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Economic Impacts of Climate Change on Tuna Fisheries in Fiji Islands and Kiribati

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Abstract

This paper discusses the possible economic consequences of a change in the tuna fisheries in the Pacific Ocean resulting from climate change. On the background of Lehodey's (2000) study of potential changes in the tuna fisheries, we survey possible economic impacts in terms of quantities and values and give examples of macroeconomic impacts. The two main effects of climate change on tuna fishing are likely to be a decline in the total stock and a migration of the stock westwards. This will lead to various changes in the catch in different countries. The price of the fish in the export market may also change as a result. The Pacific islands are generally dependent on fisheries, and may therefore be vulnerable to these changes, although some will probably gain while others will lose. Based on a very simple macroeconomic model, it is shown that the resulting effects for the national economy in general may diverge substantially from the expected. This applies, in particular, if the national economies are inflexible and a large part of the population relies on subsistence production, which is the case for many developing countries.

Content

1 Introduction

The Pacific islands are among the most vulnerable countries to climate change in the world. Most of the attention about global warming in these countries has been paid to sea level rise, which threatens the existence of many of the islands. However, changing climatic conditions may also have other significant economic impacts. Hurricanes may lead to an increase in material damage, the potential for tourism may change, agriculture will be affected, and possible shifts of ocean currents may affect fisheries.

In a recent study, Lehodey (2000) points out that climate change probably will affect tuna fisheries in the sense that their spatial distribution may shift and the abundance of tuna will decline in the Pacific. Lehodey suggests that the observed changes in tuna fisheries during El Niño and La Niña events give an indication for the future impacts of global warming. Without providing quantitative estimates, he shows that tuna have adapted relatively easily to variations in climatic conditions by migrating to new locations. The total stock remains approximately the same. The catch of tuna thereby shifts to different areas during the El Niño and La Niña events. The total catch seems to be affected only to a limited degree. Over the past 20 years, the total catch of tuna in the tropical Pacific Ocean has increased steadily, without major oscillations. Climate change may, however, imply more permanent El Niños, which are likely to cause a general decline in the abundance of tuna. Whether the individual small island states will win or lose depend on the shift in the spatial distribution, but most stand to lose.

The economic impacts of these changes will be different for the various countries in the Pacific. The economic impacts of changes in the tuna fisheries do not depend entirely on variations in the abundance of tuna within the economic zones of each country. The contribution from fisheries in general to the national economy varies greatly among the countries in the western and central Pacific Ocean. Also the contribution of tuna to the total fishing industry varies, and other species may respond differently than tuna to climatic changes, even though Lehodey considers it likely that tuna may be used as an indicator for other species as well. Finally, it matters how the income from fisheries is generated.

An economic assessment of the changes in tuna fisheries consists of two parts. First, the direct economic effect of changes in the catch, in terms of economic loss or gain, will have to be estimated. Second, the macroeconomic impacts of this change have to be developed. These impacts may affect the national economy to different extents depending on how important tuna fisheries are to the economy. Domestic companies, or fishers, generate income from the catch. This is either sold to processing in own country, or sold to households or exported directly. Some countries also collect a fee from foreign fishers that fish within their economic zones. Hence, a change in the catch will directly affect the income level and the activity within the fishing sector. An increase or a decline in the fishing sector will affect the labour market, and thereby have an impact on the entire economy.

This paper gives a brief discussion of possible economic impacts of changes in tuna fisheries from climate change for Fiji and Kiribati, on the basis of the findings in Lehodey (2000). Because of the lack of physical estimates for changes in tuna fisheries, we have had to keep the discussion at a rather general level. Therefore, the direct economic effects are discussed with reference to the present importance of tuna fisheries for the two countries, as well as attempts to derive changes in the catch resulting from El Niño and La Niña on the basis of observations. The results are, however, very uncertain.

Due to the weak indications of physical impacts of climatic changes on tuna fisheries and poor data on the contribution of tuna fishing to the total income for the two countries, the macroeconomic assessment is based on changes in the fisheries in general. This can be viewed on the background of Lehodey's suggestion that tuna may provide a good indicator for how climate change will affect other fisheries. When shifting scope to fisheries in general, it should be noted that a number of subsistence households also depend on fishing. Their catch does not enter the national economy directly, but has an indirect impact because it may affect the catch in commercial fisheries. The most important influence of the subsistence households in a macroeconomic context is, however, that they represent a 'buffer' to the labour market. The catch in subsistence households represents the income to these households. If the catch is reduced, one must expect that more people from subsistence households enter the wage labour market, and thereby increase the supply of labour. Shifts in the income of commercial fisheries, on the other hand, affect the demand for labour.

In the next section, we survey the economies of Fiji and Kiribati paying particular attention to their dependency on fisheries. In section 3 we discuss the possible direct economic impacts of climate change on tuna fishing, and present two scenarios based on an interpretation of Lehodey's results. To show how a sensitivity analysis of changes in the fisheries as a consequence of climate change could be carried out, section 4 contains a macroeconomic assessment of the Fijian economy based on a very rudimentary model.

