marine microorganism, light and oxygen. The rate of each of these cleanup processes has been estimated from the field study on the spilt oil.

PAJ started the study program on Self-cleanup mechanism of ocean for spilt oil at 1994 in the purpose to elucidate the self-cleanup mechanism of ocean for the spilt oil from more systematic investigations on various processes participating in the cleanup of the spilt oil in ocean and to propose more effective method utilizing the natural cleanup function to clean up the spilt oil. In this presentation, the overview of the study is shown.

2. Methodology

Various processes are participated in the cleanup of the spilt oil in ocean. It is important in elucidation of the self-cleanup mechanism of ocean for the spilt oil to make clear how and to what extent each process contribute to the cleanup of the spilt oil in ocean and what affect it. In the study they are examined separately by the laboratory experiment of each process. However the results of the laboratory

experiments are not necessarily applied directly to natural phenomena because many factors affecting these processes come into play simultaneously in natural ocean. Hence the field study is carried out in order to verify the results of the laboratory experiments and to recognize the cleanup mechanism of ocean for the spilt oil from the viewpoint of each process participating in the cleanup by relating the results of the laboratory experiments to those of the field study.

3. Outlines of each study

The laboratory experiment is separately conducted with each of environmental distribution, bioaccumulation, biodegradation and abiotic degradation of crude oil. In the field study, the analyses of residual oil and biota on seashore are carried out. The outline of each study is as follows:

(1) Study on environmental distribution of spilt oil

The spilt oil is distributed among water, air and oil phases according to its physico-chemical property of the oil at early stage of oil spill as it spreads and drifts on sea surface. Subsequently a part of the oil drift ashore and adsorbed to bottom sediment on seashore. These processes are thought to be strongly affected by natural conditions such as wind,wave and nature of the bottom sediment. In the study, the rate and extent of the distribution among water, oil and air phases is measured by the laboratory experiment in which crude oil or crude oil/oil dispersant mixture is put on surface of artificial sea water with generating small wave to evaluate the contribution of the process to cleanup of spilt oil.

(2) Bioaccumulation

The spilt oil dissolved or emulsified. in sea water is accumulated in sea organism and subsequently it apparently seems to elminate from sea as the spilt oil is cleaned up from ocean. Therefore the bioaccumulation is used as an indicator to monitor the extent of cleanup of the spilt oil. There are two routes of uptake of chemical substance organism in general;i.e. ,direct uptake through gill and uptake from diet. In this study, the rate and extent of the uptake and elimination of the spilt oil by fishes and shellfishes are investigated. In addition, the conducted a test concerning to smell of polluted fishes in order to examine the acceptability as a marine product.

(3) Biodegradation

Biodegradation is most important process to clean up the spilt oil dispersed in ocean or drifted ashore in long time. In this study, the laboratory experiments are conducted with weathered crude oil using natural sea water or natural sea water/costal bottom sediment mixture as testing sample to evaluate the rate and extent of biodegradation of spilt oil in sea water or drifted ashore, respectively. We conducted two categories of tests. One is to measure the "Ultimate" decomposition of oil, which is the state achieved to transform the oil to carbon dioxide and water. And other is to measure the degree of degradation by various crude oil sources. The aim of those measurmants is to clearize the effect of dispersant towards the rate of cleanup of spilt oil through testing various wheathered crude oil/mixture of weathered crude oil and dispersant,with various sea water.

(4) Abiotic degradation

The abiotic degradation in long term by sunlight and oxygen is the another important process of the cleanup of spilt oil. The contribution of these process to the cleanup of

the spilt oil is examined by laboratory experiment.

(5) Field study

In the field study, the residual oil and biota in the oh-polluted site and the non-polluted reference site(as a blank)are analyzed and

compared between bothsites to verify the results from the laboratory experiments and to get more reliable mechanism of the cleanup for the spilt oil in ocean and furthermore to evaluate the rate and extent of the cleanup at the site of oil pollution.

