

**ECONOMIC IMPACT ASSESSMENT FOR  
MANIFA FIELD DEVELOPMENT (NAFD/L-001-06):  
CAUSEWAY CONSTRUCTION AND DREDGING**

Final Report to

**Center for Environment and Water  
Research Institute  
King Fahd University of Petroleum & Minerals  
Dhahran, Saudi Arabia**

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## Summary

This report estimates the economic value of impacts to the Manifa/Tanajib Bay fishery and breeding area following construction of a causeway across the mouth of the bay. The on-site survey team and Dr. Vivekanandan have estimated that the only species which will experience a reduction in catch is shrimp. Fishing vessels formerly based at Manifa may relocate, but their presence in other waters is not expected to depress catch of any species there.

A model is developed to estimate the primary and secondary effects of a reduction in catch of a particular species in a given area. The full impact of this reduction includes the effect of diversion of fishing to other areas, and changes in targeted species and gear type, as well as the changes in cost associated with the changes in catch rates. The model is simplified for this case since relocation was not a major concern.

The correct economic measurement of losses to a fishery is lost profits rather than the value of lost catch. The value of lost catch generally would exceed lost profits, because labor and equipment could be reallocated profitably. However, in the present case, the on-site survey team expects no reduction in effort—the numbers of trips, vessels, or fishermen are expected to remain the same with and without the causeway construction. In this case, the value of lost catch is equal to lost profits.

Reduction in shrimp catch is expected in the first three years following construction of the causeway, with the initial year's depression the greatest, at 235 metric tons in 2007, with recovery during the subsequent two years, to a loss of 117 metric tons in 2008 and 58 metric tons in 2009. By 2010, shrimp catch is projected to have recovered completely to the level it would have been in the absence of construction. No allowance has been made for the possibility that the construction of the causeway would foster an increase in shrimp stock and a consequent increase in catch.

The present value of lost shrimp catch from 2007 through 2009, which equals the present value of lost fishing profits over that period, is SAR 54,196.

The vast majority of the valuation of seagrass derives from its use value in supporting commercially-exploitable species. Adding the total value of seagrass losses to the value of reduced fish catch would double count most of the value of seagrass losses. An estimate of the portion of seagrass losses that are independent of commercial fish catch is based on the non-nutrient value of seagrass and comes to SAR 1,436 per square kilometer per year. The estimate of seagrass loss is 6.63 square kilometers. Assuming it recovers at the same rate as shrimp catch gives a PDV of the non-nutrient component of seagrass losses of SAR 16,320.

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## **I. Introduction: Objective and Methodology**

At the request of the Research Institute of King Fahd University of Petroleum and Minerals, RCF Economic and Financial Consulting, Inc. has conducted an economic impact analysis for Manifa Field Development for causeway construction and dredging.

The economic impact analysis quantifies the losses associated with fishing from the construction and dredging of a causeway for oil field development. The environmental and marine-related impacts of the causeway development have been identified in the Environmental Impact Assessment (EIA) by the Research Institute of King Fahd University of Petroleum and Minerals (KFUPM/RI).

The analysis relies on methodologies which measure four main categories of economic impacts of the causeway construction:

1. Effects on fishery profits
2. Effects on fishery employment
3. Secondary and induced effects on employment due to employment loss in fishing
4. Effects on marine habitat including seagrass and coral reefs.

The estimation of effects on fishery profits relies on a model of profit-maximizing behavior by individual fishermen and fishing firms in the face of externally-imposed reductions in fish catch. Impacts on employment in fishing follow from reactions of fishermen in the face of reduced profitability of fishing, as developed in the fishery model. Estimation of secondary and induced employment effects relies on employment multipliers derived from empirical applications of input-output analysis; values for multipliers were derived from the literature rather than from a direct input-output analysis of this region, which was beyond the scope of this work. The value of impacts on marine habitat was estimated with values derived from literature around the world.

