GESAMP
Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

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Agenda item 7

SCOPING ACTIVITIES

CG2: Scoping on the impact of hydrocarbon to the marine environment and public health

Submitted by Dr. Felicia Chinwe Mogo (Member of GESAMP)

Preamble

1 As extracted from GESAMP meeting report 2015, an important topic was raised by Dr.Felicia Mogo and Dr.Gerarado Gold-Bouchot during the informal meeting of the GESAMP members in the morning of Monday 31st August 2015 addresses the "impact of residues of chronic oil spills". Frequent oil spill incidents coupled with continuous application of dispersants is leaving a large build-up of variety of chemicals that eventually deposit at different levels in the water columns in addition to their toxic impacts on biodiversity and sediments. Through the food chain/foodweb, there could be transfer of these harmful chemicals into human beings and subsequent environmental health problems. In view of these issues, it has become imperative that GESAMP carries out the above to add further knowledge on the subject matter.

Action Taken By GESAMP

2 Agreed to develop a scoping paper in the intersectional period (led by Dr. Mogo, Dr.Gold-Bouchot and Dr. Ana-Carolina Fernandez).It was also seen as imperative to ensure the viability of the scoping paper, and to involve the potentially interested sponsoring organizations.

3 At the 43rd session in Kenya, the document was presented by Felicia Mogo but required amendment; therefore, she was advised on going forward.

Introduction

4 Hydrocarbon exploration has become the main stay of many nations economy. Research shows that up to 117 countries of the world are involved in hydrocarbon exploration.

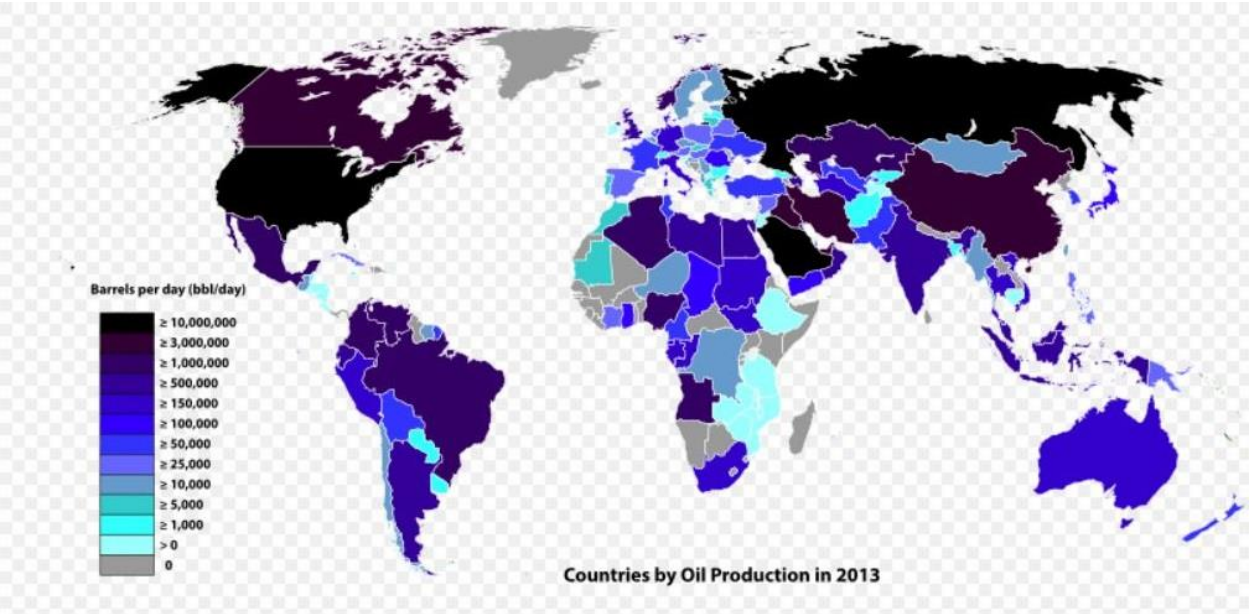


Fig 1: Countries producing Oil bbl/day, 2013. (CIA World Factbook).

