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Economic Impacts of Oil Spills on Fisheries at the Egyptian Part of the Red Sea

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Abstract: Several oil-tanker accidents have been taking place in the Egyptian marine waters, particularly in the Red Sea, Gulf of Suez, Suez Canal and south Sinai water. “El-Samidoon” Kuwaiti oil tanker was responsible for an oil spill in the Suez Canal in December. 2004. A dispute was raised between the fishermen’s cooperation in the affected area and the owner of the oil-tanker because of the demanded large amount of money by the fishery co-operation for compensation of their fishermen as opposite to the low compensation offered by the other side. The present study aimed at identifying and suggesting unbiased eight bases for evaluating damages and losses that might be raised on the fishing sector due to oil tanker accident. Statistical and econometric methods have analyzed, smoothing technique was used to forecast fish catches and fish fries production in the affected area for the period of study (2000-2007), as well as their annual rate of growth. Results of this study revealed a rather limited effect of the accident on the fishing activity in the surrounding area. The estimated growth rates of fish catch and fry production are small, the physical conditions in the place of the accident and rescue action at the time of the accident have greatly assisted in limiting damages or losses that raised by the accident. It can be concluded that any negative effects raised by the oil spill accident on the fishery effectiveness in the polluted or adjacent areas are limited

Key words: Oil spill % Suez Canal % Compensation % “El-Samidoon” % Smoothing Method

INTRODUCTION

The Egyptian Red Sea fisheries are a major component in the national capture fishery economy. Total coast length is about 850 km, in addition to Suez Canal as an international water route connecting Mediterranean Sea with Red Sea. Over 20 thousand ships pass annually across the canal, some oil tankers land their cargo in the Egyptian ports. In the last few years, several accidents had occurred in the Egyptian Red sea water causing several oil spills. "Nabila "oil tanker as an example spilled in 1984 about 8 thousand barrels. Since 2004, the rate of oil accidents has increased noticeably during the first half of the year 2009, whereas, seven accidents have been recorded as compared to one accident only during the year 2008 [1]

Two major accidents have taken place in the Egyptian northern part of the Red sea and Suez canal by Kuwaiti tanker "El-samidoon" and Lyberian oil tanker "Grigorosa" [2,3].

A recent study was carried out to investigate the effect of the oil spill caused by ‘El-Samidoon’ on the fishery resources. It also deals with the difference between the compensation value claimed by the fishing sector as opposed to those offered by the owners of the oil tanker [2].

Fahmy [4] classified losses and damages that can be raised due to pollution into two main groups of costs or losses. The first group embraces costs that can be quantified and measured in money terms. This group is divided again into two sub-groups, direct and indirect costs. Direct costs are the value of direct losses caused by the accident (e.g. total value of dead fishes). These losses are accumulating year after year, in addition to costs of dealing with and removing damages. Indirect costs are the opportunity costs or the foregone profits of the money allocated for dealing with damages and claimed compensations. The second group is costs and damages that cannot be quantified into money terms. These are intangible losses that hit human culture, health, beauty values and other social costs [4].

The aim of the present study was to identify and suggest some un-biased bases for evaluating damages and losses that might be raised on the fishing sector due to oil spills accidents.

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The study took into consideration the following bases:

- Accurate determination of the time when the accident occurred, quantity of spilt oil as well as the affected areas and any adjacent water areas.
- Starting and ending times of the measurements taken to deal with the oil spill and the final results.
- Identifying the oil polluted area, wind direction and navigation instructions in the affected area,
- Studying nature of the shore bottom in the affected area.
- Studying secular trend of fish catch and fish fry production in the area by five year period at least before and after the oil spill.
- Studying evaluation and spawning time of fish species in the polluted area.
- Studying price structure of fish species in the fish markets adjacent to polluted area.
- Measuring manpower and fishing capacity of economic resources in the primary fishing sector in the polluted area as a criterion for measuring fish catch magnitude.

MATERIAL AND METHODS

The present study deals with the oil spill caused by the Kuwaiti oil tanker "El-Samidoon". The scientific reports prepared by the National Institute of Oceanography and Fisheries (NIOF), Ministry of Environment, Suez Canal. Authority (SCA) [5], as well as NASSA for marine services (Authorized by UK P and I CLUB) [6] will be taken into consideration in the present study.

