

FINAL REPORT
STUDY OF THE EFFECTS OF OIL
ON MARINE TURTLES

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FINAL REPORT

STUDY OF THE EFFECTS OF OIL ON MARINE TURTLES

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16. Abstract (Limit: 200 words) The objective of this study was to determine the effects of oil on marine turtles. An experimental program was carried out on 3-20 month old loggerhead and 3-16 month old green turtles to determine behavioral and physiological effects of oil using South Louisiana Crude Oil (SLCO) preweathered for 48 hrs. The behavioral experiments indicated that both species of marine turtles had a limited ability to avoid oil slicks, but experiments to determine avoidance/attraction to floating tar balls were inconclusive. Controls (wooden balls) were struck at a greater rate than tar balls, but overall strike rates were low and interpretation complicated by feeding schedule and interspecific differences. The physiological experiments showed that the respiration, skin, some aspects of blood chemistry and composition, and salt gland function of 15-18 month old loggerhead sea turtles were significantly affected. Oil was observed clinging to the nares and eyes and in the upper portion of the esophagus and was found in the feces of all turtles in the physiological experiments. Some similar effects were found in stranded oil fouled turtles. Based on these experimental results, it is our opinion that given the proper circumstances, sea turtles will be at risk in the event of an oil spill. Spills in the vicinity of nesting beaches are of special concern. Mitigating strategies for such an event are discussed. Dispersants with microbial nutrients are of interest, but they should only be used if they are found harmless to sea turtles.							
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1.0 PROGRAM BACKGROUND AND OBJECTIVES

The Department of the Interior (DOI) bears the responsibility for managing the petroleum and other mineral resources of the submerged lands of the continental shelf seaward of state territorial waters. The administration of leasing and supervision of production have been centralized under the Minerals Management Service (MMS). Under statutory authority from the OCS Lands Act Amendments of 1978 the Secretary is authorized to conduct studies in areas or regions of lease sales to obtain the information to predict, assess, and mitigate the potential impacts on the coastal and offshore areas that may be affected by oil and gas development.

In environmental impact assessments for numerous lease sales, the effects of oil and gas activities on marine turtles have frequently been listed as a matter for concern. Of marine species, marine turtles are particularly vulnerable to oil spills or pelagic tar because they must surface to breathe, increasing the possibility of repeated contact with the oil or tar which floats at the surface.

All marine turtle species and their populations worldwide are classified as either threatened or endangered under the Convention of International Trade in Endangered Species (CITES) of wild fauna and flora, Appendix 1. The last two populations of marine turtles accorded this protective status were the Australian populations of Chelonia mydas (green sea turtle) and Chelonia depressa (Australian flatback turtle) which were added to Appendix 1 at the 1981 CITES Meeting. In 1978, subsequent to the enactment of the U.S. Endangered Species Act in 1973, sea turtles were placed on the Federal List of Endangered and Threatened Species. Under the U.S. Endangered Species Act of 1973, federal actions must not jeopardize the existence of endangered or threatened species nor destroy or modify their habitats.

Recognizing the need for additional information, the MMS initiated a competitive request for proposals (RFP No. 3063) to address relevant questions regarding the effects of oil on marine turtles. In September, 1983 Minerals Management Service awarded MMS Contract No. 14-12-0001-30063 entitled "Study of the Effects of Oil on Marine Turtles" to the Florida Institute of Oceanography/University of South Florida acting as a consortium of University of South Florida, University of Miami, Florida Department of Natural Resources, University of Central Florida, and Wildlife Veterinary Center.

The MMS goal for this research was to determine the possible effects of oil on hatchling, juvenile, and adult sea turtles by gathering existing information and generating new experimental information on two selected species, Chelonia mydas (green sea turtle) and Caretta caretta (loggerhead sea turtle). Sub-objectives of these overall goals were as follows:

- a. To determine the ability of marine turtles to detect and avoid, or be attracted to tar balls and/or oil slicks.
- b. To determine the effects of oil on the integument and various physiological systems of marine turtles.
- c. To evaluate the long term impact of a. and b. on marine turtle survival and behavior, such as feeding, breeding, nesting, and migration and to analyze the potential for bioaccumulation of petroleum hydrocarbons and metabolites in marine turtles.
- d. To predict, considering the known life history of sea turtles, records of past oil spills, and known climate or natural conditions, the possible impacts of oil on turtle nesting sites and on hatchlings, juveniles, and adults in an oil contaminated nearshore and open ocean environment.
- e. To identify a range of mitigating measures which would eliminate or minimize the effects of oil contamination on marine turtles.

