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Review of Potential Effects of Oil Spills on Coastal and Marine Resources on Western Libyan Coastal

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استعراض الآثار المحتملة للانسكابات النفطية على الموارد الساحلية والبحرية على الساحل الغربي الليبي

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Abstract

An oil spill can significantly affect coastal resources and the economy through economic activities that depend on clean seawater, coastal areas, and tourist sites, which may cause substantial economic losses after oil spills. However, this effect usually depends on the volume and type of oil spill and how sensitive it is to coastal and marine resources. Libya has one of the important Mediterranean marine biodiversity hotspots, which is the western Libyan coast that extends from western Tripoli city to the Gulf of Gabes with Tunisia. This work considers some of the effects of oil spills on a variety of coastal industries and social activities. In addition, this work provides a systematic literature review of biological, economic, and cultural resources and their sensitivity to oil spill scenarios on this coast. The findings of this work help provide a basis for the definition of priorities for protection to develop the capacity to respond to oil spills on the Libyan coastal.

Keywords: *Oil spill; Biological resources; Libyan west coast; Oil spill sensitivity; Socio-economic resources.*

الملخص

يمكن أن يؤثر الانسكاب النفطي بشكل كبير على الموارد الساحلية والاقتصادية من خلال الأنشطة الاقتصادية التي تعتمدفى عملها على مياه البحر النظيفة والمناطق الساحلية والمواقع السياحية مما قد يتسبب في خسائر اقتصادية كبيرة بعد الانسكابات النفطية. ومع ذلك، يعتمد هذا التأثير عادة على حجم ونوع الانسكاب النفطي ومدى حساسيته للموارد الساحلية والبحرية. ليبيا لديها واحدة من أهم النقاط الساخنة للتنوع البيولوجي البحري في البحر الأبيض المتوسط وهو الساحل الغربي الليبي الذي يمتد من غرب مدينة طرابلس إلى خليج قابس مع تونس. يأخذ هذا العمل في الاعتبار بعض تأثيرات الانسكابات النفطية على مجموعة متنوعة من الصناعات الساحلية والأنشطة الاجتماعية. بالإضافة إلى ذلك، يوفر هذا العمل مراجعة منهجية للأدبيات الخاصة بالموارد البيولوجية والاقتصادية والثقافية وحساسيتها لسيناريوهات الانسكاب النفطي على هذا الساحل. تساعد نتائج هذا العمل على توفير أساس لتحديد أولويات الحماية لتطوير القدرة على الاستجابة للانسكابات النفطية على السواحل الليبية.

الكلمات الدالة: تسرب النفط، موارد بيولوجية، الساحل الغربي الليبي، حساسية التسرب النفطي، الموارد الاجتماعية والاقتصادية.

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1. Introduction

Global trade, particularly the transport of oil products, has increased rapidly with the industrial revolution and is mainly supported by marine transportation (Naz *et al.*, 2021), which sometimes causes ship accidents, resulting in oil spills that are considered a significant threat to the marine ecosystem (Liu *et al.*, 2019). In fact, 80% of Libyan crude oil is exported via oil tankers and pipelines in the Mediterranean Sea. In addition, Libya has the largest storage and exploration of the oil and gas industry at sea on the western Libyan coast (NOC, 2021). Accordingly, these locations may all pose a serious threat to the marine habitats of ecosystems and the people living near the contaminated coastline, affecting their livelihoods and impairing their quality of life (ITOPF, 2011). Therefore, identifying and assessing coastal resources and their existing conditions can help decision-makers understand, manage, and reduce the risk of an oil spill (Oliveira *et al.*, 2014). As mentioned above, the aim of this paper is to determine the activities that are potentially damaged by oil spill risks for future oil spill disasters, such as marine protected areas, fishing, beaches, tourist and cultural sites due to their locations near potential oil spill sources along the coastline between Abu Kammash and Tripoli city (Al Garaboly). Sections of this paper are set out as follows: Section (1) Methods of data collection. Section (2) presents the socio-economic activities, their existing sensitivity to an oil spill, and its effect, respectively, including the cultural and historical sites and industrial activities. Section (3) focuses on three important biological resources: migratory birds, sea turtles, and marine mammals (dolphins) and the effects of oil spills on them. Section (4) results. Section (5) the conclusions

2. Area of Study

The area of study is located between 33°10'00" N-11°33'43" E, and 32°47'26" N-13°49'28" E. It has the largest population density in Libya, as shown in Figure (1. A) (Bureau of Statistics and Census Libya, 2021; and Badi *et al.*, 2018). Furthermore, it includes the marine protected area of Farwa Island, which represents one of the most important sites of habitats and high biodiversity used as a feeding and nesting place for loggerhead turtles and feeding places for migrant birds, as shown in Figure (1. B) (MedPan, 2021; and Etayeb *et al.*, 2012). Moreover, it includes Sabratha city, which is the biggest archaeological site as pronounced by UNESCO World Heritage Site in 1982 (UNESCO, 2021) as it covers various coastal types, such as coastal salt marsh, rocky shores, and sandy beaches. According to the survey in the available literature review, there are a few studies on the risks and sensitivity of oil spills on the Libyan coast, which reflects a wider discrepancy between the extent and detail of southern Mediterranean research. Previous studies on the Libyan coast are limited to one paper (Maitieg, 2018). This paper deals with the coastline sensitivity in only one city in Libya, "Misratah City". Actually, this paper focuses on the coastal resources along the western Libyan coastline to help provide a basis to outline the priorities for protection and information plans to achieve the best-suited response and reduce adverse environmental consequences.

