Salt production at San Ignacio Lagoon: a Sustainable Development Project?

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SUMMARY

This work is devoted to analyzing the pros and cons of the proposed San Ignacio Lagoon (SIL) salt production project in Baja California Sur, México. The analysis of the project was done taking into account the technical data of the main potential effects of the SIL project, and by comparing the SIL proposed actions with the data of Ojo de Liebre Lagoon, where an almost identical salt production project has been operating for more than 44 years. The analysis was done from the following perspectives: biodiversity, biosphere reserve management, and socioeconomic development. The resulting analysis of the pros and cons of the SIL salt production project addresses key aspects of sustainable development in Third World nations. The resulting analysis indicates that the SIL salt production project is compatible with the biodiversity conservation of the zone. The SIL salt production project seems to be one of the best options to attain the sustainable use of natural resources of the most arid and isolated zone of all México.

INTRODUCTION

During 1994, the Compañía Exportadora de Sal (ESSA; Salt Export Company), a Mexican Federal company with 49% private Japanese capital, proposed a new project to develop salt production activities in the surroundings of San Ignacio Lagoon (SIL), Baja California Sur (BCS), México (Figure 1).

The SIL salt production project has generated considerable attention and controversy, both at the national and international level. This work is devoted to the analysis of the pros and cons of the proposed project, taking into account the technical data, the main potential effects of the SIL project, and by comparing the SIL proposed actions with the data of Ojo de Liebre Lagoon, where an almost identical salt production project has been operating for more than 44 years. The analysis is made from the perspectives of biodiversity, biosphere reserve management, and socioeconomic development.

The resulting analysis of the pros and cons of the SIL salt production project addresses key aspects of sustainable development in Third World nations, such as the balance of environmental and economic considerations; ensuring and maintaining of economic, social and environmental sustainability in an isolated and restrictive region, and the difficulties of developing productive activities in an environmentally controversial and economically depressed area of a Third World economy.

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Figure 1  Location of the San Ignacio Lagoon and the proposed salt production project. Location of Ojo de Liebre Lagoon and the salt production project in operation since 1955
MATERIAL AND METHODS

We gathered all the scientific published literature concerning SIL and Ojo de Liebre Lagoon (OLL) and their surroundings. The main biological, ecological and socioeconomic characteristics of the regions where both lagoons are located were analyzed. It should be stressed that most of the published literature on the environmental and biological aspects of the project region was the work of scientists at our research centre, CIBNOR (Arriaga and Castellanos, 1995; Breceda et al., 1995; Cancino and Ortega-Rubio, 1994; Castellanos and Ortega-Rubio, 1995; Castellanos et al., 1994a; 1994b; Lluch et al., 1993; Maravilla, 1991; Ortega and Arriaga, 1991a; 1991b; Ortega-Rubio and Castellanos-Vera, 1994; Ortega and Castellanos, 1995; Ortega et al., 1988; 1989; 1990; 1991; Sanabria et al., 1995).

With all this information, and with the experience of the 20 years of professional work in the region, we proceed to review the main issues that a large number of green organizations have claimed to be problems with the SIL salt production project. We carefully weighed such claims against the biological-ecological and socioeconomical data gathered. The approach was based on a solid biological-environmental background of the persons who were developing the analysis. According to Ewel (1993), such a background, at least for conservation in tropical countries, is essential, because biologists more than any other professional, understand the tight interdependence between biological and environmental health.

RESULTS

General aspects of the SIL salt production project

The SIL salt production project consists of the modification of 24 000 ha of hypersaline soil to build shallow ponds 1-m deep. (Ortega et al., 1994). These 24 000 ha are located 2 to 5 km from the SIL coastline. They are covered by naturally impermeable hypersaline soil and are called Eriales. These Eriales are almost devoid of any native flora and fauna (León de La Luz et al., 1991). Almost 95% of the surface covered by the Eriales is naked, impermeable soil. Herbal halophytic vegetation, including species such as Eriogonum intricatum and Muhlenbergia porteri, cover the remaining 5%. Such species are also widely distributed in the region (León de La Luz et al., 1991). The proposed ponds will be filled with seawater pumped from the Lagoon. The proposed project intends to install eight water pumps in the northern part of SIL, and pump approximately 1 200 000 m³ per day of the Lagoon seawater.