The remainder of the report is organized as follows. Section II reports the sources of the data used in the analysis. Section III describes the methodologies for a) measuring changes in profits in fishing, b) estimating secondary losses in employment, and c) measuring the values of changes in the marine habitat and ecosystem. Section IV presents the analysis and the resulting estimates of impacts on fishery profits. Section V reports the findings for secondary employment effects and the value of impacts on seagrass and coral reefs. Section VI summarizes the findings and offers conclusions.

## II. Data for Analysis

The majority of the data for the analysis were provided by Dr. E. Vivekanandan, Principal Scientist, Central Marine Fisheries Research Institute, Cochin, India and the Research Institute of King Fahd University of Petroleum and Materials.

### *Catch Data*

Historical catch data from 1988-2004 for the Saudi Arabian (SA) Gulf were provided by Dr. Vivekanandan via email on August 30, 2006. A 15-year projection of catch assuming no changes from the existing state of the bay were made for 2006-2020 by Dr. Vivekanandan and provided in his “Catch Projections” report in September of 2006. Catch and price data specific to shrimp in the SA gulf were provided for several years within 2001-2004.

The causeway construction is expected to result in a reduction in shrimp biomass and subsequent reduction in catch that extend for three years. The projections of shrimp catch loss in Manifa Bay from causeway development were provided by Dr. Vivekanandan. According to Dr. Vivekanandan and the EIA, any other losses in catch are commercially insignificant and/or would be compensated through relocation of fishing operations to other areas, without depressing catch in those areas.

### *Price Data*

The most recent wholesale price data for shrimp are from 2003. Data on shrimp prices do not permit confident projection of a future trend, so real shrimp prices are assumed to remain the same from 2003 through 2009. Prices in 2003 Saudi Riyals (SAR) were converted to 2005 SAR prices, averaging the prices of large, medium, small, and mixed shrimp, to yield an estimate of SAR 14.21 per kilogram.

<b>Average Price for Shrimp (SAR 2005) = 14.21/kg</b>
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### *Discounting and Present Value*

Present value calculations were based on the 52-week Saudi Treasury Bond rate of 5.4775 percent on October 19, 2006. To convert that discount rate to a real rate, expected inflation must be subtracted. The most recent inflation data available for Saudi Arabia are from price changes between 2004 and 2005. Those rates of change have been stable in recent years, so assuming they continue at the same pace is satisfactory. The rate of change in the Saudi consumer price index (CPI) between 2004 and 2005 was 0.7 percent. This amount was subtracted from the nominal Treasury Bond rate to yield a real discount rate of 4.7775 percent.

**Real Discount Rate for Present Value Calculations = 4.7775 %**

Using this discount factor, the price calculations are applied to the data on shrimp catch loss to calculate the present value of lost profit in the area.

### ***Data for Habitat Valuation***

Data on seagrass loss was provided in a memo by Dr. Vivekanandan on October 5, and in the EIA by KFUPM/RI. The seagrass loss of a total of 6.63 square km is assumed to follow the same three-year recovery pattern as the shrimp catch. Estimates of the value of seagrass were compiled from various studies around the world and range from SAR 9,000 to SAR 22,000 per square km. Since seagrass provides beneficial services to shrimp populations such as habitat and nutrient cycling, using these estimates value of seagrass would likely already include the lost value from shrimp catch. Only one study by Costanza, et al. distinguishes between this service value of seagrass and its additional non-nutrient value as a raw material. This non-nutrient value can be considered the value of seagrass aside from its value associated with fish populations. The average non-nutrient value of seagrass is estimated to be approximately SAR 1,436 per square kilometer.

**Non-nutrient Value of Seagrass (SAR 2005) = 1,436/km<sup>2</sup>**

This estimate is used to determine the loss, aside from shrimp catch loss, from seagrass depletion.

A 2004 report by the United Nations Environment Programme estimated the value per square kilometer of coral reefs to be between \$100,000 and \$600,000 in U.S. dollars, with a maximum value of up to \$900,000 for reefs with significant use in recreation such as scuba diving and snorkeling. This is a range of approximately SAR 385,000 to SAR 3.5 million. The study indicated the costs of protecting coral reefs through marine protected areas to be substantially lower at \$775 per square kilometer. This is approximately SAR 2,987 per square kilometer.