Other needed data were collected from The General Authority for Fish Resources Development (GAFRD) year-book statistics on fish catch [7], as well as from fishery records of fishermen co-operative in Port-Said city.

Exponential function on the form of $Y= A. e^{bx}$, has been used for estimating rate of growth of fish catch and fries production [8,9].

Smoothing methods [8,9] have been used for forecasting future catches away from any un-natural circumstances that might affect magnitude of forecasted catches such as oil spills [8,9]. The study focuses on Suez area as a major fishing area with frequent tanker accidents and damages and losses such as "El-Samidoon" accident.

RESULTS

Place and Time of the Accident and Quantity of Spilled Oil: The tanker was in the south convoy from Suez Port in 14 December. 2004 carrying 160 thousand metric tones of crude oil (Kuwaiti. Export) at 19 hr 15 min. of that day due to an accident, 10 thousand cubic meters were leaked causing big oil spill covering a water area of total length of 55 kms in the area (km-58) determined by Suez Canal authority (SCA), till the area (km-03) Port Said city, SCA technical rescue team dealt with the oil spill for two weeks. Large quantity of the oil spill has been removed. The canal regained its full recovery in 12 January 2005.

Polluted Area, Wind Direction and Navigation Instructions: The cities and villages which were affected by the oil spill from the area (Km-58) to the area (Km-03) are El-Ballah, El-Kantara, El-Kab, El-Tina, Ras El-esh and Port Said. The oil spill moved rapidly northward because of strong water currents. SCA did not ban vessels passage in the canal. The vessels in their convoys crossed over the spill.

Nature of the Shore Bottom in the Polluted Area: The bottom of the area is very deep, (about 20 meters). There are no signs for plants or shallow areas suitable for any spawning or nursery grounds for larvae or any other living organism. The sides of the shore are covered as well with concrete substance, in addition to strong water current due to vessels passé. These physical features indicate un-suitable conditions for fish nursery or spawning grounds related to fishery's productivity.

Secular Trend of Fish Catch and Fries Production: Table 1 illustrates evolution of the actual fish catch and the forecasted corresponding estimates for 2000-2007 period of the study, i.e. five years before the accident and three years later. The actual fish catch has reached its upper limit (281.2 thousand metric tons) by 2001 before the time of the accident and has dropped to its lower limit (246.7 thousand metric tons) by the year 2004 where the accident has taken place. Then, the catch has further dropped to 219.8 thousand metric tons by the year 2005. It has risen again to about 242 thousand metric tones by the year 2007. The following equation indicates that the secular trend of the actual fish catch in the affected area was descending. The estimated growth rate was about -3% annually.

Table 1: Evolution of actual and forecasted fish catch in the Egyptian capture Fisheries in 2000-2007 periods (in thousand metric tones)

Capture Fisheries	2000	2001	2002	2003	2004	2005	2006	2007
Mediterranean Sea	54.9	69.6	59.6	47.0	47.0	56.7	72.7	83.8
Red Sea	76.0	73.6	72.9	70.4	63.9	50.7	46.9	47.0
Northern Lakes	141.2	144.7	133.8	135.6	132.9	108.7	108.3	106
Coastal Dep.	3.4	3.3	3.3	3.5	2.4	3.7	4.2	5.1
Total Actual	275.5	281.2	269.6	256.5	246.7	219.8	232.1	242.0
Total Forecasted	280.0	271.7	263.7	255.9	248.4	241.0	233.9	227
Difference	4.5 (-)	9.5 (+)	5.9 (+)	0.6 (+)	1.7 (-)	21.2 (-)	1.8 (-)	15 (+)

Source: The General Authority of Fishery Resources (GAFRD), Egypt; Fish catch year-books (2000-2007), Cairo, Egypt.