Objective b) was largely accomplished in this study while a), c) and d) were partially accomplished. Mitigating strategies (e) were identified from techniques reported in the literature taking into consideration the results of a) and b).

2.0 OVERALL SCIENTIFIC PLAN

The overall scientific plan for this two year research program (September 30, 1983 to October 1, 1985) was divided into five main components:

1. Literature Survey
2. Analytical Studies (Petroleum Hydrocarbon Types and Concentrations)
3. Behavioral Response to Oil
4. Effects of Exposure to Oil
5. Field Studies (Analysis of Stranding Data)

Several general considerations were common to all experiments performed. The turtles were tested under as realistic conditions as possible given experimental requirements. The turtles were obtained from headstart programs

in Florida, Texas, and the Bahamas. All experiments were designed to be sublethal. Experimental animals were healthy and the minimum number of animals was used that would still yield statistically valid results given the design of each experiment. Exposure levels for behavioral and physiological studies were selected to facilitate comparison of results, taking into account the differences in goals and experimental protocol. Stranded animals were not considered suitable for exposure experiments as they were already stressed by unknown factors. Clinical examinations of stranded animals, however, were conducted to aid in the interpretation of experimental results.

3.0 SUMMARY OF PROGRAM RESULTS

The potential effects of oil on the marine turtles are summarized as a conceptual model in Figure 1. These potential effects were drawn from documented effects on birds and marine mammals reported in the literature survey (Appendix A). It can be seen that the potential effects are both numerous and detrimental. This conceptual model was used as a basis to develop the experimental design.

As specified by MMS the oil used in this program was a South Louisiana Crude Oil (SLCO). A sufficient supply was obtained so that the same oil could be used for all phases of the program. The oil was provided at no cost from the Houma, Louisiana field and was a subtype described as South Delta Crude. Analysis of the oil indicated it was consistent in overall characteristics with other SLCOs. Based on the results of the analytical studies on the weathering characteristics of this oil it was decided that preweathering the oil for 48 hrs. over sea water with mixing would more accurately reflect oil that the turtles might encounter in the natural environment. During experiments, direct analysis of water samples indicated that the petroleum hydrocarbon concentrations used in the behavioral, physiological, and clinicopathological studies were consistent with expected concentrations during an oil spill event at various locations within the spill.

The experiments on behavior addressed the ability of marine turtles to detect and avoid or be attracted to oil slicks and/or tar balls. Figure 2 illustrates potential effects of oil on behavior, again drawing on effects previously reported in the literature. Loggerhead and green sea turtles were used in the behavior experiments (oil slick and tar ball) and ranged in age from 3 to 20 months.