The range of values is important for any future loss in coral reefs, but the EIA report indicates that protection and mitigation methods will prevent a measurable loss in coral reef area or biomass.

### III. RCF Model and Methodology

The RCF Model was created to analyze the full impact of an estimated reduction in catch for any given species. The model, implemented in an Excel spreadsheet, incorporates the potential for the reduction in catch to affect other areas, species and gear types through relocation and diversion. The model is sophisticated enough to account for (a) differential impact of causeway on fish-species, and also differences in rate of regeneration among species, (b) specialization of vessels with respect to fish catch, (c) any economic costs of changing the fishery region, and (d) exogenous constraints on the movements between Manifa Bay and other fisheries.

#### *Catch Reduction in Manifa / Tanajib Bay, Diversion of Vessels, and Lost Profits*

The economic losses from construction of the causeway across the Manifa / Tanajib Bay System are the lost profits in fishing. These losses are estimated from a comparison of profits from fishing in the absence of the causeway and with the causeway. A 20-year projection of fishing is made under the assumption that no causeway is built, and the present discounted value (pdv) of profits is calculated; next a 20-year projection of fishing is made under the assumption that the causeway is built, and the pdv of profits in that scenario is calculated. The difference in pdv between the without and with scenarios is the economic loss imposed by the causeway construction.

The following model was developed to allocate fishing vessels from fisheries dependent on the Manifa / Tanajib Bay System to other fisheries along the SA Gulf coast after a disruption caused by causeway construction. The gear types on the vessels in the model, and their parameterization, are taken from data in Center for Water and Environment (2003, Tables 6.126-6.131). The model could be used to supplement on-site survey data in predicting diversion of vessels from Manifa-based fisheries following construction. To accommodate the schedule of the evaluation project, the model was developed simultaneously with the oceanographic and social surveys, and it is accordingly capable of dealing quite generally with a wide array of possible disturbances to fish catch patterns. The actual estimation of lost profits in the case of the Manifa / Tanajib Bay System causeway turns out to be a simplified, special case of the model presented here.

Profit per vessel is  $\pi_{jkt} = \frac{\sum_i p_{it} q_{ijkt} - c_j}{K_j}$ , where the subscripts represent the following: i = species, j = vessel type, k = region, and t = time.

The total number of vessels of type j is divided between the Manifa fishery and other regions to which Manifa vessels might be diverted:  $N_{jt} = \sum_{k=1}^2 N_{jkt}$ , where region 1

is the Manifa-dependent fishery and region 2 is the diversion area. Alternatively, the vessels of type  $j$  fishing in the Manifa fishery are  $N_{j1t} = N_{jt} - N_{j2t}$ .

The change in catch over time is composed of an exogenous influence estimated from empirical trends and an endogenous component imposed by a change in the number of vessels fishing in one of the regions. The catch per vessel in any period  $t$  is the catch in the previous period adjusted for both of these influences:

$q_{ijkt} = q_{ijk(t-1)}(1 + \dot{q}_{ik})(1 + \varepsilon_k \sum_j w_{ijkt} \dot{n}_{jkt})$ , where  $\dot{q}_{ik}$  is the exogenous rate of change in the catch of species  $i$  in region  $k$ ,  $\varepsilon_k$  is the effort elasticity in region  $k$ ,

$w_{ijkt} = \frac{q_{ijk(t-1)} n_{jk(t-1)}}{\sum_j q_{ijk(t-1)} n_{jk(t-1)}}$  is the proportion of species  $i$  caught by vessel type  $j$  in the region  $k$  in the previous period, and  $\dot{n}_{jkt}$  is the percent change in vessels of type  $j$  in region  $k$  at time  $t$ .

