Sources of Oil Pollution in Vietnam Sea and East Sea

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Key words: Oil pollution, sources, classification, map.

SUMMARY

Nowadays, due to the development of oil exploitation and shipping activities, cases of oil spill is more and more increasing in Vietnam Sea and East Sea. According to the research and assessment, oil pollution may be discharged from many sources. In this paper, authors introduce the spatial distribution and classification map of oil pollution sources in Vietnam Sea and East Sea in scale 1:1,000,000. Based on the extracted data from some reports of KC.09.22/06-10 National Project belong to the Program of Sea Science and Technology Serving Sustainable Socioeconomic Development, the map has been compiled after gathering, systemizing and classifying sources of oil pollution into different groups including natural oil spill, oil production and processing, sea transportation and shipping operators, coastal activities and the shipwrecks in the second world war. In addition to the thematic layers, authors mapping some supporting layers such as wind direction, sea currents, some oil slicks derived from radar satellite images, some cases of oil pollution in the past time, and so on to estimate the spread of an oil spill. This is probably the first time that the general picture for spatial distribution of oil pollution sources has been established. The results will serve as a reference in future oil pollution researching and help in proposal of monitoring, observing and acquiring periodical satellite imagine over pollution risk area.

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1. INTRODUCTION

Nowadays, in the world, oil spill in the ocean is one of the serious sea pollution issues which is concerned by international community. The US National Research Council (NRC) has estimated the amount of oil entering the sea from different sources - a total 3.2 million tonnes worldwide annually. The biggest source of oil into the sea is from urban and industrial inputs. The NRC estimates a total from this source of 960,000 tonnes - or 30% of the total tanker. Tanker operations are the next biggest source (22%), followed by tanker accidents (13%). Offshore production is the smallest source - contributing less than 2% of the oil entering the sea worldwide. A surprising amount of oil in the oceans occurs naturally - seeping through cracks in the earth's crust. The US NRC estimates that about 8% of oil comes from these natural seeps - four times the amount arising from exploration and production. (SRC Fact Sheet 2)

Oil pollution on the East Sea in general and oil pollution in Vietnam Sea in particular are not outside that state. East Sea and Vietnam Sea area is highly potential on oil resources and crowded with international shipping routes. Up to 2004, discovered oil reserves contain about 1.7 billion tons of oil and 835 billion m^3 gas, oil reserves of about 6 billion tons of oil and 4,000 billion m^3 gas has been also forecasted (Hai, Nguyen Tien., 2008). Every year, amount of goods transferred through the East Sea is about 70% of the imported oil from Middle East to Southeast Asia, about 45% of the exported goods of Japan and 60% import – export goods of China (Improve performance of seeking and rescue activates on the sea, n.d.). Therefore, oil spill usually happens in this area with many reasons. Cases of oil spill discharged from many sources, including the investigation of pollution source and unknown sources. Hence, there is an urgent need to create a map showing the spatial distribution of oil pollution sources.

In this paper, the authors present the spatial distribution and classification map of oil pollution sources in Vietnam and East Sea in scale 1:1,000,000. The map was established from many input data based on the scientific estimation of pollution risk as well as experience of practical domestic and foreign studies. In the framework of the project, the authors had extracted data, statistics from the oil pollution reports to gather, systemize and classify sources of oil pollution into different groups. In addition to the thematic layers, the authors integrated supporting layers to estimate the spread of oil spill. The results will serve as a reference in future oil pollution researching and help in proposal of monitoring, observing and acquiring periodical satellite imagine over pollution risk area.

2. STUDY AREA AND POLLUTION ISSUE

The study area stretchs from 0^0- 25^0 North and 100^0 - 120^0 East which covered the East Sea and Vietnam Sea. This is one of the highly development sea area in oil exploitation and sea transportation. Along with the development, oil pollution issue in this area is more and more increasing.