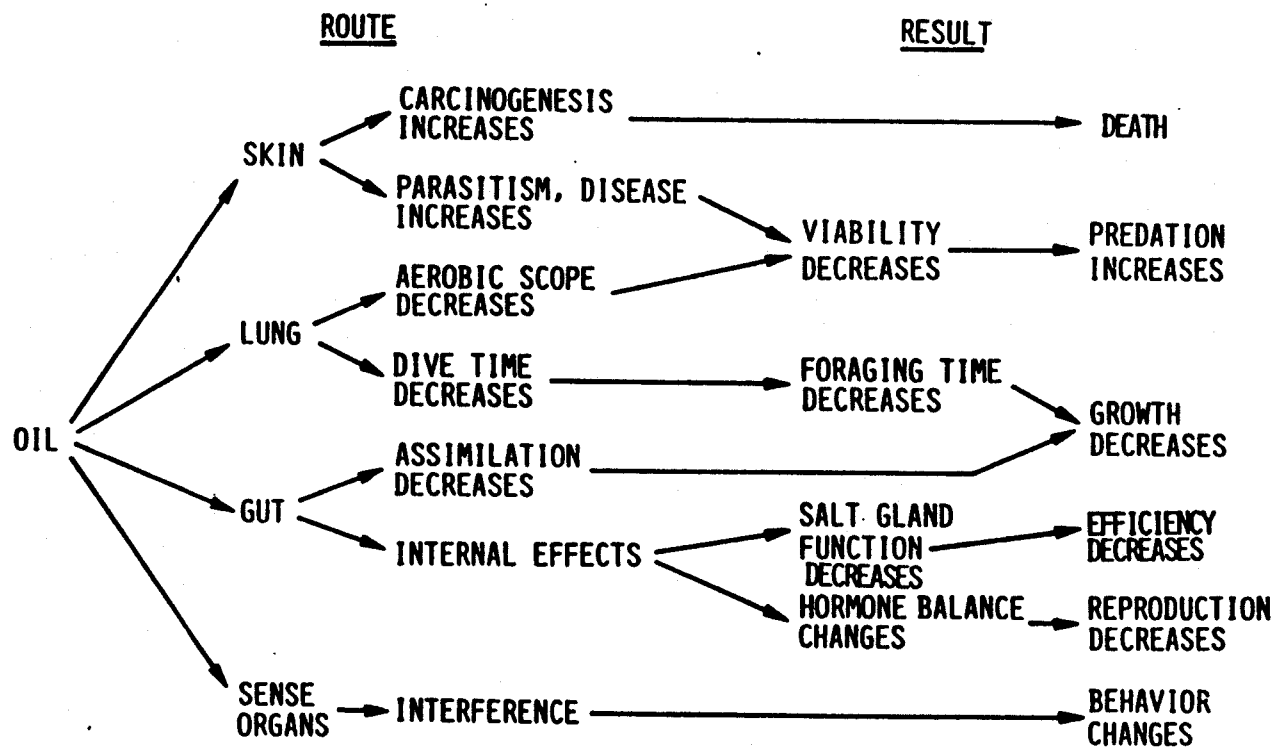


FIGURE 1. Conceptual model of potential effects of oil on marine turtles drawn from literature reports (Appendix A) of the effects of oil on turtles and other vertebrates.

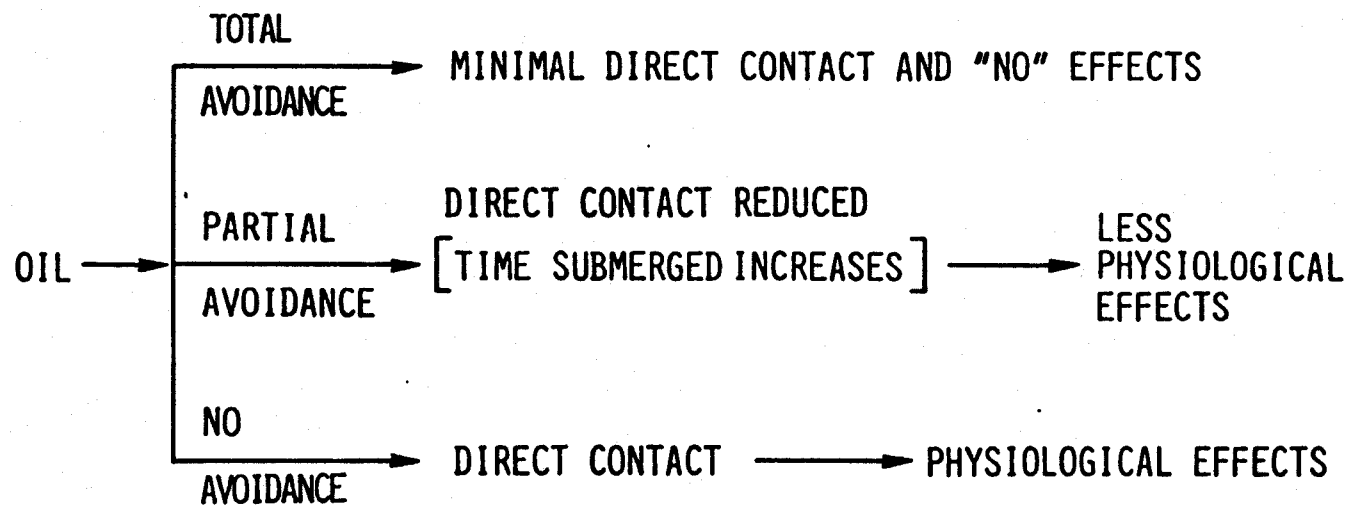


FIGURE 2. Conceptual model of potential effects of oil on marine turtle behavior.