Thus, to calculate the effect of additional vessels on the catch of any given species, the catch elasticity is multiplied by the percent change in vessels weighted by their capacity for harvesting a specific elasticity. The catch elasticity is allowed to differ between regions to allow for potential damage to the Manifa / Tanajib Bay ecosystem imposed by the construction of the causeway. To illustrate the operation of the model, suppose that the catch elasticity in the diversion area has the symmetric value of -0.74, a value derived from an empirical estimate from the Campeche shrimp fishery in Mexico (Barbier and Strand 1997). If the capacity-weighted number of vessels increased by 1 percent, catch of that species would fall by 0.74 percent, and if they decreased by 1 percent, the catch would increase by 0.74 percent. As a simple numerical example, suppose that the total number of vessels operating in the SA Gulf coastal fisheries were a round 2,000 for simplicity of calculation, and that 25 percent of them fished in Manifa-dependent areas. If the catch elasticity of -0.74 is used and 25 percent of the former Manifa vessels diverted their locations, the number of vessels diverted would be  $0.25 \times 0.25 \times 2,000 = 125$  vessels. Those 125 vessels shifted from Manifa fisheries to the diversion areas would represent a percent increase of  $125/1500 = 0.0833$  (8.3%). Multiply  $0.0833 \times -0.74$  to obtain -0.06167, or about a 6 percent reduction in the catch in the diversion area. Calculations such as these can be made in the attached spreadsheet.

The Manifa post-construction catch elasticity is assumed to be asymmetric, in the sense that a reduction of vessels will cause an increase in catch that is smaller than the reduction in catch that would be imposed by an increase in the number of vessels. In the no-construction alternative situation, which is used to estimate the losses from construction, the catch elasticity in the Manifa fishery is assumed to be symmetric and have the same value as that in the diversion areas.

The percent changes in vessels in the two regions are defined as  $\dot{n}_{j1t} = \frac{N_{j1t} - N_{j1(t-1)}}{N_{j1(t-1)}}$  for the Manifa fishery and  $\dot{n}_{j2t} = \frac{N_{j2t} - N_{j2(t-1)}}{N_{j2(t-1)}}$  for the diversion region.

The construction of the causeway across Manifa Bay could reduce fish stocks and reduce catch of vessels fishing in the Manifa-dependent fishery. The reduction in catch would reduce profits accruing to vessels operating in the Manifa fishery. Accordingly, vessel owners or operators would change their choice of fishery locations, and the corresponding adjustment of  $N_{j1t}$  would occur until  $\pi_{j1t} = \pi_{j2t}$ . The movement of vessels from the Manifa fishery to the diversion fisheries would mitigate the reduction in catch in the Manifa fishery while the increase in vessels in the diversion areas would reduce catch there. The reduction in aggregate catch in the diversion areas may not be especially large, but neither need it be negligible.

### ***Empirical Evidence on Relocation***

The premise for fishermen's decisions in the economic literature is that fishermen will choose their gear type, targeted species *and* location in order to maximize profits over time. While this theory has been found satisfactory for gear type and targeted species, the majority of the literature has found that locational choice is hampered by mobility, information, and experience and knowledge of a given area (Dupont 1993, Eales and Wilen 1986, Holland and Sutinen 1999, 2000). This evidence indicates that relocation and diversion is a longer term process since fishermen tend to be affected more by experience and inertia in the short run. Therefore, the potential to achieve greater profits in an alternate fishing area must be sufficiently high to outweigh the cost of increasing the knowledge and skills to adapt to a new location.

The condition guiding fishermen's relocation decision in the RCF model can be adjusted easily from one of profit equalization to one of minimum profit appreciation.

The RCF model would be useful in predicting the overall regional effects of a change in catch for a specific species, gear type or region. The data provided by Dr. Vivekanandan and the EIA indicate unnoticeable relocation effects which leave other species and areas unaffected. The increased costs to Manifa fisherman in the form of increased travel time are assumed to be negligible so in this case, the value of the change in fishing profits is equal to the value of the change in catch.

The RCF model could be applied in future analyses to predict the effects of relocation when the effects of changes in localized species-specific catch rates are not immediately known.