Some statistics reported that the volume of oil spills discharged into East Sea are around hundreds of thousands tons (Minh, Ta Dang., 1996):

Table 1. Discharge intensity of all sources into East Sea

Kind of Source	Discharge Intensity (tons/year)
Onshore	120,000
International Shipping	262,000
Oil tanker	100,000
Oil Filter and Petrochemistry	200,000
Exploitation in the shelf	90,000
Total	**772,000**

In Vietnam Sea, according to the reports, amount of oil spill annualy is estimated as follows (Minh, Ta Dang., 1996):

Table 2. Discharge intensity of all sources into Vietnam Sea

Kind of Source	Discharge Intensity (tonnes/year)
Onshore	4,038.5
Shipping	23,001.2
Accidents	500
Oil Exploration and Exploitation	910
Oil Transferring	370
Total	**28,819.7**

Only the oil pollution from the activities of oil and gas mention, the results of water quality monitoring Southern area of oil and gas industry in six main stations have shown that loss of oil from drilling into the sea is 270 tons in 1995 and 550 tons in 2000. From 1990 to 1995, twelve cases of oil spill from exploitation with amount of oil range from 2-3m^3 to 15m^3 is recorded. From 1995 to 2000, this figure is up to 91,497 tons discharged from 31 oil spill cases (National Report of Sea Pollution, 2004).

Another source of oil pollution is natural oil spill which can occur onshore or offshore depending on the geological structure and geomorphology at the sea. According to statistics, in the shelf of Vietnam sea, the drilling dust in the years from 1988 to 1997 (Unit: 1000m^3) was as follows: 3.6/year in 1988; 5.3/year in 1987; 6.8/year in 1989; 7.7/year in 1990; 9.6/year in 1991; 7.0/year in 1992; 12.1/year in 1993; 14.1/year in 1994; 16.2/year in 1995; 11/year in 1997. Another statistic shows that, from 1984 to 1997, Bach Ho and Rong oil fields with about 200 operating drilling wells discharged into sea about 70,000 m^3 (approximately 182,000 tons) drilling dust. At Bach Ho oil field with area of 60 km^2, this figures was up to about 0.1cm thickness (mostly and thicknest around the drilling point). Survey of Research and Development Centre for Petroleum Safety and Environment (implemented in 1995, 1996 and 1997 with fifteen samples of drilling dust at various positions in Cuu Long basin) showed that oil content of drilling dust in ranges from 0.1 - 11.7% (average 4.5%) (Hai, Nguyen Tien., 2008). Hence, thousands of tons of natural oil were discharged into this sea.

In terms of sea transportation, the current situation can be summarized as follows: annually, about 100 accidents and marine problems have occurred on Vietnam sea. Statistics from 2000 to the first six months of 2005 showed that Vietnam sea has found 497 accidents, maritime problems, including the 126 big and serious cases. The oil spills related to the port operations in 1995 was 450 tons, in 2000 was 600 tons; oil spills due to marine problems in 1995 was 500 tons, in 2000 was 1,500 tons, then the volume of oil spills from oil tankers up to 3500 tons in 1995 and 7500 tons in 2000 (National Report of Sea Pollution, 2004). This shows that the risk of oil pollution from oil tanker is very high.

Unoted pollution source but occupied a large proportion is the pollution source from land. In total 10,010 tons of polluted oil in 1995, the amount of oil pollution from land hold about 5,300 tons. According to monitoring data, concentration of oil in water was average 0.26mg/l at the river mouth of Ha Long - Hai Phong sea and average 0.29 mg/l in Vung Tau - Da Nang sea. In Ba Ria-Vung Tau, concentration of oil in water varies between 0.14 to 0.52mg/l is exceeded the limit of Vietnam Standards. In general, water quality along the coastal area was only B and C level according to Vietnam Standards 5943-1995 (National Report of Sea Pollution, 2004).

In addition, another considered source of oil pollution is caused from sunken oil tankers in the Second World War (WWII). After the Second World War, many shipwrecks had been founded including numerous of oil tankers with their different weight. Only Pacific region

mention, the Japan shipwrecks was up to 80% of the total (Rean Monfils). How much shipwrecks are in Vietnam and East Sea? It is still unknown number. This is considered as one of the unknown oil pollution at sea.

The increasing of oil spill has negatively impacted on economic, social and ecological environment of many countries in the region. In particular, the most serious series cases of unknown source oil pollution on the Vietnam sea happened at the first months of 2007 has caused bad influence in the social life of Vietnam. These seriously oil spills had affected more than 20 coastal provinces in the country. Up to 23 April 2007, the total oil collected in these provinces is about 1,721 tons. Ministry of Natural Resources and Environment held two national conferences with the presence of dosmetic and foreign agencies and experts on issues of oil pollution on the sea. However, answers about the origin of oil pollution on the sea remains open.