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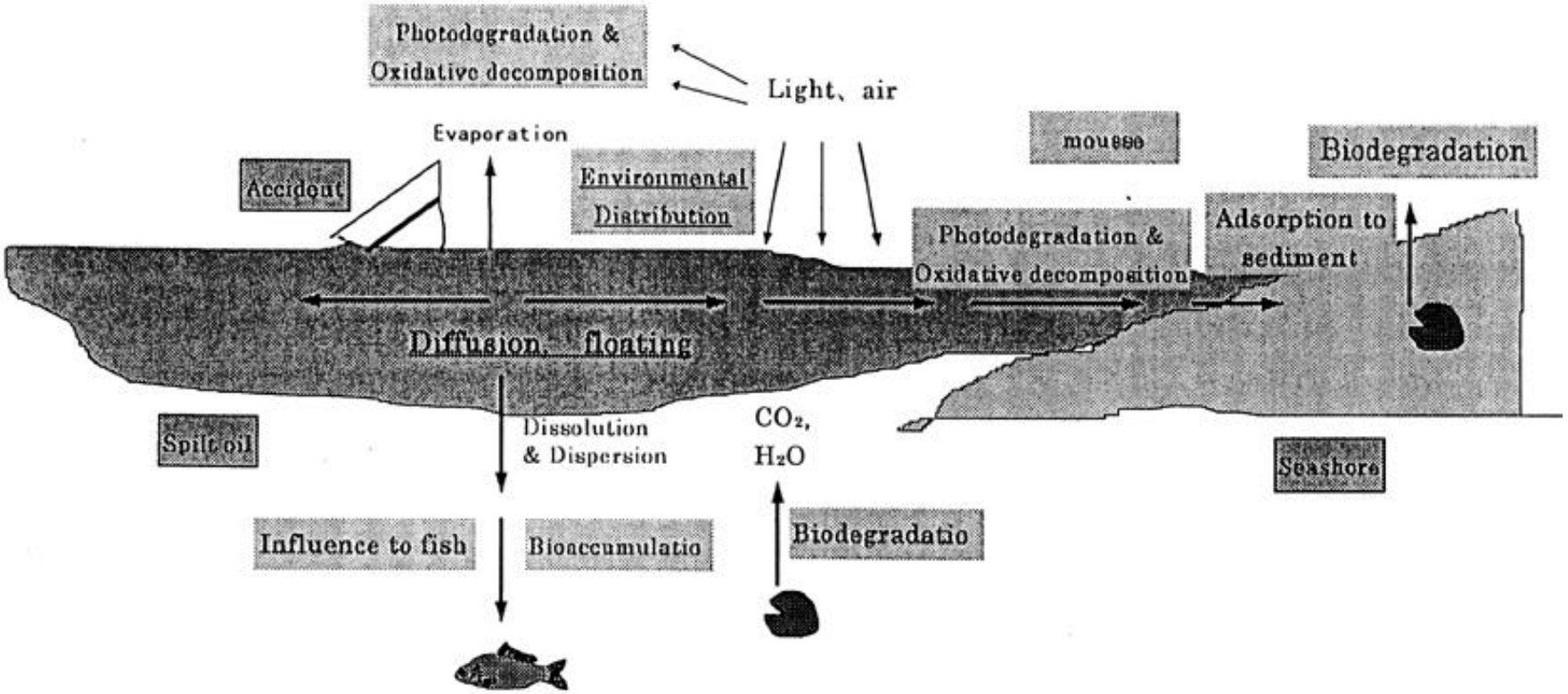
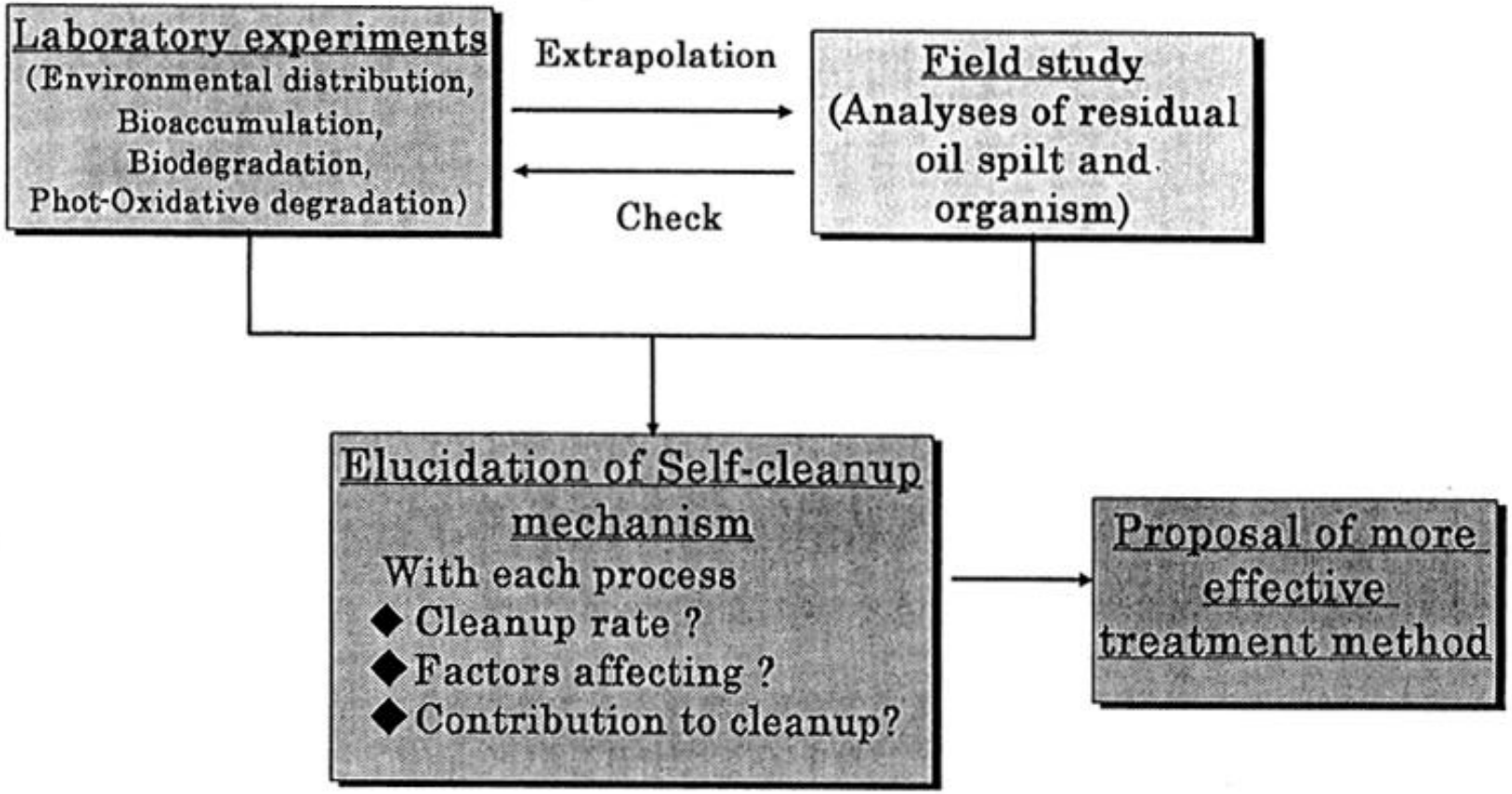