2 The Economic Importance of Fisheries in Fiji and Kiribati

Although not the most important sector, fishing constitutes an important element of the economies in both Fiji and Kiribati. Fish is also a major export product, contributing to approximately 8 per cent of total export in Fiji and 30 per cent in Kiribati. Tuna constitutes the major part of this income for Kiribati. In addition to the direct economic contribution, one must also assume that fishing is an important activity for providing food in subsistence households, which made up about 2/3 of the population in both countries 10 years ago. This share is, however, declining.

The more than 300 islands of Fiji are spread over an area of 1.3 mill km^2, of which less than 0.5 per cent is land. The population is slightly above 0.8 mill, where 1/3 is less than 15 years of age. The labour force numbers approximately 235 000, of which 65 000 are employed as salary or wage earners. The remaining labour force works in subsistence agriculture or fisheries. Six per cent of the wage or salary earners were unemployed in 1997.

The main economic indicators for Fiji are shown in table 1. GDP was estimated at USD 5.4 billion in 1998, with a per capita GDP of nearly USD 6 700. This is about 1/3 of the average for developed countries, but in the upper level for developing countries. The service sector is the largest economic sector, and it includes tourism, an important source of income to the country. The most important export product is sugar, which contributes to more than 30 per cent of the total export of USD 0.65 billion.

The export of fish contributes to slightly more than 7 per cent of the total export value. More than 80 per cent of the total catch is consumed domestically, and an additional 15 per cent is used in domestic processing. In other words, the most severe real economic impacts of changes in the fisheries due to climate change are likely to occur domestically rather than as results of changes in revenues from exports. However, the country also benefits from property rights over fishing areas. Most of the tuna fishing within the economic zone of Fiji is carried out by foreign vessels, which have to pay a charge for fishing. As a result, the income effect of changes from foreign sources may be substantially higher than the export figures indicate. Unfortunately, we have not succeeded in obtaining figures of the size of this income.

Table 1. Main economic indicators for Fiji and Kiribati

	FIJI		**KIRIBATI**	
	USD mill.	*Per cent*	*USD mill.*	*Per cent*
GDP	5 400	100	620	100
Largest sector[1]	3 200	59	490	79
Fisheries	na	na	83	13
Export	655	100	7	100
Main product[2]	210	32	4	62
Fish	48	7	2	30

1) Fiji: Service sector; Kiribati: Service sector
2) Fiji: Sugar; Kiribati: Copra

Kiribati is much smaller and more dispersed than the Fiji islands. The country consists of 32 atolls and one island with a total land area of 717 000 km^2, which is only 0.02 per cent of the total area of Kiribati. The population is approximately 85 000 people with a total labour force of nearly 28 000. However, between 60 and 70 per cent of the labour force lives in subsistence households. This share is expected to decline in the future.

Kiribati's GDP was USD 620 million in 1998, which gives a GDP per capita of nearly USD 7 300, and the highest contribution comes from the service sector. After the depletion of the sulphur resources during the 70s, copra has been the most important export product in the country. Fish contributes 30 per cent of the total export, but this changes considerably in accordance with the oscillations in catch and prices of fish in the export market.

The fisheries contribute 13 per cent of the GDP in Kiribati. Corresponding figures for Fiji are not available, but the total commercial catch in Kiribati is 25 000 tons, while in Fiji it is approximately 35 000 tons. These figures fluctuate considerably, but fisheries are clearly more important for the economy of Kiribati that of Fiji. Tuna contributes a higher share of the total catch in Kiribati than in Fiji.

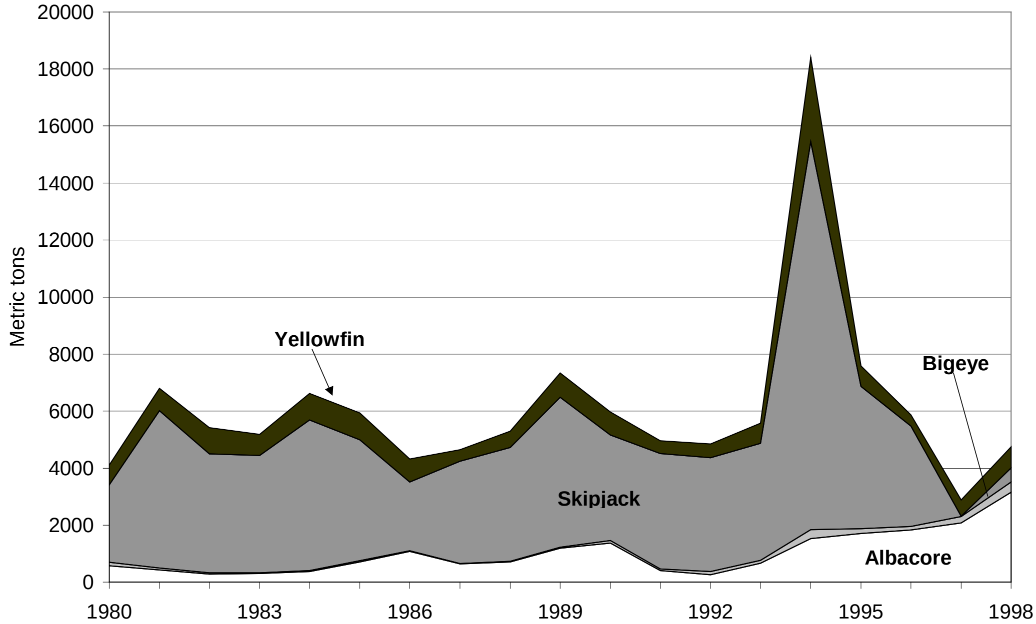
The relative contribution of fisheries to the total economy makes Kiribati more vulnerable to a change of abundance or in the market prices for fish than Fiji. On the other hand, the economic zone of Kiribati is nearly three times as large as that of Fiji. As pointed out in the next section, tuna are likely to respond to climate change by a shift in their spatial distribution. The likelihood that tuna will disappear from the economic zone of Kiribati is, therefore, less than that for Fiji. The overall vulnerability of changes in the total fisheries is, in other words, highly dependent on the response in other fisheries. Lehody (2000) suggests that other commercial fisheries may change in ways similar to that of tuna. In section 4 we will discuss the implication of this.