Table 2: Evolution of actual and forecasted fish catch in the oil spill area From Km 58 till the area km 03 Port Said city (in metric tons)

Items	2000	2001	2002	2003	2004	2005	2006	2007
Actual catch	650	560	443	398	319	231	134	137
Forecasted catch	722	567	446	350	275	217	170	134
Difference	72 (-)	7 (-)	3 (-)	48 (+)	44 (+)	14 (+)	36 (-)	3 (+)

Source: GAFRD

Table 3: Forecasted estimates of main economic fish species in the affected Are

Species	Exponential Function	R^2(%)	1-R^2 %	F
Meagre	Lny= Ln 1.3888 + 0.128 x (2.78)* (1.29)	22	78	1.097
Rabbit fish	Lny= Ln 2.397 – 0.03 x (4.09)** (-0.29)	1	99	0.07
Cuttlefish	Lny= Ln 4.212 – 0.15 x (13.55) (-2.42)	49	51	5.87
Crabs	Lny= Ln 4.563 – 0.11 x (36.69)** (-4.47)**	77	23	(19.98)**
Common sole	Lny= Ln 4.647 – 0.21 x (28.8)** (-6.43)**	87	13	(41.3) **
European seabass	Lny= Ln 2.143 – 0.16 x (3.40)* (-1.31)	22	78	1.72
Mullet	Lny= Ln 1.794 – 0.08 x (3.14)** (-0.74)	10	90	0.55

Source: Collected and estimated from GAFRD, year-books

Table 4: Evolution of actual fish production and their forecasted estimates for the main economic species in the polluted area in the 2000-2007 period

Species	Items	2000	2001	2002	2003	2004	2005	2006	2007
Meagre	Actual production (ton)	1.6	10.5	6.0	15.9	7.0	8.6	7.6	9.0
	Forecasted production (ton)	5.3	5.6	5.9	6.2	6.5	6.8	7.2	7.6
	Difference (ton)	3.7(-)	4.9(+)	0.1(+)	9.7(+)	0.5(+)	2.2(+)	0.4(+)	1.4(+)
	1-R2 =1-22%=78%						2.1(+)	0.4(+)	1.3(+)
	Price (k.g/EGP)						18	20	22
	Calculated value (thousand EGP)						37.8(+)	8.0(+)	28.6(+)
Rabbit fish	Actual production (ton)	16.0	20.3	6.8	2.2	7.4	12.8	9.3	12.6
	Forecasted production (ton)	10.3	10.0	9.8	9.4	9.1	8.9	8.6	8.4
	Difference (ton)	5.7(+)	10.3(+)	3.0(-)	7.2(-)	1.7(-)	3.9(+)	0.7(+)	4.2(+)
	1-R2 = 1-1% = 99%						3.9(+)	0.7(+)	4.2(+)
	Price(k.g/EGP)						8	8.6	9.2
	Calculated value (thousand EGP)						31.2(+)	6.0(+)	38.6(+)
Catfish	Actual production (ton)	79.0	25.1	57.4	33.1	49.3	28.4	17.4	21.9
	Forecasted production (ton)	58.2	50.1	43.2	37.2	32.0	27.6	23.8	20.5
	Difference (ton)	20.8(+)	25.0(-)	14.2(+)	4.1(-)	17.3(+)	0.8	6.4(-)	1.4(+)
	1-R2 =1-49% = 51%						0.4(+)	3.3(-)	0.7(+)
	Price (k.g/EGP)						17.2	22.4	20.4
	Calculated value (thousand EGP)						6.9(+)	73.9(-)	14.3(+)
Crabs	Actual production (ton)	100.6	84.3	57.0	54.0	57.9	44.1	41.5	49.2
	Forecasted value (ton)	85.9	77.0	68.9	61.8	55.3	49.5	44.4	39.8
	Difference (ton)	14.7(+)	7.3(+)	11.9(-)	7.8(-)	2.6(+)	5.4(-)	2.9(-)	9.4(+)
	1-R2 = 1-77% = 23%						1.2(-)	0.7(-)	2.2(+)
	Price (k.g/EGP)						10.3	11.9	11.2
	Calculated value (thousand EGP)						12.4(+)	8.3(-)	24.6(+)