## ***Employment Losses***

In a full-employment economy, labor employment losses in the fishing industry would be reallocated elsewhere in the economy, but a smooth transition is unlikely to be the case in the Manifa / Tanajib fishery. There are between 9,000 and 10,000 traditional Saudi fishermen along the SA Gulf coast who could experience impacts from disruptions in the fishery. Employment impacts on non-Saudi nationals employed on the industrial boats would not be an effect on the Saudi national economy, but some Saudi nationals are employed on some of these vessels.

In the long run, Saudi Arabia would be a full-employment economy, but with possibly high unemployment rates in lower-paid occupations, durations of unemployment could be lengthy for displaced fishermen.

Saudi unemployment statistics vary widely, and a senior figure in the Saudi Chamber of Commerce and Industry has been quoted as stating that, “Nobody has accurate figures” (Champion 1999). However, estimates range from 4 to 25 percent. According to the Saudi American Forum, Saudi Arabia has an overall unemployment rate of 4.3 percent. This overall rate includes international workers, who have virtually no unemployment, and the Saudi workforce, which it says has an 8.1 percent unemployment rate (Taecker 2003). The BBC places the unemployment rate at 18 percent and says, “The country’s . . . economy is finding it hard to absorb an increasing number of young school and university leavers, while most of the lower-paid jobs are done by foreign labour imported mainly from Asia” (Richardson 2005).

## ***Secondary or Induced Losses in the Economy***

Direct losses of employment would precipitate indirect losses, as people losing employment would spend less on the services and products of workers in other industries. RCF will obtain employment and income multipliers from other developing countries to estimate Saudi employment impacts.

Type I employment multipliers measure employment changes for both direct and indirectly affected sectors. Type II employment multipliers include the employment induced by spending in the local economy by workers involved in the directly and indirectly affected sectors.

$$\text{Type I employment multiplier} = \frac{\Delta \text{direct employment} + \Delta \text{indirect employment}}{\Delta \text{direct employment}}$$

$$\text{Type II employment multiplier} = \frac{\Delta \text{direct employment} + \Delta \text{indirect employment} + \text{induced employment}}{\Delta \text{direct employment}}$$

Table 1: Fishing Industry Employment Multipliers

Location	Date	Type I Multiplier	Type II Multiplier
New Zealand, Auckland Region	2006	1.71	2.45
S.W. United Kingdom	2003	2.20	2.62
Philippines	2000	1.41 <sup>a</sup>	
Malaysia	2000	1.19 <sup>a</sup>	
Thailand	2000	1.38 <sup>a</sup>	

<sup>a</sup>Output multipliers; employment data unavailable.

### ***Habitat Loss***

The EIA report indicated that any potential loss in coral reefs would be prevented through protection and mitigation. In the absence of any information on coral reef loss, the value is not quantified for the analysis.

It is recommended however, that if future coral reef loss is expected, the significance of the resource in recreation and general existence should be considered in order to select an appropriate estimate from the range of values for coral reefs given in Part I.

### ***Seagrass***

Seagrass is a submerged aquatic biomass which provides food and nutrient cycling, habitat, and nursery areas for myriad marine life. Seagrass perform a variety of services, which have economic value.

Table 2 shows a sample from the literature of the estimates of the value of one square kilometer of seagrass.

Table 2: Estimates from the Literature of the Value of Seagrass

<b>Study</b>	<b>SAR per KM<sup>2</sup></b>
Florida Department of Environmental Protection. Florida Coast	22,618,239
Talbot and Wilkinson, Australia	12,813,255
Costanza, world average	9,699,486
Blackwell, Australian Coast	9,928,352
<b><i>Average</i></b>	<b><i>13,764,833</i></b>

Since the loss in shrimp catch is attributable to the change in habitat and breeding area caused by causeway construction, part of the value of lost seagrass is already

contained within the estimate of lost profits from reduced shrimp catch. In this case, only the portion of the overall seagrass value, which pertains to the non-nutrient value of seagrass is used to measure the loss associated with the reduction in seagrass area as estimated by the EIA. According to the Constanza, *et al* (1997) comprehensive survey of the value of the world's natural capital, the ratio of the non-nutrient value of seagrass to the total value of seagrass is 0.000105. Multiplying this ratio by the average value of SAR 13,764,833, the non-nutrient value of seagrass is SAR 1,449. Table 3 summarizes the calculation.