3 Direct economic effects of changes in tuna fisheries.

Tuna fisheries constitute the most important commercial interest of fisheries in both Fiji and Kiribati. A substantial part of the total catch in the southwest Pacific Ocean takes place in Kiribati, which is clearly more vulnerable to changes in the tuna fisheries than Fiji. The tuna fisheries have expanded rapidly during the 1990s in Kiribati, but are subject to much larger oscillations. In Fiji, the level of total catch has been more stable, but annual variations have been substantial since 1994.

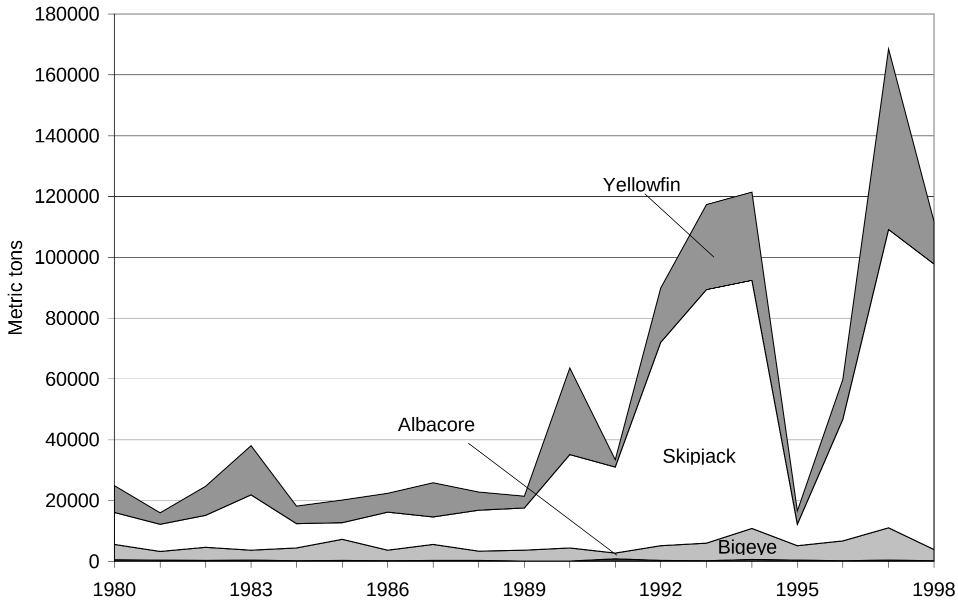
There are four species of tuna caught in the two countries: albacore, bigeye, skipjack and yellowfin. Skipjack is the most common species. In Kiribati, skipjack contributes more than 60 per cent of total tonnage caught on the average. Yellowfin contributes nearly 30 per cent, bigeye nearly 10 per cent, while albacore is caught only in small amounts in Kiribati. In Fiji, skipjack constitutes nearly 70 per cent of the total catch, while albacore makes up more than 15 per cent on the average. Thirteen per cent of the catch is yellowfin, while bigeye contributes less than 2 per cent.

Figure 1. Catch of tuna in Fiji by specie 1980 – 1998. Metric tons



The development of the catch of different species follows quite different patterns in the two countries. In Fiji, there has been a steady increase in the catch of albacore over the entire period, except for a drop in the beginning of the 1990s. The vigorous swings in total catch for Fiji is due mainly to changes in the catch of skipjack, which boosted in 1994, and dropped dramatically in the period 1995 – 1997. In 1997, it was hardly caught a single skipjack tuna in Fiji.

Figure 2. Catch of tuna in Kiribati by species 1980–1998. Metric tons.