In the experiments on the effects of an oil slick on behavior both species of turtles responded to the oil slick by spending significantly more time deeper in the water column and coming to the center of the pool (unoiled water) to breathe more frequently than in the control situation. However, because the turtles responded to dark colored mineral oil, which did not release chemical cues, in the same way as to SLCO, it was our conclusion that they were responding to the dark visual surface barrier not specifically to SLCO.

In the natural environment, confronted with an oil spill, turtles may respond by seeking open water, increasing dive times, and descending in the water column. Depending on the size of the oil spill and its cohesiveness this may or may not result in avoidance of oil contamination.

The tar ball experiments were designed to determine if young sea turtles selectively struck at tar balls floating on the surface of the water. The turtles were presented with a choice between real tar balls and visually similar dummy tar balls. The results of this study were inconclusive and may have been complicated by a regimented feeding schedule and the physical characteristics of the turtle food. In addition, interspecific differences in feeding behavior between loggerhead and green sea turtles may also play a role. From our results we can not conclude that turtles would actively strike at tar balls they encounter at sea.

The route of contamination of tar fouled stranded turtles remains unknown. One hypothesis advanced, but not tested in this study, is that since tar tends to accumulate in the windrows with Sargassum, turtles may come in contact with the tar here. In attempts to clean tar from their flippers, the turtles may contaminate their mouths with tar, impeding feeding and, in the worst case, leading to starvation.

Experiments on the physiological and clinicopathological effects of oil carried out on loggerhead sea turtles (approximately 15 to 18 months old) showed that major body systems in these turtles are adversely affected by even short exposures to SLCO (Figure 3), in both chronic (0.05 cm oil layer for 96 hrs) and acute (0.5 cm oil layer for 48 hrs). Statistically significant changes occurred in respiration in acutely oiled turtles. Breathing rate and oxygen uptake were affected, particularly in the acute exposures. The skin of exposed turtles, particularly the soft pliable skin of the neck, reddened and sloughed off. This condition was reversed approximately one month after oil exposure ceased. Physiological effects on