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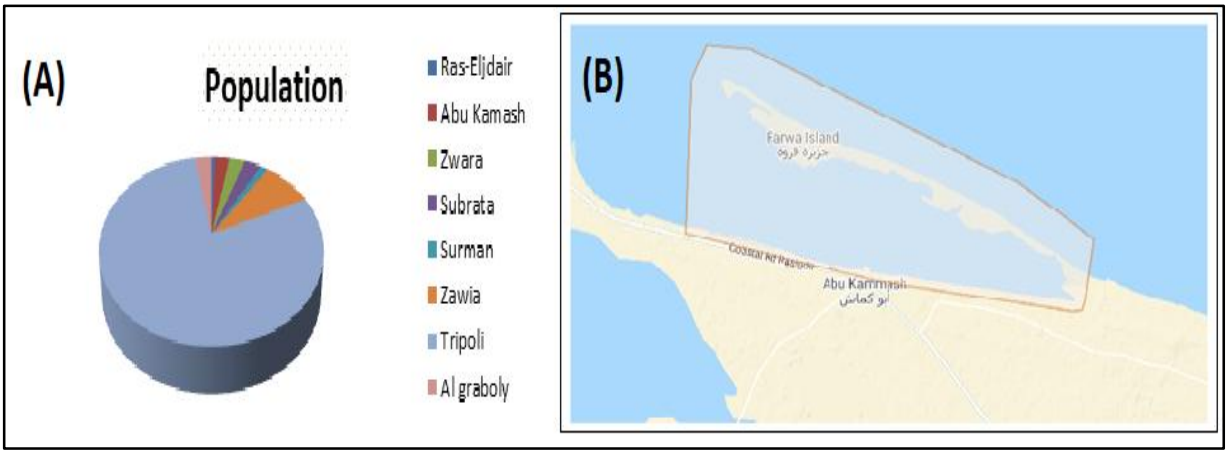

Figure 1. A) Libyan population Percentage on the western coastal (Badi *et al*., 2018); and B) Map of Farwa Island (Marine Protected Area) (MedPan, 2021).

3. Methods and Data Collection

The framework was developed for understanding oil spill impacts according to the literature review, with an emphasis on environmental and economic impacts, which were identified in several domains. It can be used to clarify the complexity of oil spill consequences, facilitate comparison across events, and support the development of planning scenarios for potential future oil spills. The acquired data on coastal habitats and species for this paper was collected from the available literature, and annual scientific reports of the United Nations Environment Programme (UNEP) as well as some Libyan government organizations such as the National Oil Corporation, Environmental General Authority, Marine Biology Center, and Bado Society for the environment. The survey conducted in 2019 was targeted at checking on literature sourced information, obtaining data on the current status of resources in the study area, as well as identifying and defining the potential negative economic and environmental effects of oil spillage. This has been performed through referring to government documents and reports and previous papers related to oil spills and their environmental and societal consequences, with an emphasis on their environmental and economic impacts (ITOPF, IPIECA). This paper identifies the sensitivity of coastal resources to oil spills along the Libyan coast from Abu Kammash to Tripoli (Al Garaboly), clarifying coastal resources' importance to local communities and defining the existing condition of coastal resources as shown in Figure (2) in a hierarchy of categories. The results of this paper help planners to identify and define the potential negative economic and environmental effects of oil spillage. Furthermore, it provides specific details to help them set up protection priorities and clean-up strategies to preserve amenity values as well as historical and cultural sites.

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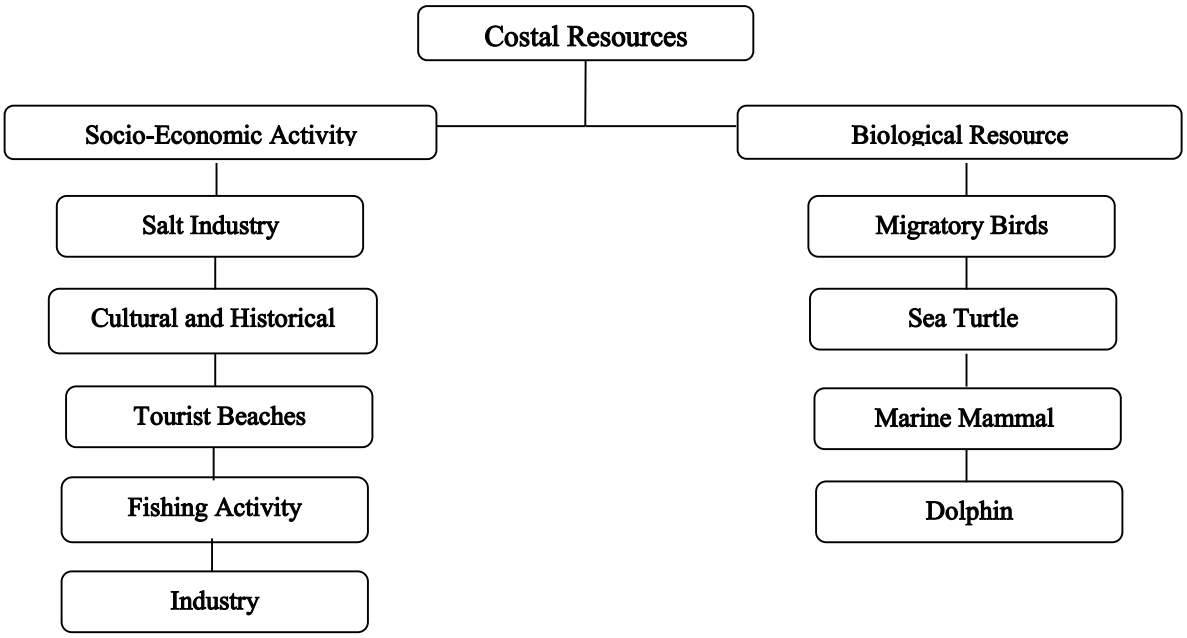