This has also led to huge transportation of products along various sea routes of the globe

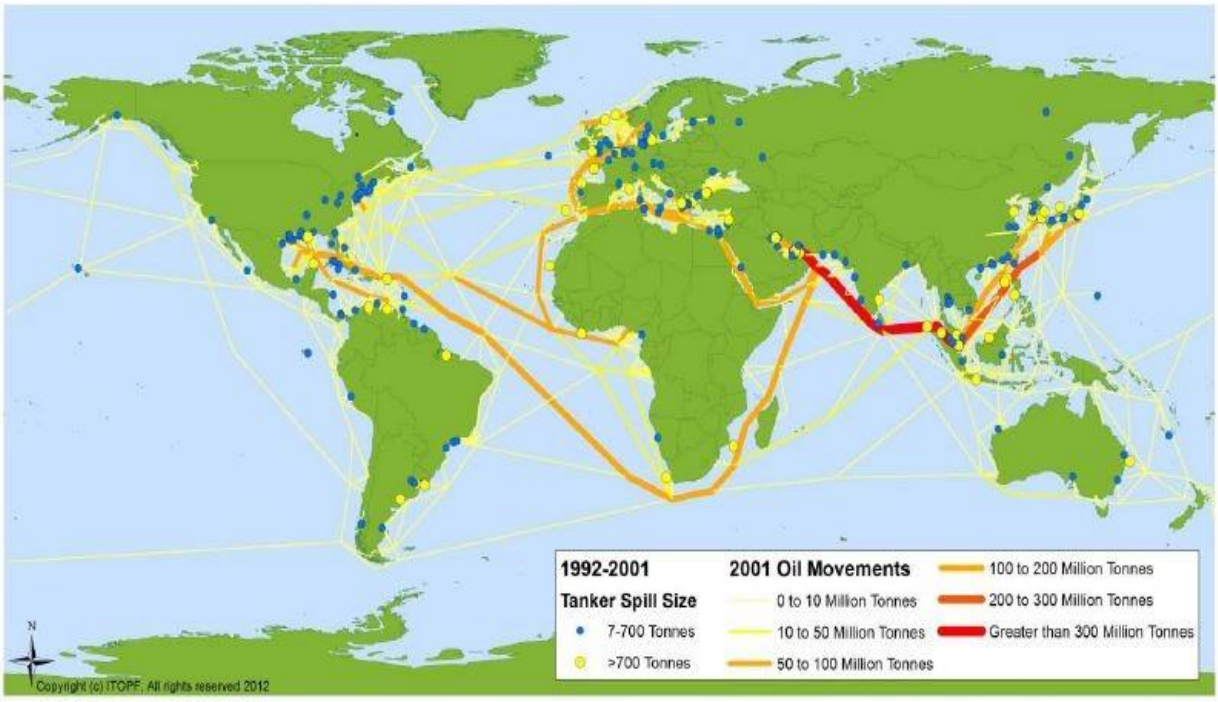


Fig 2: Oil Tanker Traffic and Tanker Spills, 7 Tonnes and Over (1992 – 2001) (Musk S. 2012)

5 The exploration and transportation of these products have in turn been associated with hues of pollution caused by oil spill leaving with it, trails of pollution both in the marine environment and surroundings with untold impact in biodiversity and human public health Efforts to combat these spill presence in the environment led to the use of dispersants as the name implies to disperse the oil spilt in the environment to encourage natural attenuation and clean up as possible.