Table 3: Non-nutrient Value of Seagrass

Average Overall Value of Seagrass (SAR)	13,764,833/km <sup>2</sup>
Ratio of Total Seagrass Value to Non-nutrient Value of Seagrass	0.000105
<b>Non-nutrient Value of Seagrass (SAR)</b>	<b>1,449/km<sup>2</sup></b>

This value will be applied to the total loss in seagrass per year and discounted to obtain the present value of loss of seagrass as a raw material.

#### IV. Analysis and Results for Fishery Profits

The following data on historical catch in the SA Gulf area were provided by Dr. Vivekanandan.

Table 4: Historical Catch in SA Gulf Area: 1988-2004

Year	Trips	Total Catch (t)	CPUE (kg/trip)
1988	24,068	14,683	610.1
1989	32,824	14,502	441.8
1990	34,188	11,355	332.1
1991	33,968	10,007	294.6
1992	34,606	14,407	416.3
1993	40,546	14,811	365.3
1994	33,783	20,271	600.0
1995	45,618	19,580	429.2
1996	45,522	22,146	486.5
1997	44,071	22,875	519.0
1998	47,812	25,979	543.4
1999	44,166	21,066	477.0
2000	43,758	24,605	562.3
2001	45,421	28,218	621.3
2002	54,952	33,223	604.6
2003	50,094	33,235	663.5
2004	51,941	34,884	671.6
Average	41,873	21,520	513.9

Trips are projected for a “standard trip”, which is calculated for the entire fishing fleet of small and large boats operating various kinds of gear (Vivekanandan). The catch, measured in metric tons, is projected as a total catch for all species measured in metric tons.

Based on the historical trend of effort and catch, the following projections were made for 2006-2015 (Vivekanandan).

Table 5: Projected Total Catch for 2006-2015 in SA Gulf

Year	Trips	Catch (t)	CPUE (kg/trip)
2006	52667	29033	551.3
2007	55334	30484	550.9
2008	58001	31866	549.4
2009	60668	33186	547.0
2010	63335	34450	543.9
2011	66002	35662	540.3
2012	68669	36825	536.3
2013	71336	37944	531.9
2014	74003	39022	527.3
2015	76670	40062	522.5

Due to Manifa’s importance as shrimp habitat and breeding grounds, the shrimp catch in the SA Gulf is important for the analysis. Using catch data provided by Dr. Vivekanandan, the share of total shrimp catch in the SA Gulf was calculated for shrimp of various sizes for 2004 and the average of 2001-2004.

Table 6: Shrimp Catch and Share in SA Gulf: 2001-2004

	<b>Total Catch (t)</b>				
<b>Species</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>Average 2001-04</b>
Shrimps (large)	1,164	1,170	1,942	1,295	1,393
Shrimps (medium)	1,484	3,869	2,164	4,944	3,115
Shrimps (small)	131	727	628	283	442
Shrimp (mixed)	157	0	1	20	44
<b>Total</b>	<b>2,937</b>	<b>5,766</b>	<b>4,735</b>	<b>6,541</b>	<b>4,995</b>
	<b>Share Of Total Shrimp Catch</b>				
<b>Species</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>Average 2001-04</b>
Shrimps (large)	39.64%	20.29%	41.02%	19.79%	27.88%
Shrimps (medium)	50.54%	67.10%	45.71%	75.58%	62.37%
Shrimps (small)	4.48%	12.61%	13.25%	4.32%	8.85%
Shrimp (mixed)	5.35%	0.00%	0.02%	0.30%	0.89%
<b>Total</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>

***Potential Changes in Shrimp Catch after Causeway Construction***

Based on correspondence with Dr. Vivekanandan, it is the case that Manifa Bay does not support large quantities of commercially important species other than shrimp. Other species in the Bay were not expected to experience a notable decline since the loss in catch would likely be made up in other areas.