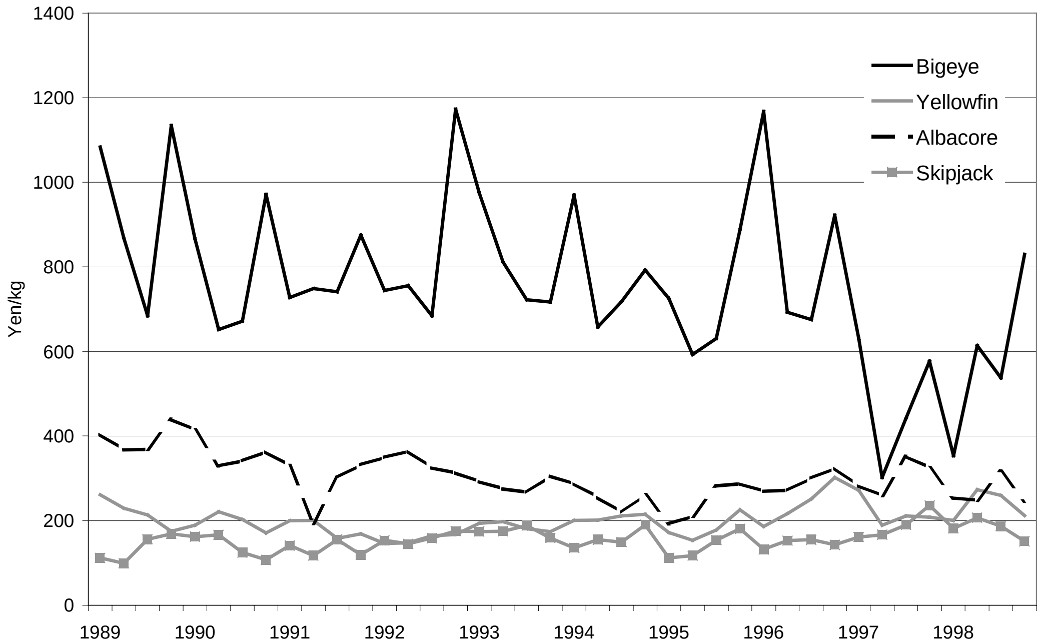
In Kiribati, the main oscillations in the catch of tuna are due to skipjack and yellowfin, which also constitute the major catch on these islands. Also in Kiribati, the drop in catch of skipjack in 1995 dominates the time series for the tuna fisheries. Moreover, the drop was also dramatic for the yellowfin catch, which was reduced by approximately 85 per cent in one year. However, the boom in 1994 and the small catch in the following years, which was characteristic for Fiji, did not happen in Kiribati. On the contrary, the catch of both skipjack and yellowfin rose again and reached a new peak in 1997, when the total catch was more than 160 thousand tons.

As a result, Kiribati has gradually grown more and more dependent on tuna fisheries during the 1990s, and this is particularly due to a greater catch of skipjack and yellowfin. For Fiji, which is much less dependent on tuna in general, the importance of albacore has gradually increased, while the importance of skipjack and to some extent yellowfin has decreased after the boom in 1994.

Before we turn to possible explanations of these patterns and discuss the impacts of global warming, it is worthwhile to look at the economic significance of the fisheries because the value of the catch is not only dependent on the quantity, but also the prices. We do not have access to average prices of tuna in the Pacific Ocean, but table 3 shows prices of various species in the Japanese Shimizu market over the period 1989–1999.

Apart from seasonal fluctuations for bigeye, the prices have been relatively stable over the whole period and indicate that a steady growth in demand has been met with an increase in the supply in the tuna market in general. For bigeye, which is the most valuable species, there is a downward trend in the prices. If adjusted for inflation, this trend is significant. We also note that the prices have tended to equalise across species over time. While the price of albacore was three to four times higher than skipjack around 1990, the difference is approximately 25 per cent at present. For skipjack the long-term trend in prices is actually increasing slightly.

Figure 3. Quarterly prices on frozen tuna in the Japanese Shimizu market by species 1989-1998. Yen/kg.



It is also worth noting that the vigorous changes in the catch observed in both Fiji and Kiribati are not reflected in the prices. This is because the two island states contribute a relatively small share of the total catch in the Pacific Ocean, which does not exhibit similar fluctuations. Hence, there are reasons to believe that the fluctuations in the catch also reflect fluctuations in income from tuna fisheries from the two countries in this period.

What the exact impact of climate change may be for the tuna fisheries in the Pacific Ocean is hard to predict. However, changing climatic conditions is a relatively well-known phenomenon because of the El Ninõ Southern Oscillation (ENSO). Lehodey (2000) suggests that the possible impacts on tuna fisheries may be studied on the basis of experiences from the ENSO, but that the climatic system may develop in different directions. Two alternative scenarios are proposed. On the basis of the results from several studies,[1] there seems to be some confidence in a scenario where the tropical Pacific evolves toward a *mean El Ninõ* state. This implies higher sea temperatures at higher latitudes. A second alternative is *increased variability,* which could be compared with a combination of El Ninõs and La Ninã events. There is, however, much less confidence in such a scenario.

Tuna is relatively sensitive to sea temperature in the sense that they move quickly to areas where the temperature is ideal. As a consequence, the total stock of tuna does not necessarily change dramatically if the sea temperature changes, but the spatial distribution may shift substantially. Consequently, some countries may experience an increase in the catch, especially countries at higher latitudes. In other countries, the catch may decrease. It is emphasised, however, that a mean state El Ninõ scenario imposes a permanent change in the system, not observed as yet. Models indicate that this may cause