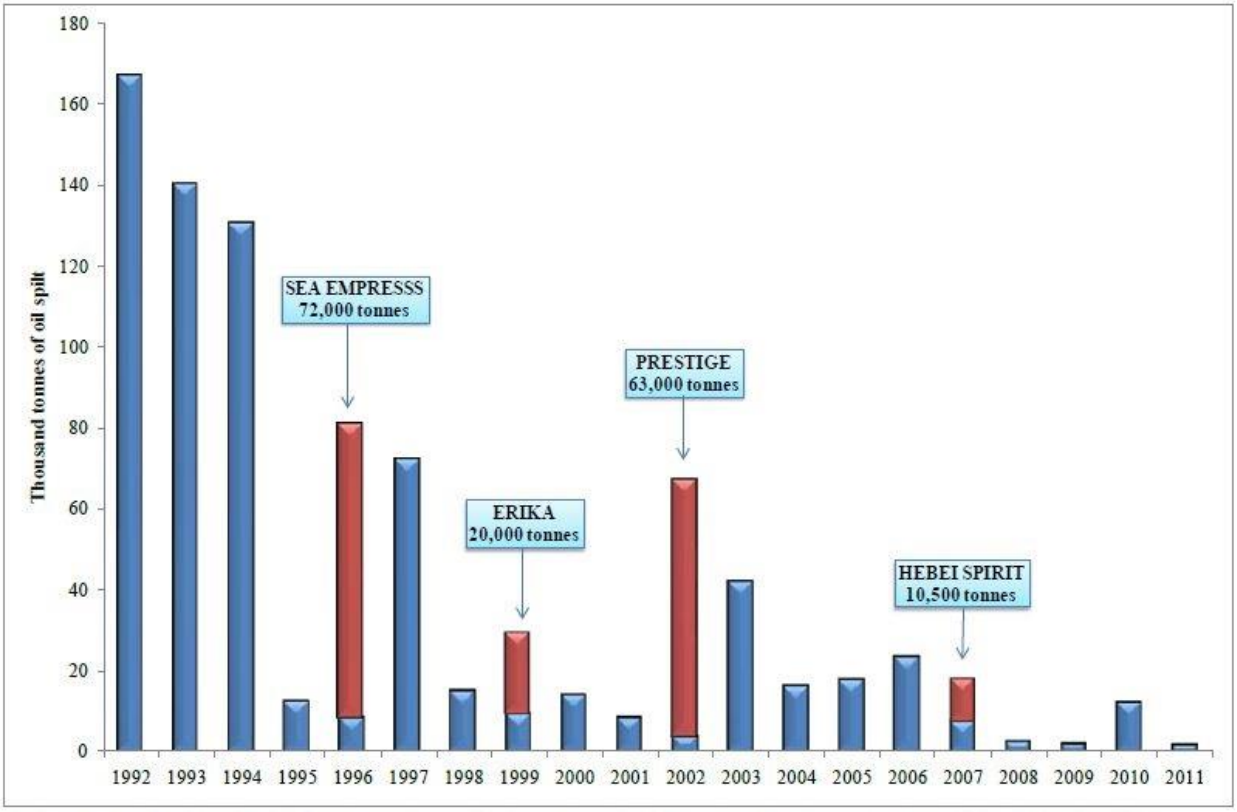


Fig 3: Quantity of oil spills of 7 tonnes and over from tankers, including significant spills, 1992 – 2011. (Musk S. 2012)

6 At this juncture it may be imperative to discuss in a nutshell what hydrocarbon is. It is an organic compound consisting entirely of hydrogen and carbon The majority of hydrocarbons found on earth naturally occur in crude oil where decomposed organic matter produces abundance of carbon and hydrogen (Wilberg E.,et al., 2001 and Miller R. D. I., et al 1989).

7 Crude oil is a complex, highly variable mixture of hydrocarbons and other trace compounds. Exposure may cause a variety of adverse effects, including narcosis, slowed growth, reduced reproduction, and death.

8 Research on environmental impact of oil spill began in the late 20th century as the oil industry developed and expanded. Large scale transportation of oil increased as a result of worldwide demand for oil subsequently increasing the number of oil spills (Chang S. E. et al 2014).

Hydrocarbons

9 Hydrocarbons are compounds made up of nothing more than hydrogen and carbons. When combusted, they give off a lot of energy, serve as source of fuel, result in the release of gases such as water vapour, carbon dioxide carbon monoxide and sulphur dioxide into the atmosphere. Hydrocarbons are classified into two major groups known as the Aliphatic and Aromatic hydrocarbons.

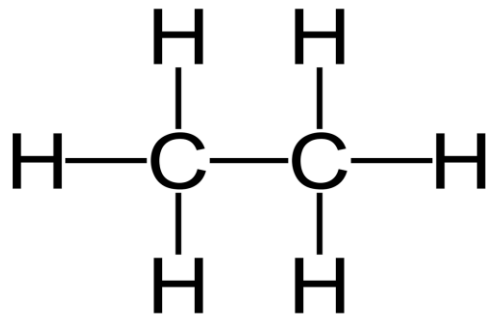
.1 The Aliphatic hydrocarbons are open-chain compounds and contain no rings of any type e.g. Ethane. They are further classified into two groups know as:

a. Saturated hydrocarbons; they are hydrocarbons which have as many hydrogen atom attached to every carbon atom;

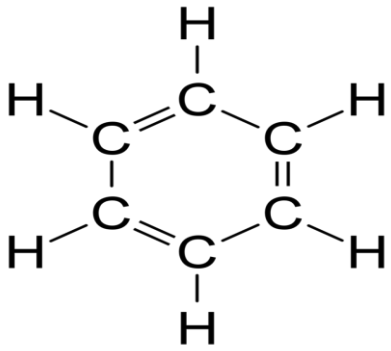
b. Unsaturated hydrocarbons; they are hydrocarbons with double or triple bond between some carbon atoms.