In this case, the only species directly affected by causeway construction is shrimp. The following table shows the change in the projected total catch with causeway construction. The numbers from Table 5 have been inserted to show the previous projection without causeway construction.

Table 7: Projected Total Catch without and with Causeway Construction

Year	Trips	Without Causeway Construction		With Causeway Construction	
		Catch (t)	CPUE (kg/trip)	Catch (t)	CPUE (kg/trip)
2006	52667	29033	551.3	29033	551.3
2007	55334	<b>30484</b>	<b>550.9</b>	<b>30249</b>	<b>546.7</b>
2008	58001	<b>31866</b>	<b>549.4</b>	<b>31749</b>	<b>547.4</b>
2009	60668	<b>33186</b>	<b>547.0</b>	<b>33128</b>	<b>546.0</b>
2010	63335	34450	543.9	34450	543.9
2011	66002	35662	540.3	35662	540.3
2012	68669	36825	536.3	36825	536.3
2013	71336	37944	531.9	37944	531.9
2014	74003	39022	527.3	39022	527.3
2015	76670	40062	522.5	40062	522.5

The years featuring shrimp loss are shown in the shaded areas. After 2009, catch will be restored back to the original projections.

The numbers and share of shrimp loss are isolated in Table 8.

Table 8: Reduction in Manifa Shrimp Catch

Year	Shrimp Catch Reduction (t)	Share of Annual Total Shrimp Catch	
		S.A. Gulf <sup>a</sup>	Manifa <sup>b</sup>
2007	235	4.72%	37.75%
2008	117	2.35%	18.80%
2009	58	1.16%	9.32%

<sup>a</sup>Based on average catch from 2001-2004.

<sup>b</sup>According to "Catch Projections" by Dr. Vivekanandan, Manifa shrimp catch is approximately 12.5% of total SA Gulf shrimp catch. This percentage is assumed to be constant from 2007-2009.

The shrimp price is constructed as described in Section II. The average shrimp price for the years 2001-2003 is weighted for the share of the various categories of shrimp and inflated to 2005 SAR. The calculation for the average shrimp price of SAR 14.21 per kilogram is shown in Table 9.

Table 9: Shrimp Price Average for 2001-2003

Species	Price(kg) <sup>a</sup>		
	2001-2003 Average <sup>b</sup>	Weighted Price Share <sup>c</sup>	Inflated to SAR 2005 <sup>d</sup>
Shrimps (large)	20.7	5.77	5.87
Shrimp (medium)	12.0	7.47	7.57
Shrimps (small)	8.4	0.74	0.75
Shrimp mixed	2.7	0.02	0.024
<b>Total</b>		<b>14.02</b>	<b>14.21</b>

<sup>a</sup>Wholesale price (SAR/kg) of fresh fish at Qateef wholesale fish market. The average is inflated to SAR 2005.

<sup>b</sup>No shrimp price data are available beyond 2003. Only large shrimp prices are available for 2001 and 2002. Average shrimp price data for other sizes are based on the 2003 prices.

<sup>c</sup>The weighted price share is the 2005 inflated price multiplied by the share of total shrimp catch from Table 1.

The total value of the reduction in shrimp catch is the estimate of shrimp catch loss multiplied by the average weighted price from Table 9 and discounted by the factor of 4.7775%. The results and total pdv of catch are given in Table 10.

Table 10: Present Discounted Value (PDV) of Reduction in Shrimp Catch

Year	Shrimp Catch Reduction (t)	Value of Catch (SAR) <sup>a</sup>	PDV of Catch <sup>b</sup>
2007	235	33,403.49	31,880
2008	117	16,630.67	15,149
2009	58	8,244.26	7,167
			<b>TOTAL PDV: 54,196</b>

## V. Analysis and Results for Employment and Seagrass

The following section discusses the importance of direct and secondary employment losses and provides analysis and results for the loss in seagrass.