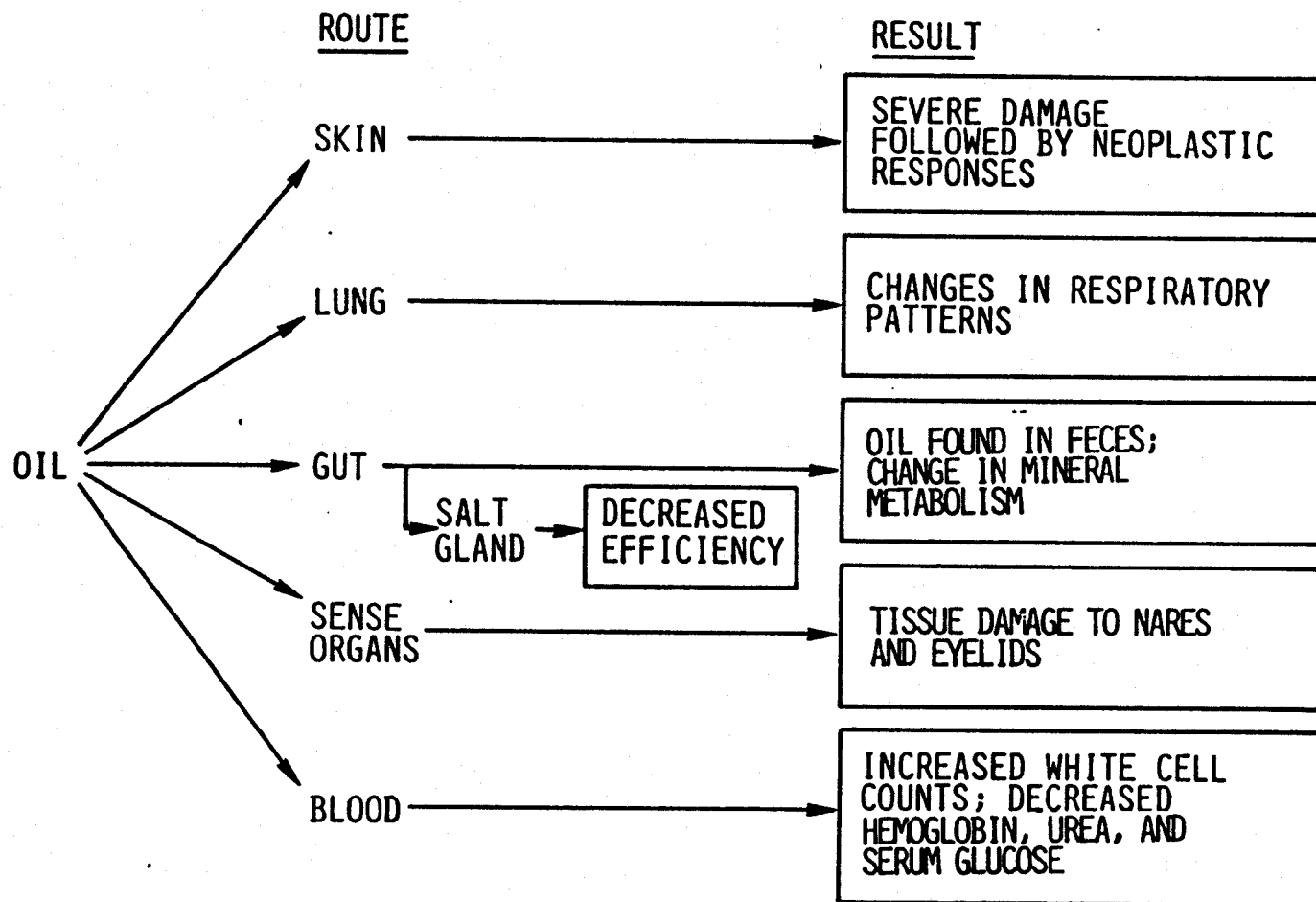


FIGURE 3. Summary of physiological and clinicopathological effects of oil on marine turtles observed in this study.

the integumentary systems, such as these skin lesions, are of particular interest as they reduce the viability of the turtles by increasing their susceptibility to infection. Further testing would be required to fully document possible carcinogenic effects and tumor formation (neoplasia) on turtle integument. There were also changes in blood chemistry and composition. Blood glucose declined in oiled turtles and white blood cells increased in number indicating an immune system response to oil. Finally, salt gland function totally ceased in acutely oiled turtles three days after the turtles had been removed from oil. Salt gland function was not tested in chronically oiled turtles. Recovery was seen two weeks later. This organ is important maintaining the turtle's internal water and ion balance required for many physiological and biochemical processes.

A question that may be asked, however, is whether these laboratory results reflect what happens in the natural environment. We approached this problem by analyzing the turtle stranding network data (1980-1984) available from Florida Department of Natural Resources. Petroleum related strandings made up a relatively small portion of the turtle strandings in Florida (3.2%). The two most important factors in strandings were drowning (22.6%) and wounds (33.6%). An equal portion of the strandings (37.7%) could not be attributed to any specific factor. A more detailed analysis of the petroleum related strandings revealed that most petroleum related strandings occurred in the southeastern section of Florida, green sea turtles were more affected than other species, and juveniles were more frequently involved than adults. Many of the trends can be explained by habitat preference and geographical location of nesting beaches. Hydrocarbon analyses of some of these oil fouled turtles from Florida and also Texas clearly showed that most of this tar came from crude oil tanker discharge. Clinicopathological analysis was also done on several still living stranded turtles to determine changes in blood chemistry and composition, and the skin. Some correlations can be made with the laboratory data showing similar effects on these parameters. Respiration and salt gland function which showed changes with exposure to oil under laboratory conditions were not measured.

4.0 SUGGESTED MITIGATING STRATEGIES

Total elimination of oil spills and anthropogenic input of oil into the marine environment is not feasible. Therefore, the objective is to identify effective mitigating strategies to reduce the impacts on marine turtle populations in the event of an accidental oil spill. Experimental and field results indicate that marine turtles would be at risk if they encountered an oil spill or large amounts of tar in the environment. Despite the high tolerance of marine turtles to severe physical damage (personal observation, P. Lutz), they have proved surprisingly sensitive to oil. The limited ability to avoid oil slicks, and numerous adverse physiological and clinicopathological effects from exposure to oil mean that the marine turtles could be heavily impacted. This impact would be particularly critical if it occurred during the nesting season when turtles aggregate and lay their eggs and the hatchlings return to the sea in large numbers from relatively restricted geographical areas.