.2 The Aromatic hydrocarbons are pleasant in odour as the name implies with sigma bonds and delocalized pi electrons between carbon atoms forming a circle e.g. Benzene

Structure of hydrocarbon



Ethane



Benzene

Public health and the impact of hydrocarbon

10 To be toxic, oil components must be bioavailable to the organisms being exposed. Toxic effects depend on the duration of exposure, and the concentration of the chemical(s) involved.

11 The amount of oil exposure an organism will experience depends on many factors, including: oil type, spill volume, shoreline type, tide stage, weather conditions

12 There are four main routes of exposure for organisms during a spill:

.1 Direct contact - an organism contacts or becomes coated with a substance.
.2 Ingestion - an organism eats or drinks a substance.
.3 Inhalation - an organism inhales a substance in the form of a vapour, mist, or spray.
.4 Absorption - an organism absorbs a substance directly through its skin or respiratory membranes.

13 Public health statement for petroleum hydrocarbon refers to the toxicological profile of Total Petroleum Hydrocarbon(TPH) while factors that determine harm from exposure of TPH, age, sex, family, life, style, proximity, duration of exposure, source of contact and state of health, diet amongst others possible combination of other chemicals (www.asdr.cdc.gov).

14 Total Petroleum Hydrocarbon (TPH) is a term used to describe a broad family of several hundred chemical compounds that originally come from crude oil. It is mixture of chemicals made entirely from hydrogen and carbon. Many TPH contains gasoline, kerosene, or oily odours, because modern society uses so many of petroleum based products, e.g. Gasoline, kerosene, fuel oil, mineral oil and asphalt, contribution to the environment by them is potentially undispersed. The amount of TPH found in a sample is useful as a general indicator of petroleum contamination at that site. Though it does not give information about the particular petroleum hydrocarbon in the sample may affect people, animal, plants, by dividing TPH into groups of petroleum hydrocarbons that act while in the soil or water.

Scientists on better know what happens to them. These groups are called petroleum hydrocarbon fractions each containing many individual compounds.

Fate of oil in the environment and bioavailability

15 After oil is spilled, it typically undergoes eight main fate and weathering processes, which may all occur simultaneously in different degrees:

.1 Spreading and advection - When spilled, oil spreads out on the surface of the water. This increases the surface area of the oil, thus increasing the potential for exposure by all routes.
.2 Evaporation - Many components of oil evaporate. This creates a vapour that can lead to inhalation of toxic compounds as they pass from the water surface to the atmosphere.
.3 Dissolution - Some components of the oil will go into solution in the surrounding water. This increases the chance of exposure through direct contact, ingestion, or absorption for water column resources.
.4 Natural dispersion - Oil breaks up into droplets in the water beneath the slick and may float away. As a result, water column resources can be exposed through direct contact, ingestion, and absorption.
.5 Emulsification - Oil and water combine to form a mousse. Exposures can result from direct contact or ingestion.
.6 Photo-oxidation - Sunlight transforms some oil components into new by-products, which may be more toxic and water-soluble than the original components. Water surface and water column resources can be exposed to the by-products through inhalation, direct contact, absorption, and ingestion.
.7 Sedimentation and shoreline stranding - Oil washes ashore and also sinks after sticking to particles in the water. Exposure can occur through direct contact and ingestion of stranded or sunken oil.
.8 Biodegradation - Oil is slowly broken down by resident bacteria into H2O and CO_2. Biodegradation is a slow process, with little effect on exposures. Mangroves have complex breathing roots which may be blocked by oil, resulting in death. Fate of oil in water varies from accumulation in sediment and ground water exposing filter feeders and other organisms to risk to evaporation, adherence to particles amongst others.

Route of exposure

16 Breathing, direct and indirect through uptake from water, food, or soil or contact are routes of exposure. Transportation through the blood stream may be fast or slow depending on type of TPH.