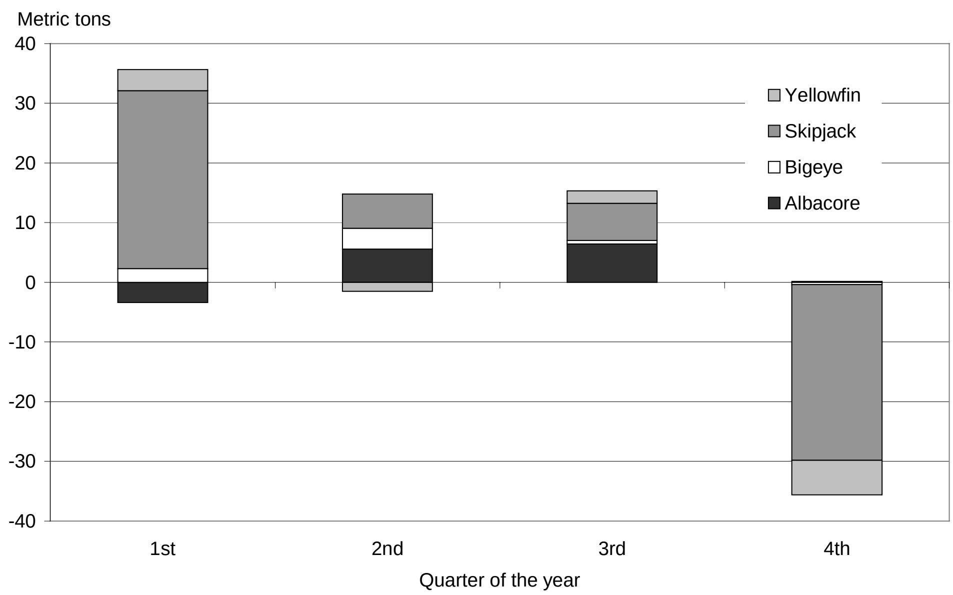
[1] See e.g. Meehl and Washington (1996), Timmermann et al. (1999)

a general decline in the upwelling system of the central and eastern equatorial Pacific. The upwelling system represents is a major condition for the biological productivity in the tropical Pacific. Such a change may, therefore, lead to a decline in tuna abundance. All in all, climate change is likely to lead to a shift in the spatial distribution, as well as a possible decline, in the total catch.

It is difficult to predict what this might mean to Fiji and Kiribati. However, the striking difference in the patterns between the tuna catch in the two countries and the total catch in the Pacific provides some evidence for a shift in spatial distribution resulting from ENSO. The drop in the catch in 1994 coincided with a strong La Ninã. This was followed by a strong El Ninõ in 1995, when the tuna fishing returned to a high level in Kiribati but failed to return to the previous level in Fiji. For the total catch in the Pacific, these events had a relatively small impact.

A more systematic study of the co-variation between ENSO and the tuna catch in the two countries does not give convincing results, however. Figure 4 shows the average change in the catch of tuna species on Fiji, resulting from a change of one unit on the Southern Oscillation Index (SOI). SOI measures the strength of El Ninõ and La Niña. The SOI is 0 in a neutral year. If the index is below –10, we have a strong El Ninõ event. If it is above 10, we have a strong La Niña event.

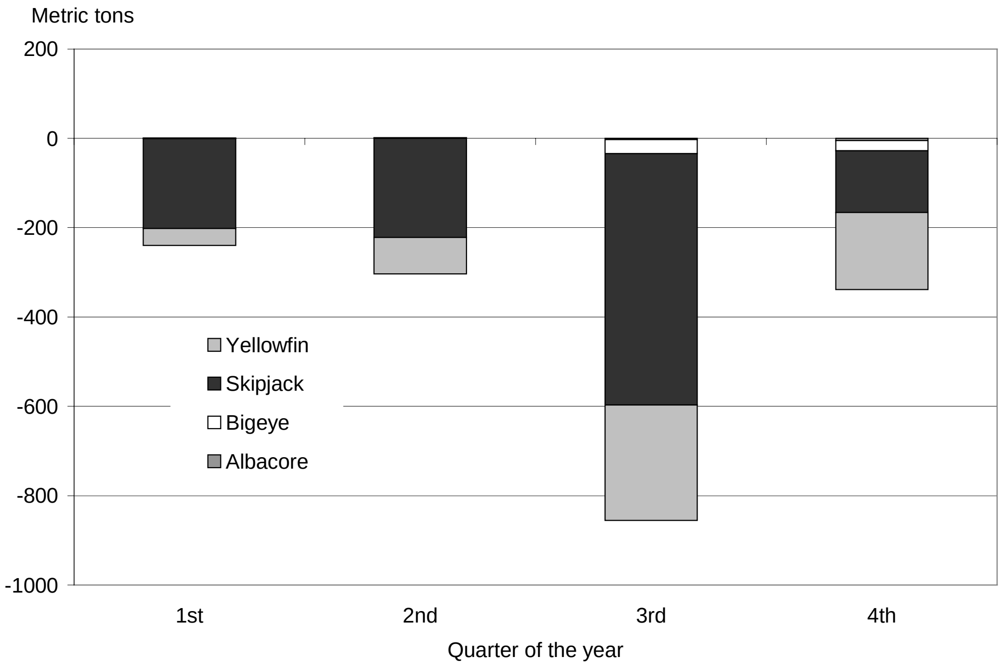
Figure 4. Changes in the quarterly catch of species in Fiji by one unit increase in the Southern Oscillation Index



The results shown in figure 4 were found by a linear regression explaining changes in the quarterly catch from 1980 to 1998 by a time indicator and the SOI. The SOI did not give significant parameters, which tells us that the SOI cannot be used as an explanatory variable only on the basis of direct observations. This may be because the shift of spatial distribution resulting from El Ninõ do not have a significant effect on tuna fishing in Fiji, though a more plausible explanation is that a linear regression is too simple to capture the complex mechanisms of the tuna fisheries in the Pacific. Another factor is the fact that tuna fisheries are relatively small on Fiji. Hence, the regression for albacore, which exhibits the most stable tuna fishery, give the most satisfying results. Figure 4 shows, however, that it is difficult to say in which direction the SOI draws.