For this reason, formulation of an emergency strategy for dealing with oil spills in areas with marine turtles is essential. Key areas such as heavily utilized nesting beaches should receive special attention. An example is the nesting beaches in Brevard County, Florida. This area has been reported as the second largest nesting aggregation of loggerhead sea turtles in the world (Ross, 1982).

The first option is to consider ways of stopping the oil from getting to the turtles. Any plans have to consider the threat to adults, hatchlings, and eggs. In certain circumstances it might be possible to physically restrict a spill, for example, a limited access beach might be protected by the use of booms. Use of dispersants is another means to consider to prevent the oil from reaching the turtles. Chemical dispersants are accepted as effective tools for breaking up oil slicks at sea. A new technique for enhancing biodegradation of oil + dispersant mixtures seems promising. The procedure, reported by Bronchart et al. (1985), is simply to mix an appropriate blend of microbial nutrients with dispersant and apply the mixture to oil slicks to enhance the rate of dispersal.

However, many dispersants have proven as or more toxic to marine life than spilled crude oil. (Cowell, 1978; Nelson-Smith, 1978; Boehm et al., 1985; Farke et al., 1985; Hoi-Chaw and Meow-Chan, 1985; Thorhaug and Marcus,

1985). No data is available regarding the effects of chemical dispersants on marine turtle behavior or physiology. Figure 4 summarizes some possible effects which should be considered and evaluated before final decisions are made on use of dispersants (Wilson, Cowell, and Beynon, 1974; Getter and Ballou, 1985; Knap et al., 1985; Linden, et al., 1985; Gilfillan et al., 1985). No dispersants should be used until it is demonstrated they are harmless to turtles.

The second option is to consider ways of removing the turtles from an impending oil slick. Clearly contingency plans are required to remove eggs from a beach that is going to receive an oil spill and place them in a hatchery. Similar plans are needed to release hatchlings into clean off shore waters if the near shore waters are contaminated. However, considerations of natal beach imprinting and the incubation temperature determination of sex must be taken into account. Rehabilitation measures for treating oil impacted turtles also need to be formulated. These would include a plan for cleaning up oiled turtles, followed possibly by a convalescence period until there was sufficient recovery for the turtle to be released. The treatment during convalescence would depend upon which of the effected systems was most critical for survival. For example, if the temporary inhibition of the salt gland proved to be a serious burden then affected turtles might be held in water that imposed a minimum osmotic and salt burden (dilute sea water or fresh water) until recovery.

And finally, the most pessimistic prognosis is that nothing can be done for sea turtles in the face of an oil spill. But if we have a decent estimate of what the effect will be on a sea turtle population then this would allow management to assess the damage, and formulate a turtle rehabilitation plan for the area.

5.0 RECOMMENDATIONS FOR FURTHER RESEARCH

After careful review of the data resulting from Year 1 and 2 of the program the research team developed a series of recommendations for further research. They are as follows:

- (1) Continued support of behavioral, physiological, and clinico-pathological studies with hydrocarbon analytical back up support.