Marine water will slowly circulate from pond to pond allowing evaporation by solar heating and air flow. It will need two years of slow evaporation and movement of the water from pond to pond until the original marine water arrives at the small crystallization ponds where the salt will precipitate. The salt produced will be mechanically harvested and transported by a band conveyor system to a pile near the coast for temporary storage. According to the proposal of the project (Ortega et al., 1994), the waste products after salt harvesting, ('Amargos') the 'bitters', will be in part used for table salt production and the remains will be disposed of in the open sea, at least 5 km from the coast line. Most the salt works around the world dispose of their bitters directly into coastal water, not in the open sea.

Twenty-five kilometres north of the Lagoon mouth (Figure 1), a dock is to be constructed and operated for the loading of the salt into large vessels. To avoid dredging, the dock will be 2-km long to allow the docking of large ships. The first 200 m of the dock will consist of a solid stone layer, and the remaining length, 1800 m, is proposed to be sustained by vertical piles placed every 34 m. In the operation phase, only two vessel trips per week will account for all loading and transporting of the product to its final destination; thus heavy ship traffic is not to be expected.

The proposed SIL project (Ortega et al., 1994) includes the creation of 200 permanent jobs, the production of 7 000 000 t of salt per year and the generation of $100 000 000 every year. Of this quantity, approximately 40% will be devoted to pay State and Federal taxes. There will be no new permanent human settlements produced by this project. The people hired for the SIL project will be living at Abreojos and San Ignacio, already established towns.

Table 1 summarizes the main arguments against the SIL salt production project to date. The first column presents the cons against the proposed
Table 1  Main arguments against SIL salt production project and technical data gathered

<table>
<thead>
<tr>
<th>Arguments against the proposed project</th>
<th>Technical data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laguna San Ignacio</td>
<td>This huge quantity of water taken from the head of the Lagoon represents less than 0.3% of the water exchanged every day between the lagoon and the open sea through the mouth of the Lagoon (Lluch et al., 1993)</td>
</tr>
<tr>
<td>Pier</td>
<td>Only 200 m of the pier are solid rock structures. Only 0.1% of the whales arriving to BCS will ever swim near this proposed dock. After 44 years of operating ESSA 2 piers in the same region, monthly receiving 6 ships and 45 tugboats, there has never been reported a large toxic spill. Along their route from Alaska to BCS, the whales pass near important piers, both military and commercial, along the Pacific Coast of Canada and USA. Both countries plan to build new piers along these coasts in the following years</td>
</tr>
<tr>
<td>Grey whale</td>
<td>Of about 30 000 grey whales living in the world, only 6000 arrive at Mexican lagoons (Maravilla, 1991). Of these, approximately 350 arrive every year at San Ignacio (Maravilla, 1991). Most of the whales coming to México, 1200, come every year to Ojo de Liebre Lagoon, where an identical salt production project has been operating for more than 44 years. At Ojo de Liebre Lagoon, the whales arriving have been constantly increasing their numbers</td>
</tr>
<tr>
<td>Biosphere reserve</td>
<td>The Vizcaíno Biosphere Reserve comprises almost 3 million hectares. According to the presidential decree of creation, and both management plans for this Reserve, the sustainable use of the natural resources outside of the core areas of the Reserve must be enhanced. The Eriales surrounding San Ignacio Lagoon are located outside the core areas of this Reserve</td>
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<tr>
<td>Socioeconomic aspects</td>
<td>At San Ignacio Lagoon, as has been proved at Ojo de Liebre Lagoon, fishing, ecotourism and salt production can coexist quite well. Fishing inside the San Ignacio Lagoon is marginal and has reached its upper growth limit. For ecotourism, only 1% of the money spent by whale watchers is spent on salaries and purchases in the area. One of the best alternatives for real economic growth in this area is salt production</td>
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Expected changes in the environment

Soil use

In the terrestrial environment, the largest modification by the project would be the replacement of the hypersaline soil, 5 km from the Lagoon, by 24,000 ha of shallow ponds. This area, as well as most of the land around the SIL, 64,000 ha, is characterized by a natural hypersaline condition (Ortega et al., 1988; Ortega and Arriaga, 1991a; 1991b; Ortega and Castellanos, 1995).