Figure 2. Classification of coastal resource categories along the shoreline from Abu Kammash to Tripoli city

4. Socio-economic Activity and Their Existing Sensitivity to Oil Spill

4.1. Salt Industry

Coastal wetlands are considered the most productive ecosystems on Earth (NOAA, 2021). The salt industry depends on salt marshes, which were turned into salt deposits following the evaporation of seawater (Eiser and Kjerfve, 1986). In Libya, most of the salt industry is concentrated around the cities of Abu Kammash, Zwara, Zultoon, and Misratah, as well as the Sirte coast and Benghazi region, as shown in Figure (3.A). The salt industry in the study area region relies on the Subkhas, located in the western part of Libya. Subkha Abu Kammash is considered the most important salt marsh in this area, with a total area of about 50 km^2. This is a unique salt marsh of the Mediterranean Sea where the saltwater pumps from the marsh through the tubes into the chemical plant Abu Kammash to make pure salt (El Magsodi *et al.*, 2011). Sensitivity to oil spill: Coastal wetlands are registered as vulnerable to oil spills because the low wave energy of a salt marsh does not remove oil effectively (Kankara and Subramanian, 2007). In addition, crude oil contains PAHs, which are the most toxic contaminants in marshes (Mendelssohn *et al.*, 2012). Hence, accidental spillage of oil into this area by offshore platforms or the Zawiya refinery could significantly impact the salt industry. For example, most of the oil leaked from the DWH disaster reached coastal marshes in the United States (Reddy *et al.*, 2012).

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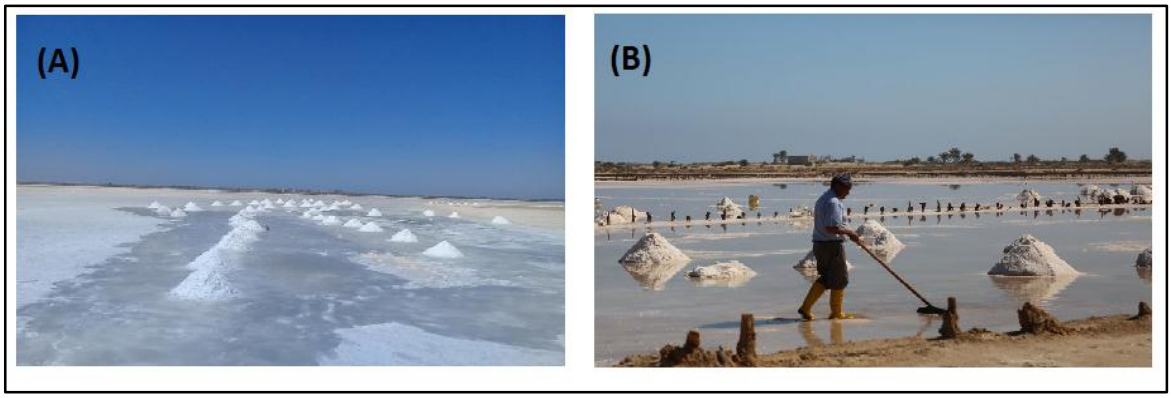

Figure 3. The locations; A) The Abu Kammash marsh; and B) **Zwara** salt marsh. (Source: Author).

4.2. Cultural and Historical Sites

Libya has several historical sites of such considerably important socio-economic along the Mediterranean coast that they are included on the World Heritage List by UNESCO such as Cyrenaica, Leptis Magna, and Sabratha (UNESCO, 2021). Sabratha city is considered one of the best-preserved Roman sites outside Italy, as it is located on the coast about 67 km from Tripoli and has a seafront of about 400 m (Finzi,1996), as shown in Figure (4). Furthermore, there is another historical site in this region, which is the Turkish Fort of Abu-Kammash, built close to the Farwa lagoon. The fort was guarded by Turkish soldiers until the Italian war at the start of the 20th century (Temehu, 2021). Sensitivity to an oil spill: Because these archaeological sites are located on the beach, they have a high risk of damage by cleanup operations equipment from an oil spill that requires careful care during use or hydrocarbon contamination that adversely affects radiocarbon dating (ITOPF, 2011).

Figure 4. The archaeological site of Sabratha (African World Heritage sites, 2020).

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4.3. Tourist Beaches

The beaches of Libya lie along a 1,770-km coastline and are considered among the longest in the Mediterranean Sea (IUCN, 2011). Moreover, resorts and swimming beaches are important places for coastal tourism in Libya. Hence, beach tourism is deemed the most important economic activity in Libya as support is a part of the gross inner product (Onofri *et al.*, 2013). Furthermore, beach tourism is mostly internal, with the beaches along this stretch of coastline being used for amenity purposes by Libyan nationals. The sand beaches in this study area cover 52.55 km of the Libyan shoreline, such as Abu Kammash, Zwara, Telil, and Al Garaboly beaches, which are distinguished by their white sands. Sensitivity to an oil spill: The most important beaches that extend along the western Libyan coastline, such as Farwa Island Marine Protected Area and Telil tourist resort, are under oil pollution pressure due to their locations near oil spill sources such as the Melitah oil complex and Zawiya Oil Refining. Therefore, in the event of an oil spill, resorts will suffer economic income losses and property damage.