Types of effect

17 Compounds of TPH such as benzene, toluene, and xylene can affect the human central nervous system and leukaemia (cancer) death at high dose. Further breathing toluene at concentrations greater than 100 parts per million (100 ppm) for more than several hours can cause momentary fatigue, headache, nausea, and drowsiness and long-time effect of permanent damage to the central nervous system as n-hexane) can "peripheral neuropathy" and paralysis in extreme cases. Animal studies have shown effects on the lungs, central nervous system, liver, kidney, developing foetus, and reproductive system from exposure to TPH compounds, generally after breathing or swallowing the compounds. Polycyclic Aromatic hydrocarbon (PAH) has been tagged the most toxic form of hydrocarbon and the content of run-offs of crude oil entering the marine environment. Fish exposed to this PAH exhibit an

array of toxic effects including genetic damage, morphological deformities, altered growth and development and mortality (Porterfield W., 1993; Wilberg E.,et al., 2001 and Miller R. D. I., et al 1989).

Possible potentiated effect of hydrocarbon and dispersants

18 The combination of oil and dispersant can have stronger negative effects on marine species than the oil alone (George 1961, De Vogelaere and Foster 1994, Cohen et al. 2001, Vosyliene et al. 2005).

19 The bioavailability of oil increases after dispersal, which can directly expose organisms to increased levels of hydrocarbons and allow the hydrocarbon-dispersant compound to enter the food chain (Mascarelli 2010).

Variables that may influence impact of oil spill in the environment

20 Certain factors are now known to be critical in influencing the action of spilt oil in the marine environment. Such as physical environment, weather conditions, geographical proximity and so on.

21 Marine ecosystems are structured in complex ways by many interacting species, and an oil spill will have a different impact on each of them. Although each ecosystem is unique, previous oil spills suggest several key variables .The chemical composition and quantity of the oil to which organisms are exposed are important factors determining how populations will respond to spilled oil. Toxicity pathways in different species are myriad and some examples may include ingestion of oil, accumulation of contaminants in tissues, DNA damage, impacts to immune functioning, cardiac dysfunction, mass mortality of eggs and larvae, e.g., in fish, loss of buoyancy and insulation for birds, and inhalation of vapours (Ormseth and Ben-David 2000, Rogers et al. 2002, Ma et al. 2003, Kazlauskiene et al. 2008, Incardona et al. 2009, Aguilera et al. 2010, Judson et al. 2010, Major and Wang 2012).

22 Ecosystem response to an oil spill is dependent upon both direct impacts on species and indirect impacts through altered species interactions.

23 Webler and Lord (2010) opined that apart from direct health impact, social, cultural, economic issues can fall out from oil spill incidents leading indirect health issues in human phycology.

24 Second, local conditions in the marine physical environment, in particular, wave exposure, tides and currents, and connecting waterways, would lead to dispersion patterns that may be quite distinct from offshore events. Many of the processes that influence the fate of oil after a spill, e.g., evaporation, emulsification, and sedimentation, are difficult to predict without knowing specific characteristics of the oil and ambient weather conditions, but some general trends can be described from general local hydrodynamic conditions. Niche differentiation or strata of habitation of organisms also influence impact and exposure to spill.