Various cleanup processes for spilt oil

Purposes of the study

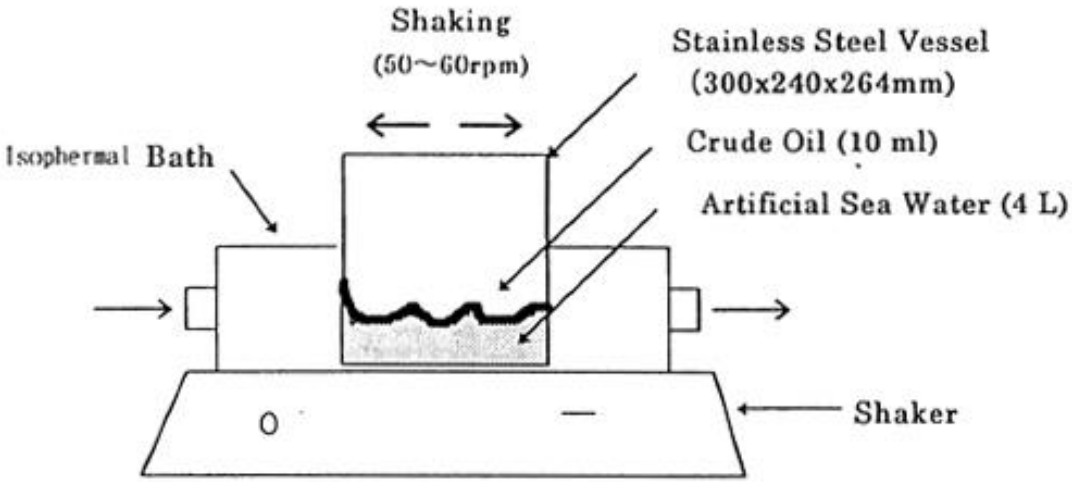
- ◆To elucidate self-cleanup mechanism of ocean for spilt oil by investigating various processes relating to cleanup of spilt oil in ocean
- ◆To propose more effective treatment method of spilt oil utilizing the cleanup function of ocean for spilt oil