4.4. Fishing Activity

Libya has the second-largest continental shelf and the richest fishing region in the Mediterranean (Filogh, 2019). Marine fisheries and fishery-related activities are important strips of the Libyan economy (Milanese *et al.*, 2008). Most boats and loading sites in Libya are concentrated in the western Libyan coastal part, about (55%) (IUCN, 2011), as shown in Figure (5). Libya's production of fisheries dropped to about 26,012 tons in 2015 due to the deterioration of the security situation in the country, and the Libyan fishing sector depended on foreign workers (mostly from Egypt). These foreign workers have left Libya since the outbreak of the revolution in 2011 (Filogh, 2019). Sensitivity to an oil spill: Following the Exxon Valdez oil spill, studies focused on polycyclic aromatic hydrocarbons (PAHs), which are toxic to fish (Incardinate *et al.*, 2011). Water areas whose water depth is shallow and their habitats are in the intertidal zone become the most vulnerable to oil spill risk. For example, the Farwa lagoon, whose water is shallow and semi-enclosed, might be at risk of an oil spill if it happened.

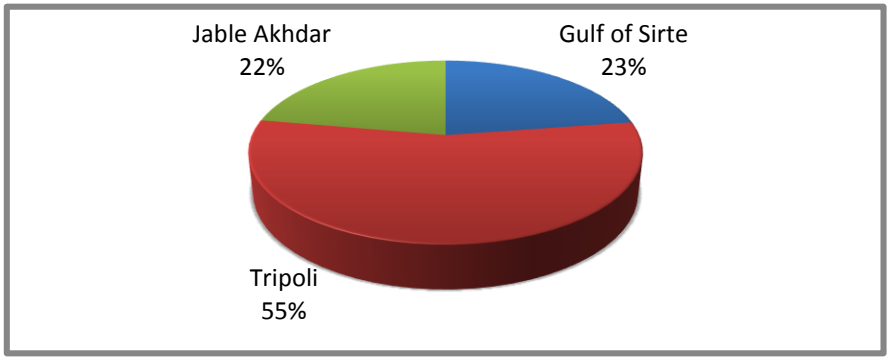

Figure 5. Shows the percentages of the most important fishing production regions on the Libyan coast (IUCN 2011).

4.5. Commercial Ports

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Libya enjoys a strategic site on the south shore of the Mediterranean Sea. There are 18 ports distributed along the coastline, as shown in Figure (6). The main commercial ports are Tripoli, Khoms, Misratah, and Benghazi, while the ports of Zwara, Sirte, Tobruk, and Darnah are classified as secondary ports. These ports are considered the key feeding points for international trade imports and exports in Libya (Elferjani and Ghashat, 2017). Sensitivity to an oil spill: if an oil spill occurs in these ports, particularly in Tripoli port, the port authorities will demand the cleaning of the hulls of vessels before they are permitted to sail. In this case, this may cause disruption to normal port operations, vessel movements, or delays in traffic in and out of a port that would incur economic losses.

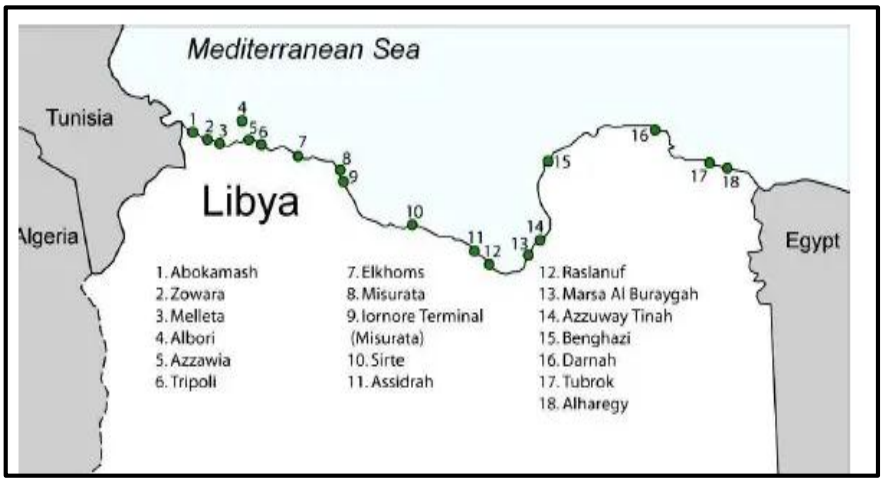

Figure 6. The Geographical Distribution of Libyan ports location (Elferjani and Ghashat, 2017).

4.6. Energy and Electricity Power Plant

The total number of energy plants in Libya is 16, with a total energy generation capacity of 6.3 GW (Ahwide and Aldali,2014), as the largest electric energy plants are to be found on the western coast such as Zawiya and Tripoli West power plants as shown in Figure (7), which covers the whole West of Tripoli region (GECOL, 2017). Since 2011, Power transmission systems have suffered many incidents of damage due to military clashes and robbery, which have caused weaknesses in the electric network system. Sensitivity to an oil spill: most electrical energy plants depend on cooling water for electrical energy generation. The US Department of Energy noted in the May 12th report about (BP) incident in the Gulf of Mexico. "Cooling water systems could be at risk of damage if the water source for these plants was polluted with oil" (National Geographic, 2021). As a result, this risk is one of many risks on energy power plants in the western Libyan coasts that may cause a power failure for a long time if an oil spill happens.