Table 4: Continued

Common sole	Actual production (ton)	72.0	73.6	59.3	50.2	49.7	24.5	19.2	23.4
	Forecasted value (ton)	84.9	69.2	56.3	45.9	37.4	30.4	24.8	20.2
	Difference (ton)	12.9(-)	4.4(+)	3.0(+)	4.3(+)	12.3(+)	5.9(-)	5.6(-)	3.2(+)
	1-R2 = 1-87% = 13	1.8(-)	0.6(+)	0.1(+)	0.6(+)	1.7(+)	0.8(-)	0.8(-)	0.4(+)
	Price (k.g/EGP)						14.5	13.8	14.9
	Calculated value (thousand EGP)						11.6(-)	11.0(-)	15.3(+)
European seabass	Actual production (ton)	1.9	11.8	5.3	10.9	6.6	3.9	1.9	1.2
	Forecasted production	7.2	6.1	5.2	4.4	3.8	3.2	2.7	2.3
	Difference (ton)	5.3(-)	5.7(+)	0.8(+)	6.5(+)	2.8(+)	0.7(+)	0.8(-)	1.1(-)
	1-R2 =1-22 % = 78%						0.5(+)	0.6(-)	0.9(-)
	Price (k.g/EGP)						23.0	25.6	18.9
	Calculated value (thousand EGP)						11.5(+)	15.4(-)	17.0(-)
Mullet	Actual production (ton)		3.5	3.5	10.9	6.4	2.2	3.1	3.1
	Forecasted value (ton)		5.1	4.7	4.4	4.1	3.7	3.5	3.2
	Difference (ton)		1.6(-)	1.2(-)	6.5(+)	2.3(+)	1.5(-)	0.4(-)	0.1(-)
	1-R2 = 1-10 % = 90%		1.4(-)	1.1(-)	5.6(+)	2.1(+)	1.4(-)	0.4(-)	0.1(-)
	Price (k.g/EGP)						13.1	15.5	15.4
							18.3(-)	6.2(-)	1.5(-)

Resource: Collected and calculated from GAFRD.

Table 5: Evolution of actual fish fries production and their forecasted estimates on the Egyptian level and in three fry collecting stations adjacent to the affected area in 2000-2007period (Million units)

Item	2000	2001	2002	2003	2004	2005	2006	2007
Actual production	94	134	137	109	96	69	41	77
Forecasted production	116	114	113	111	109	107	105	104
Port-Said Actual production	52	61	36	37	31	18	18	23
Port-Said forecasted production	57	49	42	36	31	27	23	20
Ismailia Actual production	7	9	6	3	8	5	2	8
Ismailia forecasted production	7	7	6	6	5	5	4	4
Suez Actual production	8	27	24	16	15	11	7	12
Suez forecasted production	14	15	17	18	19	21	22	24

Source; collected and calculated from GAFRD.

Table 6: Seasons of spawning of main resident fish species in the affected area

	Species	Hatch period
1	Sole	March/May
2	Bruchtooth	March/August
3	Crabs	April
4	Bogue	April/May
5	Guzayella	April/July
6	Red Mullets	April/July
7	Octobus paracuda	May/July
8	Sardinellas	May/August
9	Mullets	May/December
10	Shrimps	May/December
11	Golden	July/August

Source; Fishery Biology Lab.Fisheries Department, NIOF, Alex. Egypt

$Y= 288.5\ e^{-0.03X}$ $R^2= 0.72$ F = (15.49)

The forecasted fish catch was higher than the actual catch for the years 2000, 2004, 2005 and 2006, while it was less than the actual catches for the years 2001, 2002, 2003 and 2007.

Evolution of Actual and Forecasted Fish Catch in the Affected Area: Table 2, reveals actual fish catch drop in the affected area from (km-58) till the area (km-03) in Port Said city, from about 650 metric tons in the year 2000 to about 134 metric tons only by the year 2006. The estimated growth rate was descending by an annual rate of about -24% as shown in the following equation;

$Y= 918.03e^{-0.24x}$ $R^2= 0.96$ F = (131.87)

Fish Catch by Main Economic Fishes in the Affected Area: Tables 3 and 4, illustrate the estimated exponential functions of main economic fish species and their annual forecasted growth rate in the fisheries that have been affected by the oil tanker's accident.