Overview of the study

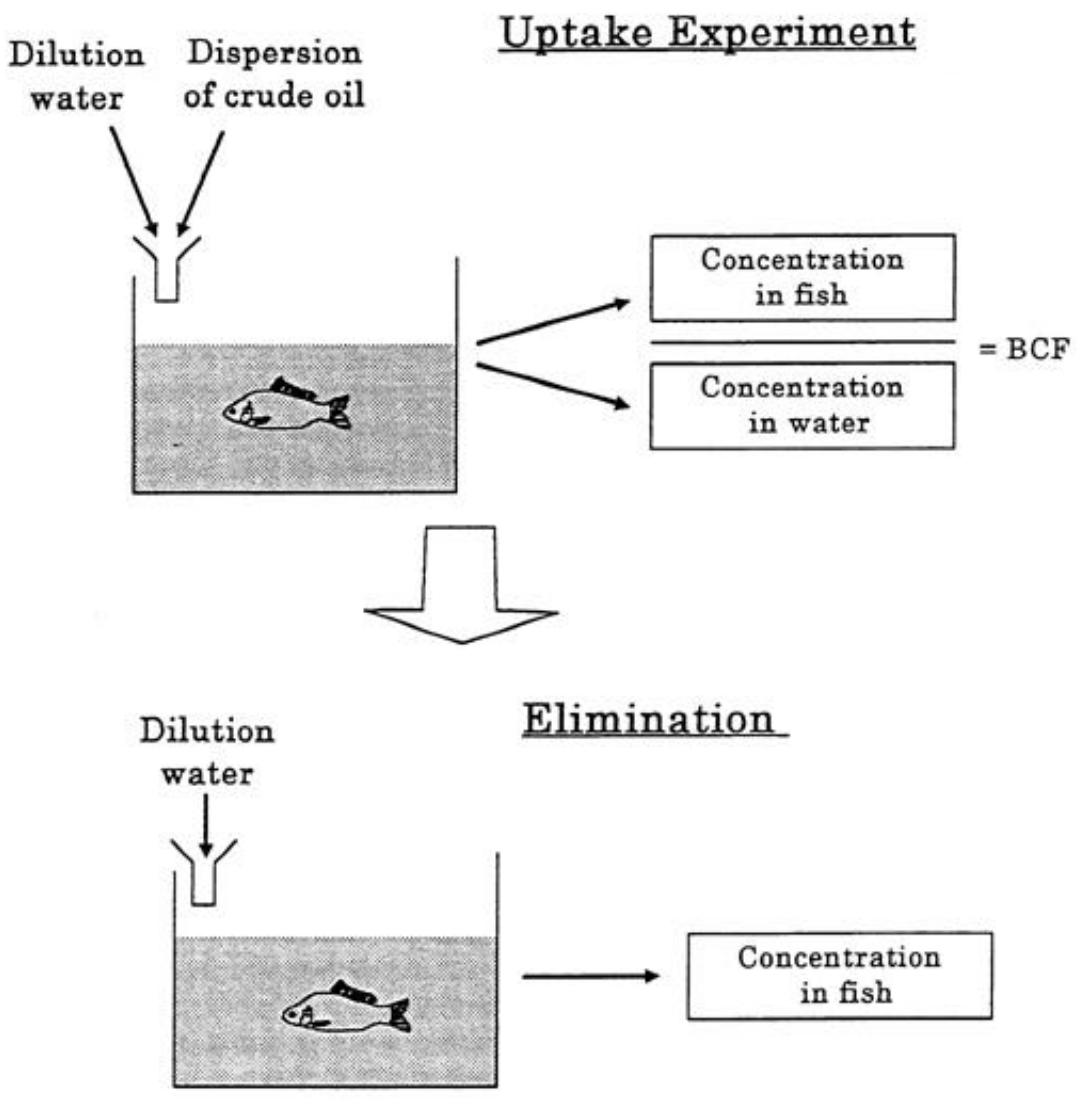
Study items

Items	
Laboratory experiments	
◆Environmental distribution	Distribution between air/sea water
	Adsorption to sediment
◆ Biodegradation	Biodegradation in sea water
	Inherent biodegradation in sea water
	Biodegradation on seashore
◆ Abiotic degradation	Photolysis and oxidative degradation
◆ Bioaccumulation	Direct bioaccumulation in fish and shellfish