For Kiribati, the results are slightly less ambiguous. Significant parameters for the SOI indicate that the catch increases under El Ninõ, in particular for the most important species, skipjack and yellowfin. According to figure 5, the total reduction in the catch increases by 200 to 800 metric tons per unit of the SOI. This means that a strong El Ninõ leads to an increase of the catch between 2000 and 8000 tons, which is up to 10 per cent of the total catch. Again, it has to be emphasised that a linear regression is too simple to provide reliable estimates. One cannot, therefore, claim that the hypothesis about an increase in the catch resulting from El Ninõ is confirmed in the case of Kiribati, only that we cannot discard it.

Figure 5. Changes in the quarterly catch of species in Kiribati by one unit increase in the Southern Oscillation Index



The impacts of climate change on the tuna fisheries in Fiji and Kiribati will have to be considered on the background of the general development in the tuna fisheries in the Pacific. With respect to abundance, two characteristics seem to be of importance. First, a shift in the spatial distribution is likely to occur. To the extent that it is possible to draw any conclusions from the experiences of ENSO, the catch of tuna in Fiji will be affected only to a limited degree. The results give a slight indication, however, that the total catch may decrease under climate change because there is a vague tendency towards smaller catches under El Ninõ. For Kiribati, the opposite seems to be the case. The catch of yellowfin and skipjack seem to respond positively to El Ninõ. If climate change can be related adequately to the medium El Ninõ scenario, Kiribati may therefore gain slightly from climate change if we look at the spatial distribution of tuna in isolation.

However, a the decline in the upwelling in the central and eastern equatorial Pacific may lead to a general reduction in the total abundance of tuna. Hence, Fiji may actually be affected negatively by climate change, while Kiribati remains more or less unaffected, if we measure total catch. On the other hand, the demand for tuna has increased steadily over the period 1980–2000. Despite a rapid growth in the catch of tuna, the long-term trend in the current price has been relatively stable. Real prices have, however, declined. A reduction in the catch may lead to an increase in the prices, or at least a stabilization of real prices, but it is very difficult to make reliable predictions. All the countries of the Pacific will gain from an increase in prices, but as Lehodey points out, changes in the prices may also lead to a pressure on the resources, which may have serious impacts in the long term. Experience from fisheries in other areas tells us that international fisheries adapt very slowly to new situations, and the consequences for the resources may be disastrous. The difficulties in adapting sufficiently to new conditions may be particularly challenging if it turns out that the “increased variability” scenario comes into effect. The need to compensate losses due to a drop in the catch in one period may lead to over-fishing in the next. This may lead to a rapid extinction of the stocks.

4 Indirect economic effects

Although it is possible to sort out some effects of climate change relevant for the abundance of tuna, it is very difficult to say what the economic impacts for the specific countries in the Pacific may be. This is partly because some countries may actually gain from climate change while others are likely to face a loss if we look at the tuna fisheries in isolation. The economic impacts will depend on how important the fisheries are to the national economies, how tuna fisheries are integrated in the economy, etc. To make a full analysis of the economic impacts, a more detailed assessment of each economy would be required. In this section, we confine ourselves to a rather general assessment of the economic impacts of changes in the fisheries. We base our scenarios on the description of the two alternatives in section 3, adding the assumption suggested by Lehodey that changes in the tuna fisheries may serve as an indicator for changes in other fisheries in the Pacific.

The assessment in this section is relatively general. Since our aim is to illustrate some possible indirect economic effects without too much emphasis on the exact figures, we limit the focus to one of the island states. Although fisheries are much more important to the economy of Kiribati than to Fiji, the remaining part of the economy in Kiribati is very small. Indirect effects may therefore depend on specific conditions, which we do not know enough about. The economy on Fiji, which is ten times larger, is probably better represented by the general characteristics of macroeconomic relationships. This section therefore focuses on the Fiji islands.

By indirect economic effects, we mean macroeconomic consequences of changes in the fisheries. We were unable to trace very specific economic impacts of climate change on tuna fisheries. Instead, we illustrate possible impacts on the economy by changing the directions of variables in a very simple macroeconomic model, variables that are likely to be affected in the two scenarios in section 3