We can see the likely source of oil pollution on the sea are many and difficult to determine the exact cause in unexpected cases. To determine the source of oil seepage, the spatial distribution and classification map of oil pollution sources on the sea is one of the essential factors. At first, the map will provide an overall picture of the pollution source position then localize the suspicious area to investigate and search for possible polluter. Next, the map will help for the prevention and warning of oil pollution at the active situtation. The statistics and classification also has given a general overview of oil pollution on the Vietnam and East Sea. Especially, the spatial distribution and classification map of oil pollution sources on the sea will be the premise for the establishment of the zoning map of oil pollution risk on the sea.

3. MATERIAL AND METHODS

3.1. Data set:

a. Reports, statistics:

This study used input data from many sources including reports, statistics of oil pollution sources. Reports have been carried out based on collected statistics and new surveys on a large scale. The statistics of oil content and pollution intensity was conducted by relative specialty offices.

- The possibility of natural oil spill is assessed based on the opencast oil. Through the process of research, review and evaluation, opencast oil points in Vietnam Sea and East Sea is declared in a project of Dr. Phan Trong Trinh.

- Figures and information of pollution sources from shipping activities are mainly collected from reports of Center of Environmental Monitoring and Data Information cooperation with Vietnam Department of Maritime

- Figures and Data of oil spill caused by exploitation and processing extracted from reports of Faculty of Oil and Gas, Hanoi University of Mining and Geology contribution with Vietnam Oil and Gas Corporation

- Oil content discharged by coastal activities is measured at coastal monitoring station of Environmental Monitoring and Data Information Center

In addition, some database of cases of oil spill in the past time is also used as a supporting layer in this map

b. Satellite images:

Satellite images are one of the input data of the project. In this project, the authors used 20 scenes ALOS-PALSAR purchased from Earth Remote Sensing Data Analysis Center (ERSDAC-Japan). Data is obtained in ScanSAR mode, 100m resolution, scene size 350km x 300km, level 4.2. Acquired time ranges from January, 2007 to December, 2008 when occur big case of oil spill unknown sources in Vietnam. After processing, PALSAR images have been analyzed to detect oil slicks. Other information of oil slicks such as coordinate, length, area, size was also calculated.

c. Reference maps:

Some reference maps were used in this study, as follow:

- At present, in Vietnam, no publication of location map of WWII shipwrecks were declaired but a global shipwrecks database was contributed. Therefore, this study used these global database to extract information of ship type, tonnage and location of vessels lost in WWII in study area
- Location of pollution sources by coastal acitivities such as tourism point, industrial area, aquaculture area is mapped based on thematic layers in Vietnam Atlas published by Ministry of Science and Technology
- Supporting layers like wind direction and sea currents are also presented on the map to study the spread of oil slick
- In addition, the authors refered the project result by members of Centre for Remote Imaging, Sensing and Processing, National University of Singapore. Based on the layer of oil pollution intensity in Vietnam sea and East sea, we can estimate which area has high or low risk. By these appraisement, planning of prority monitoring the high risk area can be favourably made decision.

d. Public domain data:

The 30 arc-second DEM grid was used as a seabed topography background. This gridded bathymetry data was downloaded from the website of General Bathymetric Chart of the Oceans

A copy of the grid can be found at:
http://www.gebco.net/data_and_products/gridded_bathymetry_data/

3.2. Methods:

The authors has established database and map of pollution sources based on the integration of remote sensing, oil infrastructure data, oil cases in the past and oil slicks detected in PALSAR images in GIS system. Map and database content is contributed and standardized by ArcGIS software. Map projection is the World Mecartor, Ellipsoid WGS-84, scale 1/1,000,000, using different symbols and colors cooperation with methods of map presentation to show location, geographical distribution of pollution source objects. Map content was separated in three groups:

- Background group
- Thematic group
- Supporting group

In background group, along with the basic objects likely shoreline, administration boundaries, bathymetry, there are some supplymentary layers for estimating the spread of oil slicks when problems occur such as the main sea currents and the main wind direction. In this map only two specific wind directions have been considered and they are Northwest and Southeast monsoon, two sea currents of January and July were displayed on the map. Position of the sedimentary basin is also one of place required tracking, monitoring and preventing of the natural oil pollution because of potential oil and gas resources distributed mainly in this basin.