	Bioaccumulation through diet
	Fish tainting
Field study	
◆ Analysis of residual oil in the oil-spilt site	
◆ Analysis of biota in the oil-spilt site	



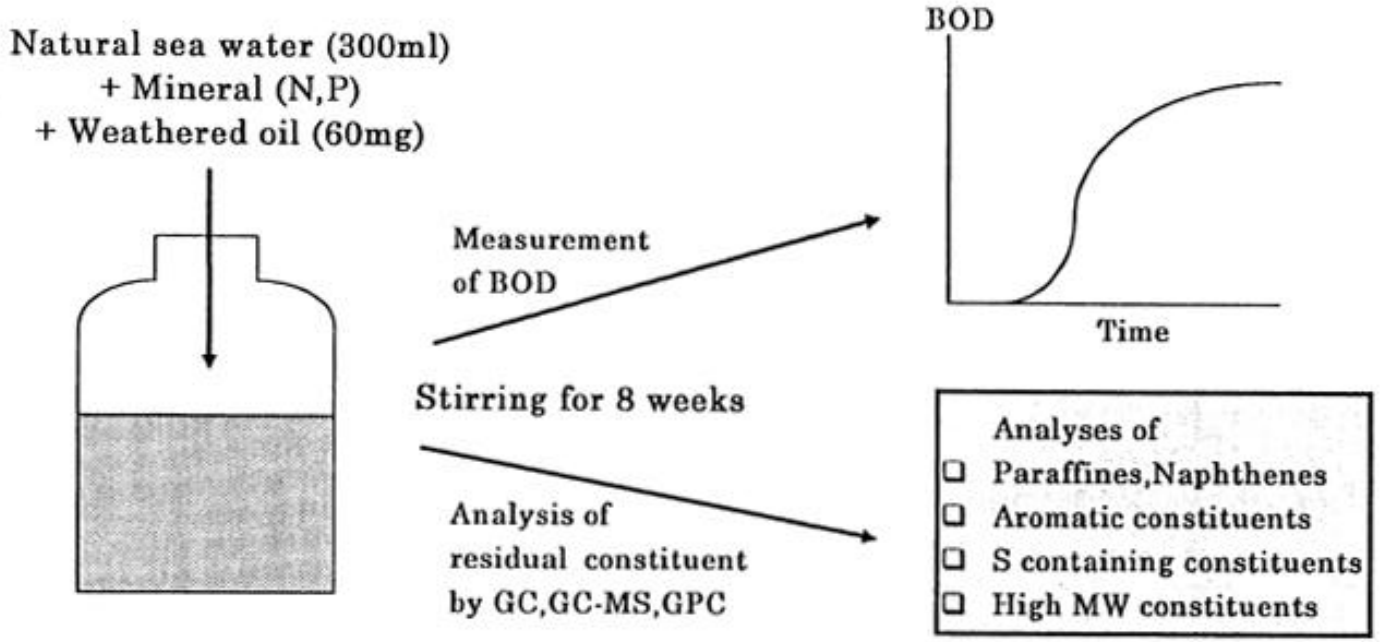
- ◆ Evaporation rate of oil and variation in oil composition
- ◆ Time-course of concentration of oil constituents dissolved in sea water
- ◆ Variation in air/sea water distribution kinetics by temperature, kind of oil, addition of treatment agent,