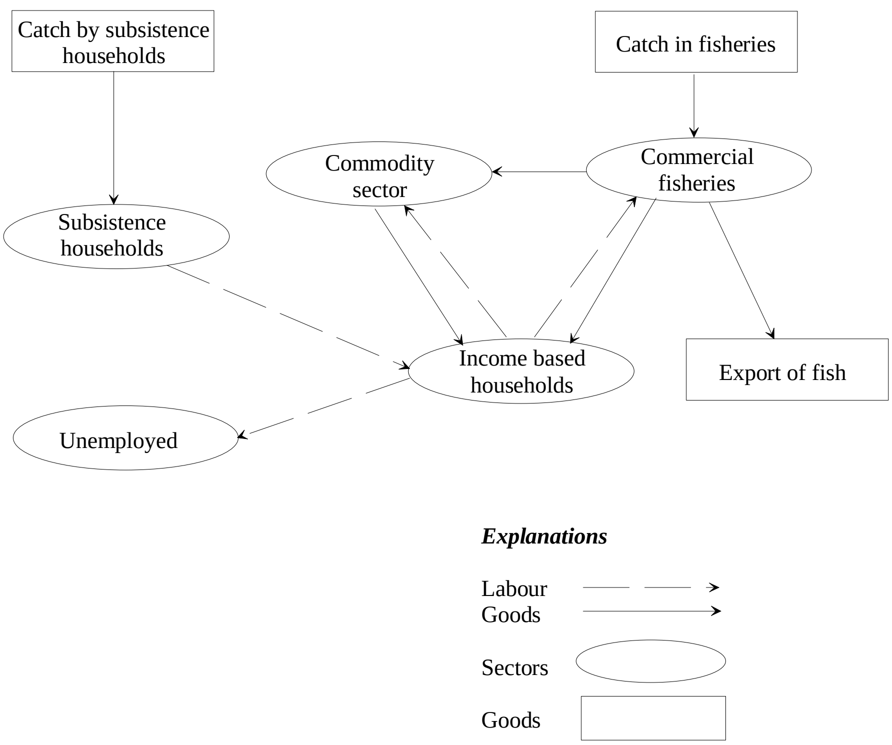
The model divides the economy into two production sectors, fish and other commodities, and two household sectors, income based households and subsistence households. To be able to detect the macroeconomic impacts of various changes in the fisheries, we assume that the price of fish is exogenously determined in an international market. We also assume that the catch of fish is exogenously given and subject to assumptions about the direct effects of climate change. The same applies for the amount of fish caught by subsistence households. Although a link between the macroeconomic model and a model for fish abundance and catch might provide insight to the interdependencies between commercial and subsistence fisheries, such a link is not assumed here.

The economy is modelled in the traditional way. We chose a given rate of substitution for input factors in the commodity sector and for consumption goods in income based households. Fiji is a developing country, and we have therefore assumed that the ability to substitute is limited in the production sector (rate of substitution equal to 0.6 in the commodity sector and 0.9 in the household sector). The fisheries use labour as the only input, which is proportional to the exogenous catch. This implies that we do not consider long-term changes in the capital stock. The fish are used partly as input in processing, partly to households, and the remainder is exported. The demand for labour and fish in the commodity sector, as well as for commodities and fish in the income-based household sector, depends on the relative prices plus production level and income, respectively.

The number of subsistence households in the Pacific is high. In this illustration, we have assumed that most of these households are based on agriculture, but a small number depend mainly on fish. In order to limit the extent of this illustrative model, we have included only a small number of subsistence households based on fishing. The relationship between subsistence households and the rest of the economy is, to some extent, due to the dependency on fish, but the linkage to the labour market is also of major interest.[2]

In accordance with the Harris-Todaro (1970) model, we assume that an increase in the wage level will attract people in subsistence households to the labour market. In order to give up subsistence, the expected wage in the labour market will have to be as high as, or higher than, the value of the consumption level for the subsistence households, which we assume is equal to the market value of the fish they eat. The expected wage in the labour market can be expressed by the weighted average wage of employed and unemployed persons (with wage equal to 0), using the unemployment rate as the weight. Hence, the model allocates people into employed, unemployed and subsistence categories.

Figure 6. Structure of the macroeconomic model



Data for Fiji was used to calibrate the model, and we have compared the solution of a 'base case' with alternative scenarios for the price of fish, catch in commercial fisheries, catch in subsistence households and a change in the cost of the fisheries. Alternatives A and B reflect an increase in the abundance of fish within the economic zone of Fiji, while the recruitment in rest of the Pacific declines. This is the 'winner's outcome' of the most

[2] Glomsrød et al. (1998) use a similar assumption in a more comprehensive model for Nicaragua.

likely medium El Ninõ scenario sketched in section 3. Because the purpose of these calculations is to illustrate possible indirect impacts, we also present the results of partial changes. Alternative C is included to demonstrate the importance of including subsistence households, and implies that the catch in this sector is reduced because of climatic changes. For example, the frequency of extreme weather events may increase and reduce the possibilities for coastal fishing. Alternatives D and E can be associated with the case of an increase in the stress on the resources, which leads to an increase in the cost of fishing. This cost has two dimensions. First, the use of labour will increase, and second, the use of capital will increase, which can be considered as a reduction in the (net) price of fish. This might be the most important consequence of the least likely increased variability scenario. More specifically, the alternatives are

(A) a 12.5 per cent increase in the catch of fish by the commercial fisheries in Fiji,
(B) a 10 per cent increase in the price of fish,
(C) a 33 per cent reduction in the catch of fish by subsistence households,
(D) a 10 per cent reduction in the price of fish,
(E) a 10 per cent increase in the cost of fishing (increased efforts to catch a given quantity).

Table 2 displays the results of the five alternatives in terms of per cent change from the initial state. As long as fish is the only exported product, the increase in the catch of fish (alternative A) leads to a substantial increase in exports. However, the GNP goes down. This may seem counter intuitive and indeed makes GNP problematic to use as an indicator for the economic cost. The explanation is that the increase in the catch of fish is brought about by an increase in the use of labour in fisheries. This drives the wages upwards, and contributes to reducing profits and the demand for labour in the commodity sector. To the households an increase in wages and export income is not enough to compensate for the increase in unemployment and loss of profits. Income is therefore reduced, and GDP goes down.