Figure 1. Background group

In thematic part, authors divided pollution sources into different groups. Base on this division, we can evaluate which group has the high capability of causing oil pollution and which group is less capable of causing oil pollution. Particular groups:

- Natural oil pollution sources
- Pollution sources caused by oil exploitation and processing
- Pollution sources caused by sea transportattion and shipping operations
- Pollution sources caused by sunken oil tanker in the Second World War
- Pollution sources caused by coastal activities

The detail objects of each group will be shown in the following figures:

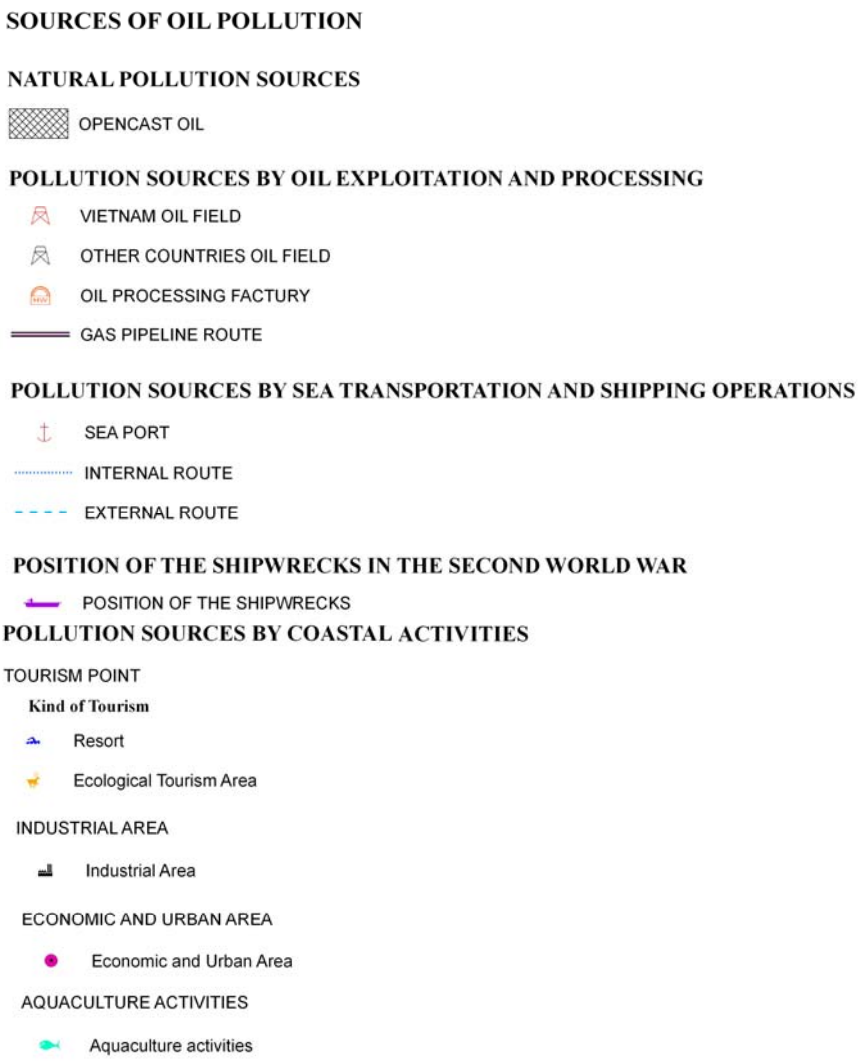

Figure 2. Thematic group

In each thematic layers, in addition to the spatial data shown on the map, the attribute data was attached to present the information of pollution source groups such as characteristics, properties and oil content measured in monitoring stations in these sea area.

Attributes of Aquaculture

FID	Shape *	ID	NAME	AVERAGE	OILCONTENT
0	Point	1	Quảng Ninh	18.648784	0.25
1	Point	2	TP. Hải Phòng	18.905848	0.38
2	Point	4	Nam Định	10.340743	0.25
3	Point	6	Thanh Hoá	9.1188	0.4
4	Point	7	Nghệ An	9.917186	0.4
5	Point	8	Hà Tĩnh	13.248942	11.04
6	Point	9	Quảng Bình	17.981195	5.05
7	Point	10	Quảng Trị	17.784196	9.03
8	Point	11	Thừa Thiên- Huế	13.532982	3.08
9	Point	12	TP Đà Nẵng	30.575631	2.05
10	Point	14	Quảng Ngãi	35.184492	20.07
11	Point	15	Bình Định	46.011232	11.19

Figure 3. Oil content obtained in sea monitoring stations at coastal aquaculture

The supplementary information such as oil slicks detected from satellite images, the cases of oil spills in the past, etc. .. also be presented to support the research and evaluation of oil pollution sources. In this part, attribute data are genearted for illustrating such as some information on date of capture, coordinates, location, size and area of oil slicks detection from satellite images. With regard to cases of oil spills in the past, this layer contain information about dates, locations, causes as well as the impact and loss of these accidents.