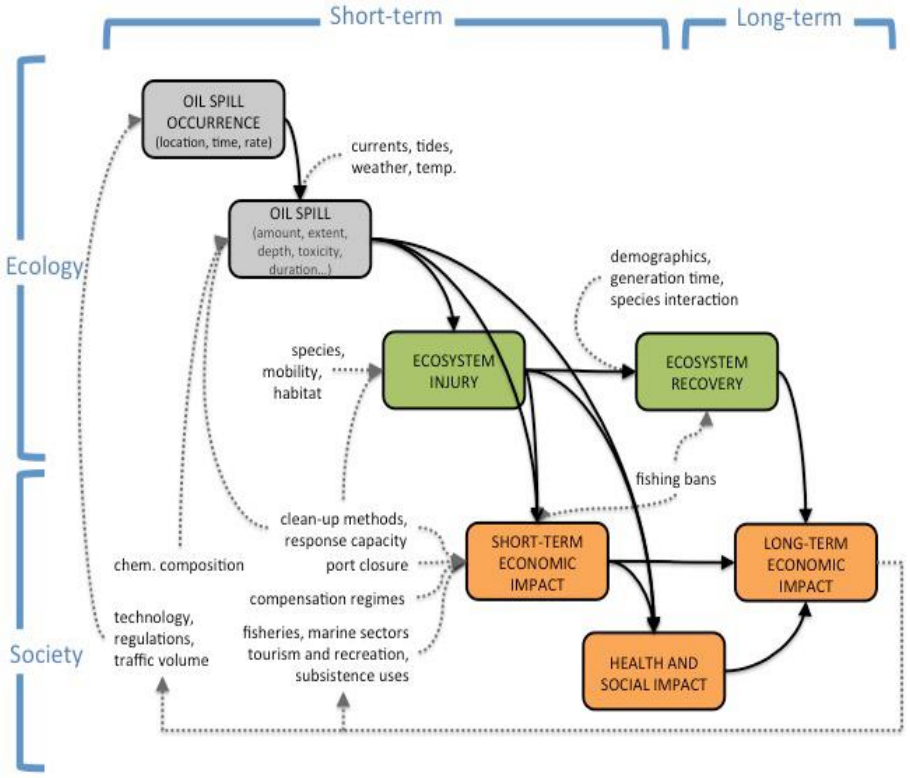


Fig 4: Oil spill impacts framework. (BOXES = outcomes, lowercase = variables, solid lines = linkages between oil spill occurrence and socioeconomic impacts, dotted lines= linkages between exogenous variables and outcomes. Grey boxes indicate oil spill outcomes; green boxes, ecosystem consequences; and orange boxes, societal consequences.) (Chang S. E. et al 2014)

Effects of chemically dispersed oil (Boyd J. N. et al., 2001)

25 The two main factors influencing aquatic toxicities of dispersant-oil mixtures are:

- Dispersed Hydrocarbons – properties and toxicity of oil; quantity and location of treated oil spill; characteristics, including mixing behaviour upon dispersion, persistence, stability of emulsions and dispersions; degree of weathering; and chemical and/ or physical toxicity of dispersed oil which depends on the species, life stages, habits, season, physiology, biochemistry, behaviour, Sand ecology of exposed organisms (Mackay and Wells, 1981).

- Dispersant – historically, the view was that the dispersants themselves contributed greatly to the toxicity of the dispersant-oil mixture. However, current studies indicate that low levels of dispersant contribute less to the toxicity of the mixture than the oil itself does (Lunel and Lewis, 1999). Dispersant factors include: composition and toxicity; ratio of dispersant to oil required for proper application; and potential interaction between dispersant solvent and surfactants with particulate and dissolved oil.

Exposure considerations

26 Dispersants are considered controversial by some in the response community because their use represents a deliberate introduction of chemicals into the water and, if they are effective, this results in an increased hydrocarbon concentration in the water column

(ITOPF, 1982 and IT Corporation, 1993). Although they are much less toxic than in the past, dispersants are toxic, just as oil is. Despite this fact, dispersant use may be the best, and least ecologically damaging, response option in certain spill situations.

27 The key to understanding the effects of dispersed oil is exposure, which includes both amount and duration (NRC, 1989). In areas where the dilution potential is the greatest (i.e., open ocean), concentrations of dispersed oil high enough to cause adverse effects are unlikely to persist for more than several hours (ITOPF, 1982; and NOAA 1994). Oil concentrations are typically less than 50 ppm below dispersed slicks, although slightly different upper levels are reported by the different authors where circulation is more restricted in near shore environments or in bays and estuaries) where the water level is low coupled with less circulation,, dispersed oil in the water column may not be diluted as quickly and as such, risk of impact is more. Surface dwelling organisms benefit more in the event of using dispersants as the oil film is reduced unlike bottom welling that received the dispersed oil settling downwards and therefore more exposed.

Action requested of GESAMP

28 Available information of which few have been presented above have confirmed that indeed chronic oil spill and dispersants pose problem to the marine environment and the ecosystem based on the type of oil, dispersant, bioavailability of the chemical to organism. Oil spill behaviour can also be influenced by many factors. The health impact to human may be in form of sub lethal effect or chronic in nature and also direct and indirect. Different physical factors also influence the impact of spill and the recipient physical environment may be impacted differently too and so on. Hence GESAMP is invited to consider and approve this proposal and carry out a research to add to the knowledge of impact of chronic oil spill to the marine environment and man based on regions. The outcome will assist in determining environmental and human safety at hot-spots; aid government in making informed decisions on standards and guideline for clean-up of oil spill and the use of dispersants to mention but a few.

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