Table 2 Per cent change of economic indicators by partial changes in fishing activities

	A	B	C	D	E
GNP	-2.2	-0.1	2.5	-1.7	-2.5
Export	211.3	33.5	-14.3	-23.7	15.2
Prod of commodities	-9.0	-2.6	3.2	0.3	-3.2
Profits	-17.1	-188.2	30.1	155.1	-44.6
Wages	2.7	12.5	-1.8	-10.2	1.4
Households' income	-1.0	-1.3	2.6	-0.6	-2.5
Employed	-2.7	-2.2	2.7	0.3	-1.3
Rate of unemployment	2.8	2.3	-1.8	-0.3	1.4

Perhaps the most interesting result is the effects of a change in the (exogenous) price of fish in alternative B. From the outset, it is probably uncontroversial to claim that an increase in the price of the export product is ‘good’. The result of this simple model is, however, not that clear. Both GNP and income are reduced as a result of an increase in the price of fish. The main explanation is that, being a developing country, the commodity sector cannot easily adapt to a change in the prices. The increase in the fish price makes the sector aspire to become less dependent on raw materials from the fisheries, and instead start up more labour-intensive activities. This makes them bid up the wages. In order to attract more people, however, they have to 'overcompensate' the implicit value of the fish consumed in the subsistence sector, which has increased because of the increase in the price of fish. As a consequence, both the production level and the profits of the commodity sector are reduced substantially, and unemployment increases.

Alternative C displays the macroeconomic effects of a reduction in the catch of fish in subsistence households. The immediate effect is that people from subsistence households supply their labour to the production sector. This reduces the wage level, which leads to an increase in the demand for labour. This makes the production in the commodity and service sector increase, and results in an increase of profits. Altogether, the income in the households increases, leading to a general increase in economic activity. The reduction in exports is due to the assumption that the exported amount of fish is the residual catch after domestic demand has been met. Note also that despite the initial increase in the supply of labour, the final effect on the labour market is a reduction in unemployment.

A reduction in the world market price of fish in alternative D partly reverses the results in alternative B, leading to a major drop in wages and thereby reducing the rate of unemployment. Lower wages increases profits, but not enough to compensate for the reduction in wages. Hence, the income in households is reduced. This leads to a reduction in the GNP, which is the same effect as when the price of fish increases in alternative B.

The increase in the labour costs of the fisheries in alternative E means that the demand for labour increases, which makes wages go up. The production of commodities thereby becomes more expensive, and the profits in both the commodity sector and in the fisheries decrease. Income thereby decreases as a result, and the level of demand cannot be sustained. As a result GNP goes down substantially. The income effect on the demand for fish is apparently stronger than the price effect resulting from a relative increase in wages. Hence, export of fish, which is the residual when domestic demand has been met, increases.

Recall that the economy is assumed to be very inflexible, because Fiji is a developing country. With a more modern economy, the results, especially of the increase in the export price of fish, would be different. For example, in a more flexible economy, the commodity sector would be better able to take advantage of the increase in fish prices and hire more labour. This would make the increase in wages less, thus having less impact on the profits and possibly reducing the rate of unemployment. As a consequence, GDP could increase.

Alternatives (A)-(C) all give the same signs for the anticipated economic effects of an increase in abundance within the economic zone of Fiji. On the positive side, the export value increases and the rate of unemployment declines. However, the income level will go down, partly because the economy is inflexible and cannot adapt sufficiently to new conditions for the fisheries without a substantial cost. In the long run, however, this might be considered a cost of transition.

The results of an increase in the costs of fisheries are shown by alternatives (D) and (E). An increase in the labour costs has quite different effects than an increase in the capital costs, if this can be regarded as an implicit reduction in the price of fish. The increase in both components contributes, however, to a reduction in the income level and the GNP also goes down. All the other items in table 2 give different signs on the national level, and it is therefore difficult to assess the overall effect on the basis of these calculations.

5 Conclusions

The impact of climate change in fisheries for the Pacific islands might be studied on the basis of experiences from the ENSO events. There are relatively strong indications that tuna is adaptable to changes in climate, in the sense that they follow their ideal temperature and move from place to place. However, the expected 'mean El Ninõ' scenario leads to general declines in the total fisheries, with a slight shift in the abundance from east to west. To the fisheries of individual countries, this may lead both to increases and declines in quantity and prices. Fisheries are important to the national economies of both Fiji and Kiribati, and the economies may therefore be strongly affected by climate change. The direction of the impact depends, however, of a number of factors. First, it is difficult to say whether prices and quantities will increase or decrease. Second, the macroeconomic impacts, such as effects on income and unemployment, will depend on the extent to which the economies are able to adapt to new conditions. But for developing countries in general, however, there is a danger that any change will be painful, even if the isolated effect on the fisheries is advantageous. The expected cost of climate change related to the fisheries in these countries is therefore positive. The 'increased variability' scenario may have similar macroeconomic consequences in the short run, but the most severe effect of this scenario is likely to be related to the dynamics of fisheries. With vigorous cycles in the resource stock, the danger for extinction of stocks may become large.

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