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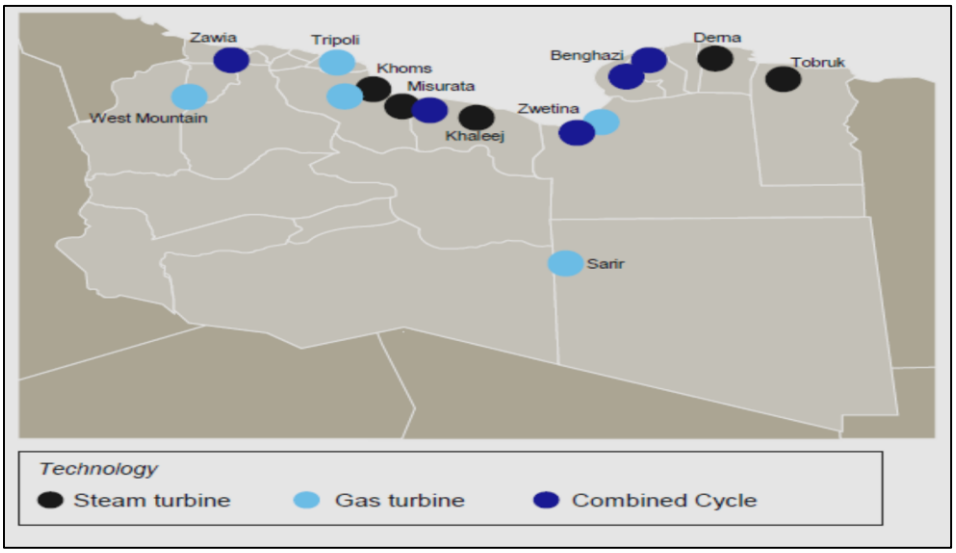

Figure 7. Shows Locations of Generation Plants along the Libyan Coast (GECOL, 2017).

4.7. Desalination Plants

Despite the importance of desalination technology in providing water worldwide, the past governmental regime in Libya has not invested in this field. The main focus has been on providing drinkable water for the Libyan people through the man-made river project (MMRP), which is considered one of the principal civil engineering projects, although, it has not ultimately solved the water problem in Libya (Brika, 2018). The largest production of desalination plants lies in the northwest of Tripoli city on the Mediterranean Sea, such as Zawiya, Zwara, Tajoura, and Tripoli west desalination plants. Sensitivity to an oil spill: Oiled seawater obviously damages coastal desalination plants. Once an oil spill reaches intake, it easily causes biofouling of water treatment filters, which in turn cause a reduction in the capacity of overall plant performance (ITOPF, 2011). Accordingly, it is necessary to develop an early assessment of the risk associated with the oil spill impact for desalination plants on the Libyan coastal.

5. Biological Resources and Their Existing Sensitivity to Oil Spill

The object of determining biological resources is to identify the most sensitive life-stages locations of the highest concentrations. In addition, species those have sensitivity to oil spills; and species that are threatened and endangered. In general, coastal, marine, aquatic, wetland, and riparian species and habitats are highlighted. In some cases, the sensitivity of a habitat type may be low, but the sensitivity of species that use or rely on the habitat is high (Doan, 2015). The Libyan coastal and marine environment is recognized as one of the world's 25 top biodiversity hotspots with a large number of endemic species (UNEP/MAP, 2012). Unfortunately, extensive coastal habitats and species data are unavailable. This section,

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therefore, focuses on three important biological resources: migratory birds, sea turtles and marine mammals (dolphin).

5.1. Sea Turtle Nesting Area

Libya is one of the most important Mediterranean countries for the sea turtle population during their nesting and foraging (Casale *et al*., 2020). Although loggerhead turtle nesting occurs across the Mediterranean Basin, more than 96% of clutches are laid in Greece, Turkey, Libya and Cyprus, as shown in Figure (8) (Casale *et al*., 2018). The green turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta caretta*) are two common sea turtle types in Libyan waters (IUCN, 2011). The loggerhead turtle nesting season in Libya ranges from late May to early September, with a peak in nesting in June-July (Hamza, 2010). Some levels of nesting sites were recorded in western Libya essentially concentrated at coastal areas Abu Kammash, Sabratha and Al Garaboly, where nesting sign density as measured by single surveys was reported to be higher in these coasts, notably on the beaches of Farwa island, Zwara (Laurent *et al*., 1999). Sensitivity to an oil spill: oil pollution is a major threat to nesting beaches in Libya because many nesting sites are near oil-exporting terminals. As a result, the oil pollution risk for turtles and their nesting area is greatest during the nesting season in May to August on the western Libyan coastline, especially on Farwa Island and Zwara.