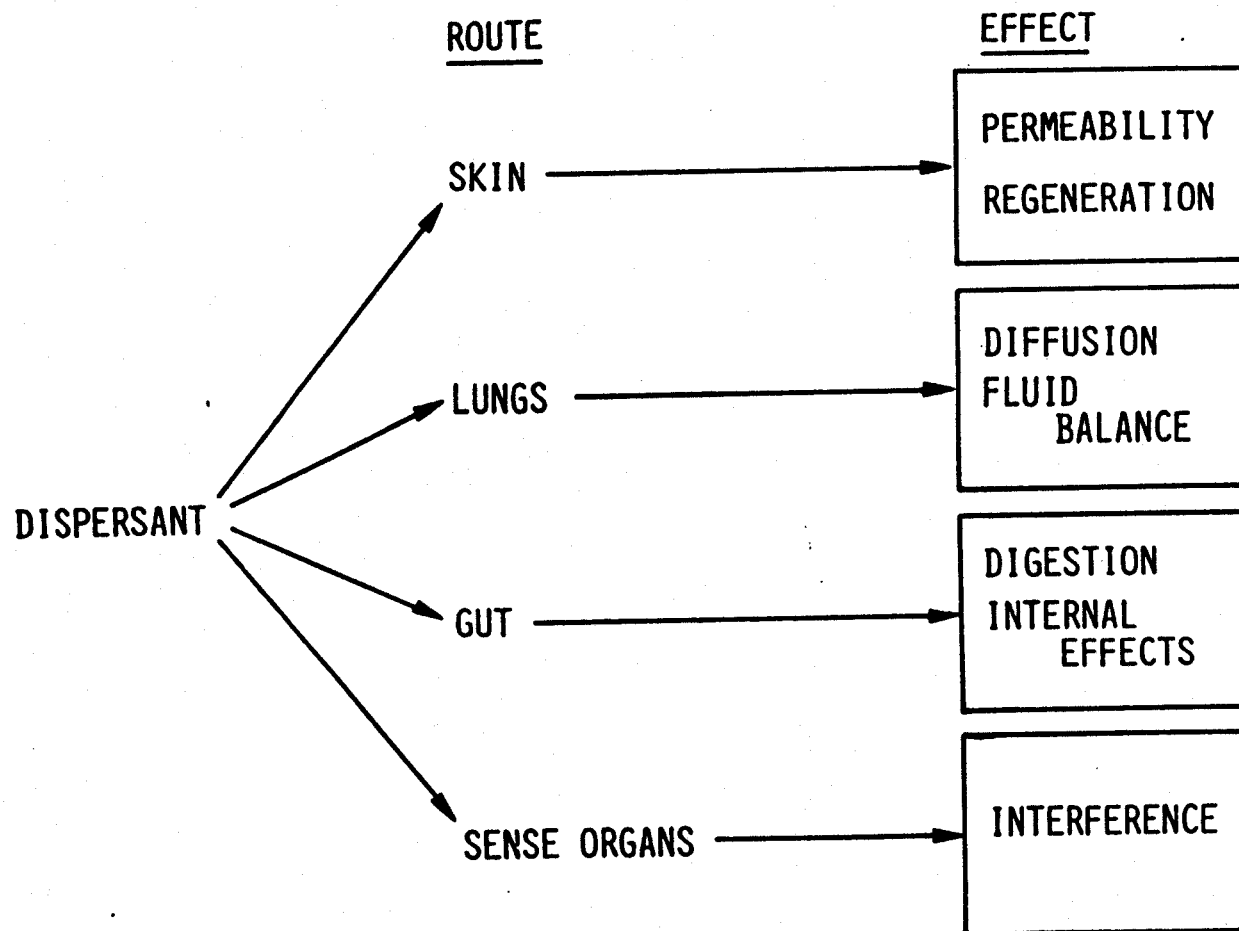


FIGURE 4. Potential effects of oil dispersants on marine turtles drawn from literature reports of effects of oil dispersants on turtles and other vertebrates.

- (2) Continued analyses of environmental tar samples collected from stranded turtles, beaches, and seawater to definitively determine its source.
- (3) Analyses of internal tissues and biopsies from stranded turtles for comparison with experimental results.
- (4) Determination of changes in internal lipid biochemistry of sea turtles due to oil impact.
- (5) More extensive correlation of hydrocarbon concentrations with behavioral, physiological, and pathological effects.
- (6) Comparison of the effects of dispersed and undispersed oil on turtle behavior.
- (7) Physiological experiments to determine the effects of oil on lung diffusion capacity and its carcinogenic effects on the skin.
- (8) Determination of the effect of oil on salt gland function in greater detail, including secretion onset and duration, flow rate, and composition
- (9) Determination of the effects of dispersants and dispersants + microbial nutrients on the physiology of turtles including blood chemistry, integument, clinicopathology, and digestive efficiency.

These listed recommendations are intended to provide sufficient data for a decision on recommended mitigating strategies to minimize the impact of oil on marine turtles in the event of an accidental spill.