For Meagre species, the estimated rate was increasing by about 12% annually. On the other hand, the corresponding rates for Segan, Sepia, Crabs, Soles, sea-bass and mullet were of descending trend by about 3, 15, 11, 20, 16 and 8%, respectively. The calculated RG^2 for each equation indicates that the effect of time factor (before and after the accident) on the catch growth rate is very low for the whole fish species (except for crab and sole which are mainly demersal species which might be far away from the oil spill).It ranges from a too small value of about 1% for Segan and a little bit higher value of about 49% for Sepia

Fish Fries Production and Spawning Time in the Affected Area: Table 5, illustrates evolution of actual fish fries production in the period of study and their forecasted estimates on the national level as well as On three fish fries collecting stations adjacent to the affected areas, namely Port Said, Ismailia and Suez zones.

The total actual fry production on the national level has raised from about 24 million units in the year 2000 to about 137 million units by the year 2002. Then it gradually decreased from about 109 million units in the year 2003 to about 41 million units only in the year 2006, finally it increased again to about 77 million units in the year 2007.

As to the forecasted fish fries production in the same table, it was higher than their corresponding actual production in several years of the period of study. The forecasted production was descending as well during the period of study.

As to Port-Said collecting station in the affected area the actual production dropped from about 61 million units in the year 2001 to about 18 million units in the year 2005. Similarly, the corresponding forecasted fry production dropped from about 57 million units in the year 2000 to about 20 million units only in the year 2007.

As to Ismailia collecting station in the affected area, the actual production dropped as well from about 9 million units in the year 2001, to about 2 million units only in the year 2006.

Similarly the corresponding forecasted fries production dropped from about 7 million units in the year 2000 to about 4 million units in the year 2006.

As to the third fry collection station in Suez, the actual fry production was fluctuating between a low level of 7 million units in the year 2006 and a high level of 27 million units in the year 2001. On the other hand, the corresponding forecasted fry production was found of ascending trend from about 14 million units in the year 2000 to about 24 million units in the year 2007.

Table 6, shows time of spawning and hatching of main resident fish species in the affected area. It can be seen that this times of spawning and hatching are away from the time of accident.

Manpower and Fishing Capacity in the Polluted Area: There are three fishermen's CO-OP. Societies in the affected area. The first society in El-Kabooty owns 200 wooden otter-boat of 3rd class (4fishermen/boat). Catch per boat is about 4 kg and boat fishing activity is about 270 day/year.

DISCUSSION

The accident took place in winter season, which is characterized by fluctuating weather conditions affect fishing activity particularly in Suez Canal due also to strong winds. SCA did not ban ships passage after the accident. This resulted in the dispersion of the oil spill and increased aeration rate in the affected area, which is necessary for any living aquatic organisms. SCA rescue team cleaning role in the affected area for a whole month (from 14 December 2004 till 15 January 2005) has assisted as well in the aeration process [5]. It is noteworthy to

reveal that the movement of the sea water due to ship passage and rescue action assisted in dissolving about 29.45 cm^3 of air containing about 10.27 cm^3 of oxygen. Fish species require about 5 PPM of dissolved oxygen for their living in the sea water. In other words, one cubic meter of water will dissolve in the case of agitation 10.3 thousand cm^3 [10].

In winter, which is the time of the accident, fishes and other aquatic living organisms move downwards for shelter against low temperature in the surface layers. This assists greatly in protecting fish stocks in the affected area from any harm that might take place as a result of any oil spill.

The bottom nature of the area of the oil accident and its shore structure are not suitable for any fishing activity or fry collection.

Wind direction assisted in moving the oil spill northwards away from the fisheries of Timsah and bitter lakes, which are known for their good catches.

Spawning and hatching season of native fish species in the affected area take place in March far away from the time of the accident or rescue period. The water agitation and well aeration condition in the affected area protect any aquatic living organisms from any harm.

The obtained results of fish catch trend in the affected area in 2000-2007 period has revealed a decreasing and a negative trend. The fisheries near the affected area are characterized also by a fluctuating year to year catching, away from any harm consequences stemming from the accident. Actual and forecasted estimates of fish catches in the periods of study were close to each other.

It could be concluded that any negative effects raised by the oil spill accident on the fishery effectiveness in the polluted or adjacent areas are limited.

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