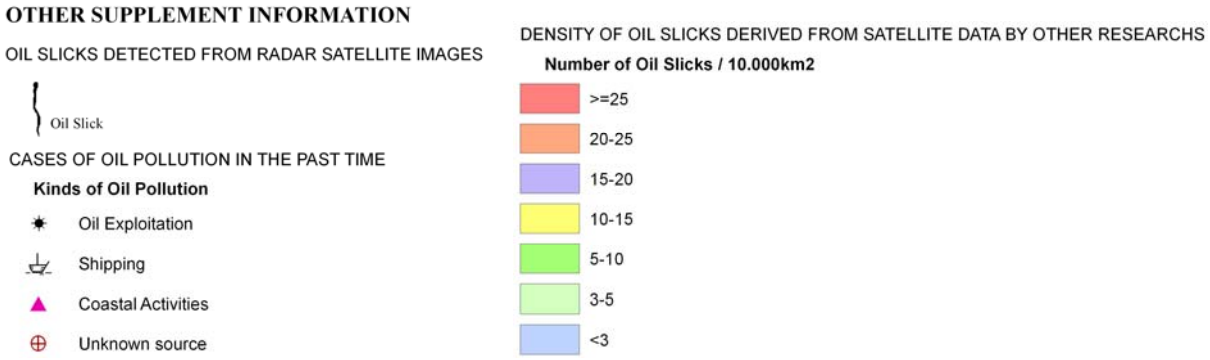

Figure 4. Supporting group

Besides, this study used methods of data and information statistics and collection from the reports of oil pollution afterward classification and evaluation the pollution intensity of each group.

Method of digital image processing is also used in this study. Satellite images after correction, noise filtering and contrast enhancement have been used for oil slick detection. Since then oil slicks were converted to vector and overlaid on the map. Radar data with some advantages such as ability of cloudy weather and night conditions obtaining, wide coverage, low revisit and near real time observation is useful information source for localizing oil spill. Combination of remote sensing and GIS can significantly improve management of oil spill monitoring and surveillance.

4. RESULTS AND DISCUSSION

Based on collected and processed data, spatial distribution and classification map of sources of oil pollution on coastal Vietnam and East Sea has gathered and presented most oil pollution sources on the sea, including onshore and offshore pollution. This study has generated a set of database including both of spatial and attribute data which illustrated information about characteristics and properties of the source groups in these sea area. Map in scale 1:1.000.000 covered all study area of East Sea and Vietnam Sea. In GIS environment, calculation of size and query of location of oil slick as well as pollution sources can be easily implemented.