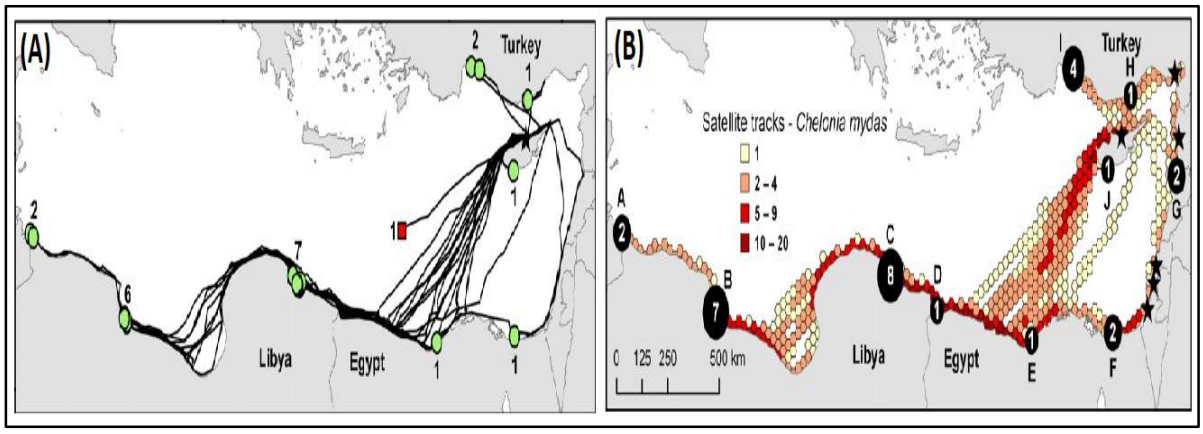

Figure 8. Maps of Satellite tracking of turtles; A) migratory corridor including Libyan coastline; and B) The foraging destination grounds: Turkey, Cyprus, Lebanon, Egypt, Libya and Tunisia (Stokes *et al.*, 2015).

5.2. Migratory Birds

Water birds were counted in a study between 2005 to 2010 about 110 Libyan wetland sites and 101 species of water birds (EGA-RAC/SPA, 2012), as shown in Figure (9). Some of these sites exist on western Libyan coastal beaches, e.g., Farwa Island, Sabkhat Abu Kammash, Sabkhat al Manqub, Al Mallahah and Wadi al Masid. In addition, Farwa Island is a rare wetland type in the Mediterranean and meets the numerical criteria, in terms of bird numbers, for designation as a wetland of international importance under the Ramsar Convention (EGA-RAC/SPA, 2012). Sensitivity to an oil spill: Identifying potential seabird sites and feeding areas can provide information to planners on how to avoid oil risk to coastal habitats. Moreover, it is

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highly important to take account of temporal variability due to seasonal migrations of seabirds (Labelle *et al*., 1982). In fact, oil can impact birds by reducing their ability to move and get their feeding (IPIECA-IOGP, 2015).

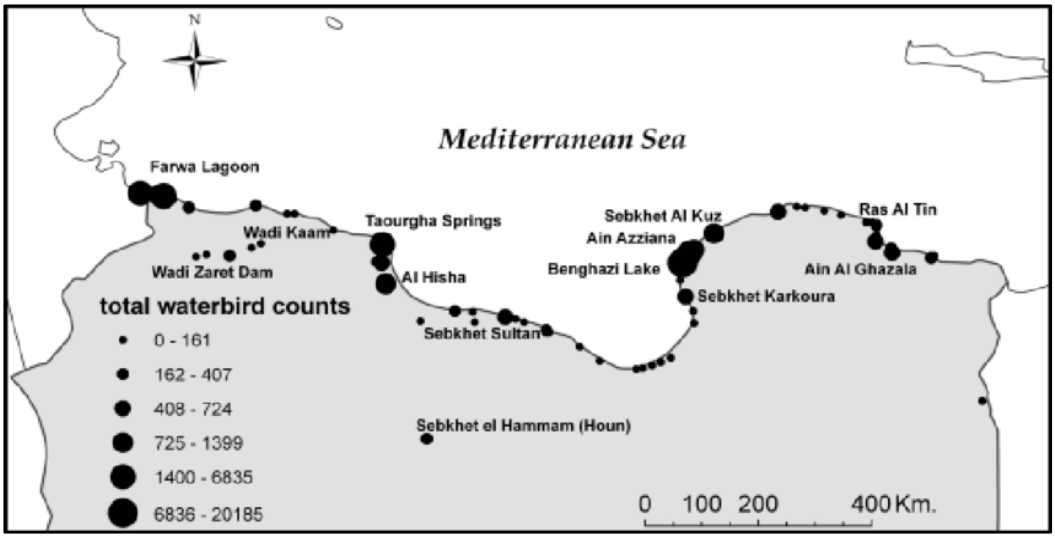

Figure 9. Map of Libyan wetland sites and distribution seabird on Libyan coast (EGA-RAC/SPA, 2012).

5.3. Marine Mammal

In Libya, literature regarding marine mammals (and marine biota in general) is very limited despite the relatively long coastline of the country (SPA/RAC, 2016). The marine environment associated with the Libyan coastline varies considerably and can be divided according to depth, slope, habitat, and topography (IUCN, 2011). These particular areas are suitable habitats for marine mammals, such as the Farwa lagoon and adjacent areas that are considered of importance for cetaceans. Hence, there are several records of sightings of bottlenose dolphins in this region (SPA/RAC, 2016). Based on this our interview survey with local researchers and fishermen at Farwa Island, Tripoli and Al Garaboly demonstrates that dolphins (bottlenose) are abundant and may be increasing in numbers according to the statements of fishermen and due to their appropriate environment. Sensitivity to an oil spill: The greatest risk to most cetaceans from an oil spill would occur in this area if they surface to breathe in an oil slick and inhale oil and toxic petroleum vapors (Helm *et al*., 2015). For instance, the Deep-Water Horizon (DWH) oil spill in 2010 impacted the reproduction and health of coastal bottlenose dolphins in the northern Gulf of Mexico (NOAA, 2020).