Air/sea water distribution test



- Rate and extent of uptake in fish
- Rate of depletion from fish

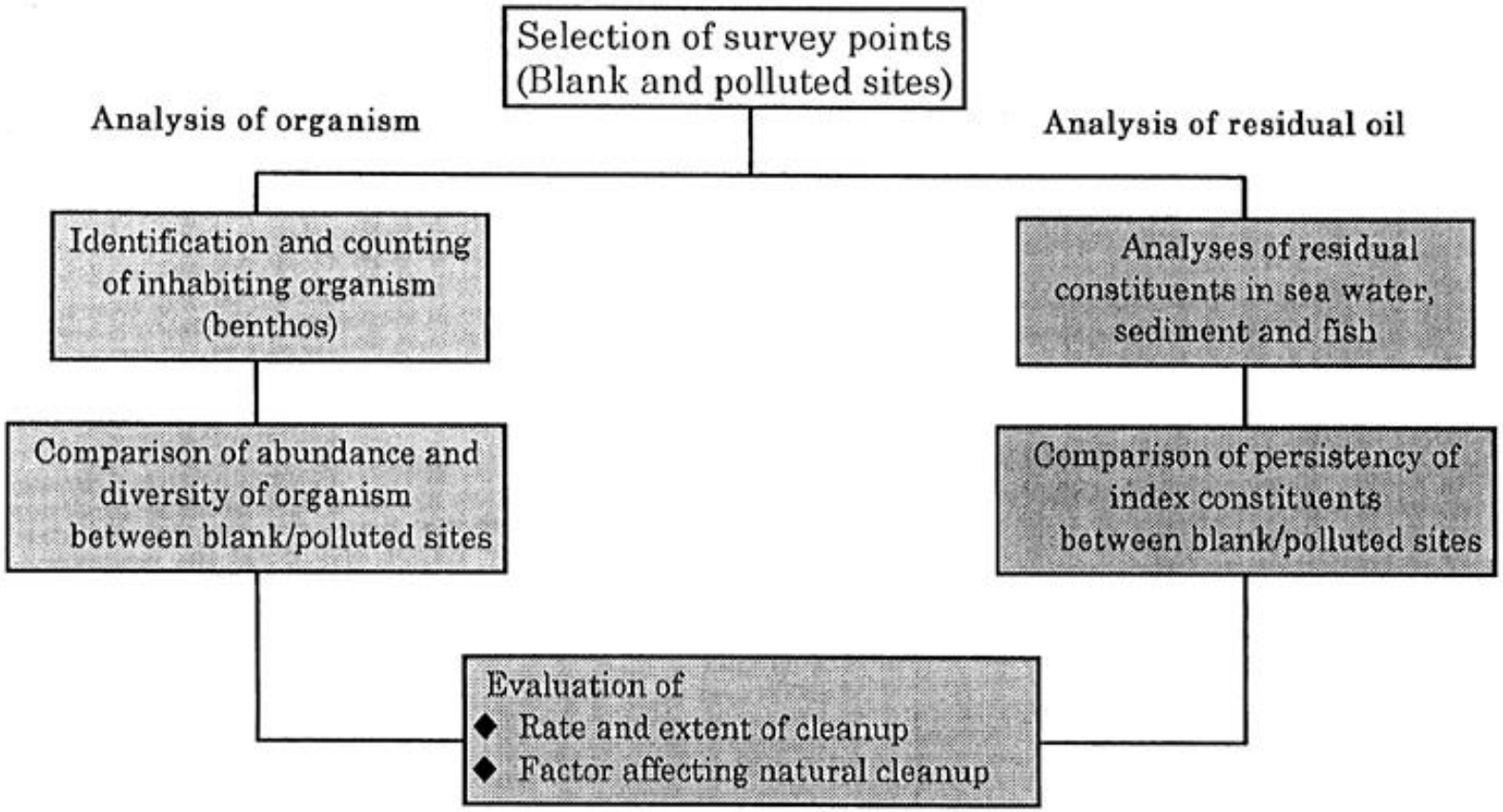
Method of bioaccumulation test



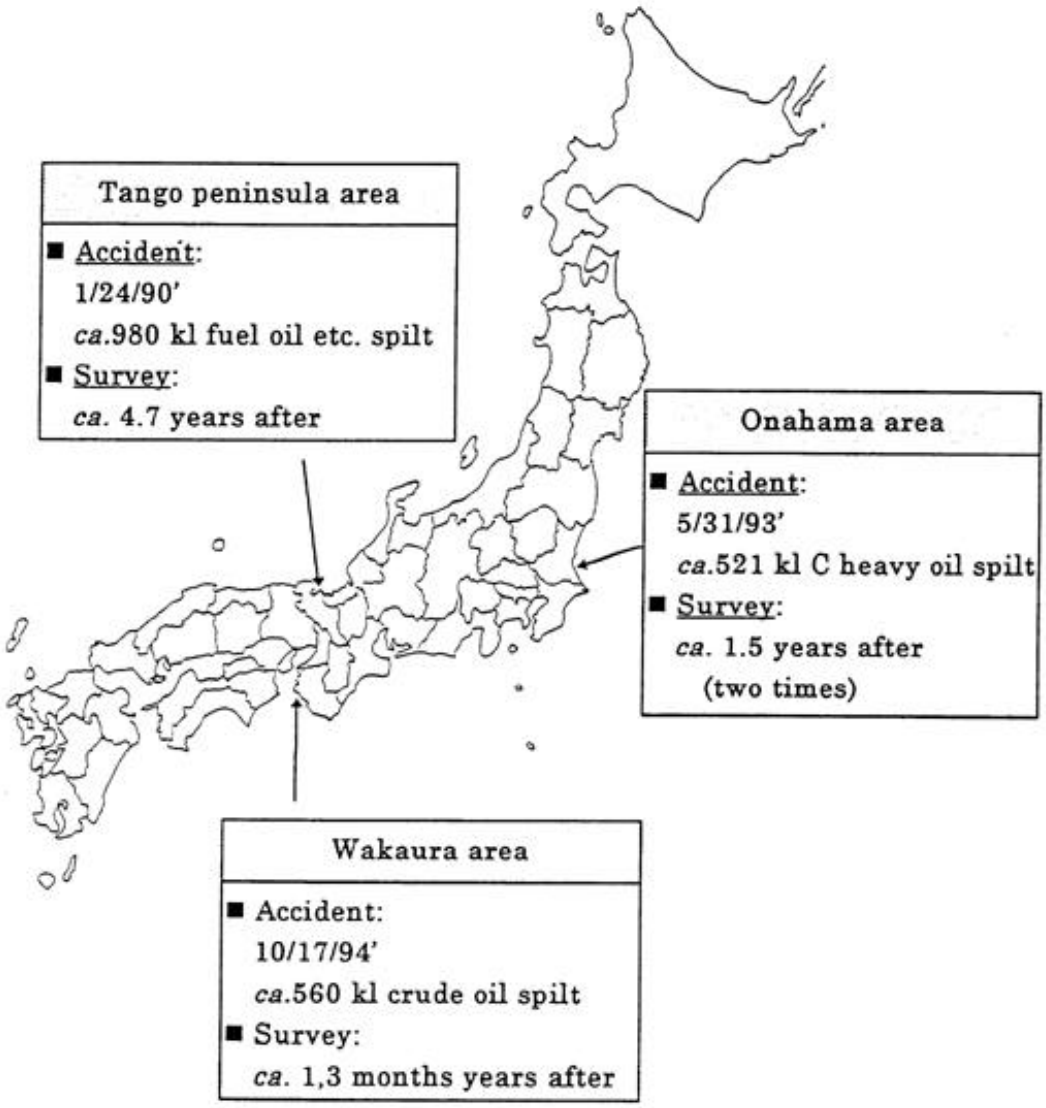
Rate and extent of

- "ultimate" biodegradation and
- biodegradation of each constituent

Method of biodegradation test

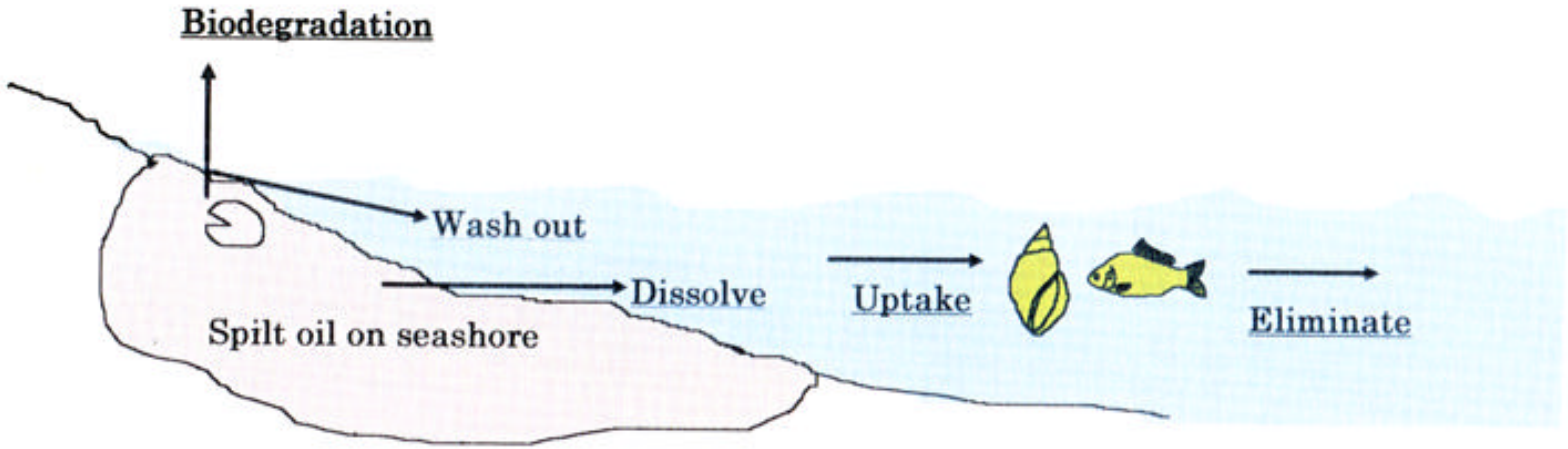


Field Test of Spilt Oil



Survey Area and Time of Field Test

Analyses	Selection of Index species	Assessment of cleanup
Blank & Pollutes sites Sea water, Fish & Sediment Alkyl Naph., Phen., BzT., DBzT, Pristane etc.	Indexes of Biodegradation Washing out Dissolution and Residual potential in fish	Rate & extend of cleanup Biodegradation Washing out Dissolution and Elimination from fish



Outline of analysis of residual oil