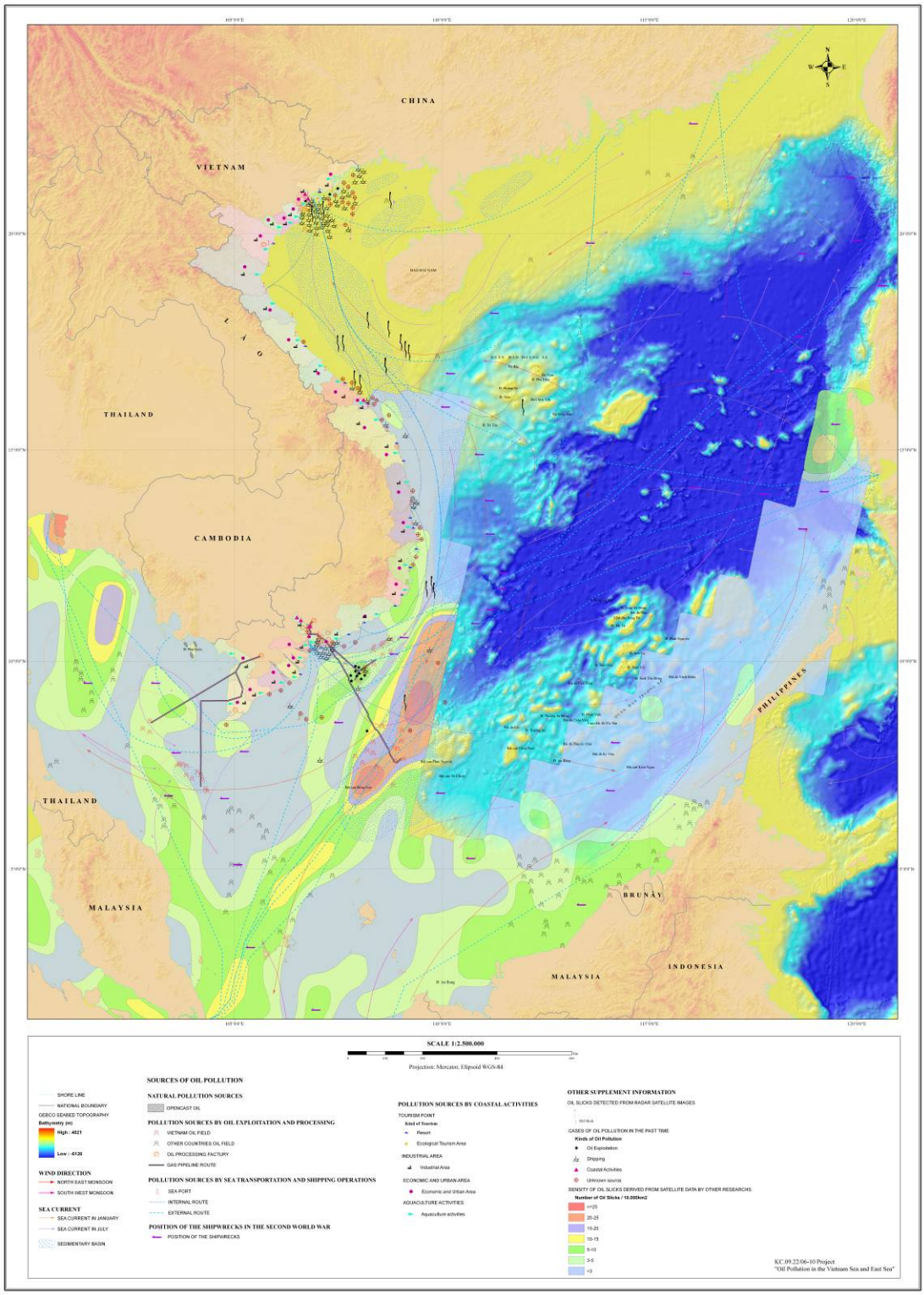

Figure 5. Spatial distribution and classification map of oil pollution sources

From the visualization map, we can found that more oil pollution sources concentrated along the shore. However, amount of oil discharged from these sources is less than offshore sources. The location must be pay attention are port areas and shipping routes where the cases of oil pollution usually occur. Volume of oil seepage from these sources is quite much that causes seriously sea pollution. Therefore, this is one of the sources should be focused on monitoring and prevention of oil pollution. Oil exploiting and processing areas is also the place where has many oil slicks detection from satellite images as well as the cases happened in the past. It means that source from oil exploiting activities is one of the areas need attention. In addition to common sources, the position of sunken oil tankers in the second world war is also one of the unknown sources causes oil spill. On the map, location of oil tankers usually concentrated along the shipping routes. Besides the oil spill with specific causes, there is still a lot of oil pollution cases we haven't known causes of oil seepage. Based on the supplementary information as wind direction, sea currents, oil spills of unknown origin may be analysed in combination with mathematical model to find out the cause. Additionally, the database enlosed with the map is also the supporting information for evaluation of the pollution level of source groups.

As the results shown on the map, we can localize range of areas concentrated on more risk of oil pollution on the sea then design the priority monitoring workflow such as seting of satellite images obtain with regular frequency mode or building more monitoring and measurement stations for these area. In this paper, the oil and gas exploitation areas and shipping routes are two positions should be focused monitoring. Proposals of preventing and minimizing pollution from the sources are also outlined more actively. A general map of pollution sources cooperation with the mathematical model will give the more persuasible supposition in searching for the origin of oil pollution. Moreover, from the spatial distribution and classification map of oil pollution sources on the sea, we can generate more new derivative maps. For example, from the result map, using spatial analysis tool in GIS combination with weight evaluation model we can build zoning map of pollution risk areas. In the other side, the result will be cooperated with other information and attribute data to contribute the database supporting the predicted and responsed acitivities of oil spills.

This is probably the first time an overall picture of the distribution positions of the oil pollution sources in East Sea and Vietnam Sea is developed in form of map. Up to now, some sources is only mentioned in some reports without statistic, aggregate of all the concrete sources including sources of direct and indirect, onshore and offshore pollution. In the future, this topic will be continuously researched and expanded for set of complete data to serve the oil pollution study. The newest data such as satellite images and database will be updated usually in this study. An extended GIS system with overall workflow from data collection to processing and final database management for preventing and responding oil spill can be developed from this application.

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