6. Results

An oil spill can have a significant impact on the marine ecosystem, the economic coastal activities and the communities that use the resources of the sea. In general, the effects of oil are toxic and threaten birds, sea turtles and fish. Moreover, marine habitats can be affected by cleaning up operations or indirectly through the physical damage they sustain due to the

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different activities related to oil spills on the western Libyan Coastal, such as Zawiya oil refining port, Mellitah oil terminal and the Offshore Platforms in the Mediterranean Sea. Furthermore, the natural environmental pressure of several socio-economic impacts is predicted. These impacts are summarized by the threat to the salt and fish industries and energy plants that supply electricity for the western Libya region, in addition to the tourism and cultural sites. This is in addition to threatening biodiversity which is used as feeding and nesting for loggerhead turtles and feeding places for migrant birds, especially in Farwa Island. Authorities that are threatened by oil spills have realized the risk; therefore, they developed plans to counteract the risk of marine pollution. Although Libya has not developed a national contingency plan yet, the outcomes of this work could help Libyan authorities identify coastal and marine resource features of the western Libyan coast so they can prepare a framework to map the sensitivity of oil spills that is part of a national contingency plan (NCP), which would lead to reducing the environmental consequences of oil spills in the future.

7. Conclusion

Like the first study discussing the Libyan coastal resources, this paper covers the Libyan west coast from Abu Kammash to Tripoli (Al Garaboly). Indeed, studies on the coastal resources in Libya is seldom, and this paper attempts to determine effects of oil spills and their impacts on the marine and environmental coastal resources of western Libya. The coast of Abu Kammash city from Ra's Ajdir to Farwa Island, including the Farwa lagoon, is more sensitive to oil spills due to the fact that there are many threatened ecosystems and habitats in this shoreline that include hatching grounds for turtles during May–September, locations of sandy beaches and wetlands areas used for the passage of migrant birds.

References

African World Heritage sites. (2020). Available online at: [https://www.africanworldheritagesites-.org/cultural-places/frontiers-of-the-roman-empire/sabratha.html]. Accessed on: 10/2/2020.

Ahwide F. and Aldali Y. (2014). The current situation and perspectives of electricity demand and estimation of carbon dioxide emissions and efficiency. *International Journal of Environmental and Ecological Engineering*, 7(12): 979-984.

Badi I., Ballem M., and Shetwan A. (2018). Site selection of desalination plant in Libya by using combinative distance-based assessment (CODAS) method. *International Journal for Quality Research*, 12(3).

Brika B. (2018). Water resources and desalination in Libya: A review. In: *Multidisciplinary Digital Publishing Institute Proceedings*, 2(11): 586.

Bureau of Statistics and Census Libya (2021). Available online at: [http://www.bsc.ly/downloars-_file.php?Id=144]. Accessed on: 22/1/2021.

Casale P., Broderick A.C., Camiñas J.A., Cardona L., Carreras C., Demetropoulos A., and Türkozan, O. (2018). Mediterranean sea turtles: current knowledge and priorities for conservation and research. *Endangered Species Research*, 36: 229-267.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Casale P., Hochscheid S., Kaska Y., and Panagopoulou A. (2020). Sea turtles in the Mediterranean Region. *MTSG Annual Regional Report 2020*. Report of the IUCN-SSC.

Doan Q.T. (2015). *Application of Environmental Sensitivity Index Map for Coastal Oil Spill Incident Response Case Study of Cat Ba Island, Vietnam*. PhD dissertation, Department of Environmental Engineering, Da-Yeh University, China.

EGA-RAC/SPA Waterbird Census Team. (2012). *Atlas of Wintering Waterbirds of Libya, 2005–2010*. Tunis: Imprimerie COTIM. Available online at: [http://www.isprambiente-.gov.it/files/pubblicazioni/pubblicazionidipregio/Atlas_of_wintering_waterbird_in_Libya_2005 2010.pdf].

Eiser W.C. and Kjerfve B. (1986). Marsh topography and hypsometric characteristics of a South Carolina salt marsh basin. *Estuarine, Coastal and Shelf Science*, 23595-23605.

Elferjani I. and Ghashat H. (2017). Enhancing the performance of Libya's Ports: An investigation of local stakeholders' experience. *IAME 2017 CONFERENCE | KYOTO, JAPAN IAME Paper ID 890*.

Etayeb K.S., Taboni E., and Essghaier M.F. (2012). Aspects on Libyan Legislation for Biodiversity conservation and propose Farwa complex as protected area. *2nd Djerba International Mediterranean Environment Sustainability Conference*, Vol. XI: 81-90

Filogh A. (2019). Libya Fishing Industry. *Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi*, 5(1): 16-26.

Finzi C.V. (1969). *The Mediterranean Valleys: Geological Changes in Historical Times*. Cambridge University Press.

GECOL-General Electricity Company of Libya (2017). TASK C – REPORT 4.2: *IMPROVING GECOL TECHNICAL PERFORMANCE*.

Hamza A. (2010). Sea turtles in the Mediterranean Sea: distribution, threats and conservation priorities. *IUCN, Gland*, 157−170.

Helm R.C., Costa D.P., DeBruyn T.D., O'Shea T.J., Wells R.S., and Williams T.M. (2015). *Overview of effects of oil spills on marine mammals. Handbook of oil spill science and technology*. John Wiley & Sons, Hoboken, NJ.