### *Direct Employment*

Data from various sources suggest that the annual income from fishing in the SA Gulf region is roughly around SAR 11,200 (KFUPM/RI 2003, Figure 6.179; FAO 2003). Total losses from lost fishing profits amount to approximately SAR 54,200, spread over three years. This is equivalent to 1.6 person-incomes each year. The additional SAR 16,200 of seagrass damages depend on sales of products from seagrass, other than fish

using it for nutrients. It is unclear whether those costs would actually be realized in this location, but if they were, they would amount to slightly less than ½ of a person-income per year, again spread over three years. It is unlikely that a reduction in employment of this magnitude, considering the total employment in fishing in the SA Gulf region, would be detectable.

***Secondary and Induced Employment Losses***

From the range of values of the multipliers in Table 4.1, an average of 1.25 for the Type I impact and possibly 1.5 for the Type II are reasonable. Type II multiplier estimates for the Asian nations are not available, but with their lower income levels, the Type I and Type II values should not be as divergent as in the New Zealand estimate, and the U.K. Type I estimated value is unusually high. The Type II multiplier would give an additional loss of employment of 3.15 jobs per year, for three years.

While this estimate must be interpreted with care, since it is a short-term loss which would be absorbed elsewhere in time, it is small enough to be considered noise in a regional economy with a million population.

***Seagrass***

According to the EIA and correspondence from Dr. Vivekanandan on October 11, 2006, the total loss in seagrass area from causeway construction is 6.63 square kilometers. In the absence of any other information, it is not likely that the seagrass will fully restore itself within one year of construction, so the assumption is made that the timing of the seagrass recovery will correspond to the shrimp loss and recovery. In this case, the same rate of recovery is assumed for the years 2007-2009.

The following table shows the rate of loss and recovery based on the shrimp loss from Table 8, as well as the present discounted non-nutrient value of the seagrass. The present discounted value is computed as the seagrass loss per year times the non-nutrient value of seagrass of SAR 1,449, discounted by the real rate used for the shrimp calculation of 4.7775 percent.

Table 11: Non-nutrient PDV of Seagrass Loss

Year	Shrimp Loss	Rate of Recovery	Seagrass Loss (km <sup>2</sup> )	Non-nutrient Value of Seagrass (SAR)	PDV of Seagrass (SAR)
2007	235	1	6.63	1449	9,167
2008	117	0.4979	3.30	1449	4,782
2009	58	0.2468	1.64	1449	2,371
					<b>TOTAL PDV: 16,320</b>

## VI. Conclusion

In summary, the main economic losses associated with causeway construction and dredging in the Manifa Bay area come from the reduction in shrimp catch and the loss non-nutrient value of seagrass.

The RCF model was developed to assess the direct profit loss from catch reduction, in addition to any relocation effects and subsequent profit loss. The model is general enough to be used in other situations where catch reduction and relocation are predicted. In the Manifa Field case, the model is simplified so that the value of shrimp catch loss is equal to the value of profit loss with no relocation effects.

**PDV of Profit Loss from Shrimp Catch = SAR 54,196**

The primary and secondary employment effects are insignificant due to the small reduction in catch and ability to relocate, if necessary. The employment multipliers could be used in the future if further reductions in catch are predicted.

The empirical estimates of seagrass incorporate the loss associated with fish populations and therefore, would double count the loss already estimated for shrimp reductions. In this case, the additional value of seagrass derived from its non-nutrient value as a raw material is used based on an estimate from the literature. The pdv loss of non-nutrient seagrass can be considered to be an additional loss from the causeway construction.

**PDV of Loss in Non-nutrient Seagrass = SAR 16,320**

The total losses to the area based on the data provided by the EIA and Dr. Vivekanandan are the pdv of profit loss from the reduction in shrimp catch and the pdv of loss in non-nutrient seagrass.

**PDV Loss from Causeway Construction and Dredging = SAR 70,516**

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