Incardona J.P., Collier T.K., and Scholz N.L. (2011). Oil spills and fish health: exposing the heart of the matter. *Journal of exposure science & environmental epidemiology*, 21(1): 3-4.

IPIECA-IOGP (2015). *Impacts of oil spills on marine ecology*. IPIECA-IOGP Good Practice Guide Series, Oil Spill Response Joint Industry Project (OSR-JIP). IOGP Report 525. Available online at: [http://oilspillresponseproject.org].

ITOPF (2011). Effects of oil pollution on social and economic activities. *The International Tanker Owners Pollution Federation, ITOPF Technical Information*, UK, Paper ID: 12.

IUCN (2011). *Towards a Representative Network*. Available at of Marine Protected Areas in Libya. Available online at: [https://www.cbd.int/doc/meetings/mar/ebsaws-2014-03/other/ebsaws-2014-03-submission-iucn-04-en.pdf]. Accessed on: 22/11/2019

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Kankara R.S. and Subramanian B.R., (2007). Oil spill sensitivity analysis and risk assessment for Gulf of Kachchh,India, using integrated modeling. *Journal of Coastal Research*, 23(5): 1251–1258.

Labelle, R.P., Rainey, G., Lanfear, K.J., (1982). An Application of a Vulnerability Index to Oil Spill Modeling in the Gulf of Mexico. US Geol. Surv.

Laurent L., Bradai M.N., Hadoud D., El Gomati H.M., and Hamza A. (1999). Marine turtle nesting activity assessment on Libyan coasts. Phase 3: survey of the coast to the west of Misratah. *Mar. Biol. Res*., 35.

Liu P., Li Y., Xu J., and Wang T. (2019). Oil spill extraction by X-band marine radar using texture analysis and adaptive thresholding. *Remote Sensing Letters*, 10(6): 583-589.

Maitieg A., Lynch K., and Johnson M. (2018). Coastal Resources Spatial Planning and Potential Oil Risk Analysis: Case Study of Misratah's Coastal Resources. *Conference: 19th International Conference on Geography and Environmental Studies, Libya*.

Mendelssohn I.A., Andersen G.L., Baltz D.M., Caffey R.H., Carman K.R., Fleeger J.W., and Rozas L.P. (2012). Oil impacts on coastal wetlands: implications for the Mississippi River Delta ecosystem after the Deepwater Horizon oil spill. *BioScience*, 62(6): 562-574.

Milanese M., Sarà A., Manconi R., Abdalla A.B., and Pronzato R. (2008). Commercial sponge fishing in Libya: Historical records, present status and perspectives. *Fisheries Research*, 89(1): 90-96.

National Geographic (2021). Available online at: [https://www.nationalgeographic.com/news/2010-/5/102705-energy-oil-spill-risks-gulf-power-plants/]. Accessed on: 20/11/2021.

National Oil Corpoation (NOC) (2021). Available online at: [https://noc.ly/index.php/en/]. Assessed on: 15/02/2021.

Naz S., Iqbal M.F., Mahmood I., and Allam M. (2021). Marine oil spill detection using Synthetic Aperture Radar over Indian Ocean. *Marine Pollution Bulletin*, 162: 111921.

NOAA NRDA. *Gulf Dolphins Questions and Answers*. Available online at: [http:// www.gulfspill-restoration.noaa.gov/2012/03/gulfdolphinsanswers]. Accessed on: 12/2/2020.

NOAA. *National Oceanic and Atmospheric Administration*. Available online at: [https://www.-fisheries.noaa.gov/national/habitat-conservation/coastal-wetlands-too-valuable-lose]. Accessed on: 15/2/2021.

Oliveira E.R., Silveira B., and Alves F.L. (2014). Support mechanisms for oil spill accident response in costal lagoon areas (Ria de Aveiro, Portugal). *Journal of sea research*, 93: 112-117.

Onofri L., Nunes P.A.,and Bosello F. (2013). *Economic and climate change pressures on biodiversity in southern Mediterranean coastal areas*. MEDPRO Technical Paper.(24) ,

Reddy C.M., Arey J.S., Seewald J.S., Sylva S.P., Lemkau K.L., Nelson R.K., and Camilli, R. (2012). Composition and fate of gas and oil released to the water column during the Deepwater Horizon oil spill. *Proceedings of the National Academy of Sciences*, 109(50): 20229-20234.

Stokes K.L., Broderick A.C., Canbolat A.F., Candan O., Fuller W.J., Glen F., and Godley B.J. (2015). Migratory corridors and foraging hotspots: critical habitats identified for Mediterranean green turtles. *Diversity and Distributions*, 21(6): 665-674.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Temehu (2021). Available online at: [https://www.temehu.com/Cities_sites/abu-kammash.html]. Accessed on: 10/2/2020.

The Mediterranean Protected Areas Network (MedPan). Available online at: [https://medpan.org/conservation-of-sea-turtles-and-their-habitats-in-the-island-of-farwa/].Accessed on: 10/01/2021.

UNEP. Available online at: [http://web.unep.org/unepmap/]. Accessed on: 15/10/2021.

UNEP/MAP (2012). *State of the Mediterranean marine coastal environment*. Available online at: [https://www.eea.europa.eu/data-and-maps/indicators/nutrients-in-transitional-coastal-and-4/unep-map-2012-initial-integrated.8]. Accessed on: 22/2/2021.

UNESCO (2021). Available online at: [https://whc.unesco.org/en/list/184]. Accessed on: 22/2/2021.