The area consists of low flats that, for hundreds of years, have been periodically covered by seawater during extremely high tides. Part of this water remains in the soil until its ultimate evaporation, because of the combined action of prevailing low precipitation, winds, and high insolation (Maya and Troyo, 1991). The salt accumulation that results from this process has deprived most of this area of any native flora and fauna, leaving almost sterile and impermeable sand-and-salt flats, called Eriales (Figure 2). This same process is what makes the area good for natural salt production and precludes other possible economic development (Ortega et al., 1988; 1992; 1994).

We believe the replacement of this kind of biologically and economically unproductive soil (the Eriales) by extended and shallow ponds will result in habitat enhancement. In these ponds, the marine biota will flourish, from a diverse collection of fish, clam, and shrimp in the low-salt concentration ponds (most of the flooded area), to a very specific halophilous microflora in the small hypersaline ponds (Lopez, 1991). The flourishing of the marine biota in the shallow ponds will enable the marine bird community to increase their species richness and their population (Castellanos et al., 1994a; 1994b; Castellanos and Ortega-Rubio, 1995).

Lagoon water quality

One million two hundred thousand cubic metres pumped daily out of SIL is a large quantity of seawater, thus there have been strong concerns about the possible effects of this removal on the characteristics of the Lagoon (Danemann and Saenz-Arroyo, 1995; Velasco, 1996). However, the SIL contains approximately 600 million cubic metres of seawater (Lluch et al., 1993). This means that the proposed project will take daily less than 0.3% of the total seawater volume contained in the Lagoon.

Moreover, and since the Lagoon consists of a narrow central, deep channel surrounded by shallow bottoms, between 40 and 60% of its total seawater volume currently enters and leaves the Lagoon through tidal currents and natural flow patterns. Such tidal exchanges take place two times a day (Lluch et al., 1993). Because of this continuous movement and significant natural interchange between the Lagoon and the open sea, we expect the local effects at the head of the Lagoon, including current circulation patterns and their effects on the plankton, will be minimal, as compared with the huge volumes of seawater changed twice a day.

Thus, taking into consideration this daily seawater recharge pattern, it is unlikely that salinity and temperature will change in SIL as a result of the proposed pumping of water from the Lagoon.

Effect of the dock construction and operation

One of the main SIL project concerns relates to the potential ‘barrier effect’ of the dock on coastal fishing grounds near the area, because of changes
in littoral sediment transport at this location. However, the expected changes in current and sediment transport along the coast, because of a 200-m barrier (the part of the dock to be constructed as a solid rock layer) are restricted to only about 600 m on either side along the shore, depending on the prevailing current speed and direction. (Ortega et al., 1994). Even under the worst simulated conditions, the distance of the proposed dock from fishing grounds that exist in the area precludes any significant impacts on these fishing areas (Ortega et al., 1994).

The other 1800 m of the dock are not expected to have significant impact on the natural patterns of marine currents and sediment transport. This larger portion will not represent a 'barrier' because it consists of vertical piles spaced at a far larger distance than their diameter and will not present any obstacle for the prevailing shore transport (Ortega et al., 1994).

Another concern is the possibility of accidents during the operation of vessels at the proposed dock, particularly the occurrence of fuel spills (Velasco, 1996). The SIL proposed project contemplates the proper plans, equipment, and staff for attending spills (Ortega et al., 1994). At their facilities to date, ESSA successfully operates a dock at Cedros Island for salt loading, and another dock inside Ojo de Liebre Lagoon for salt transportation (Ortega-Rubio et al., 1998). During 44 years of operating both docks, there have been no significant reported accidents or fuel spills from the ships and tugboats. This record suggests that significant oil spills are unlikely.

The SIL project contemplates the use of similar equipment, and staff currently used at OLL to prevent and control potential fuel spills. At the pier located 25 km to the north of SIL, it is proposed that every ship tying up to the pier will be immediately surrounded by an antispill barrier. There will be ready two 300-foot antispill barriers, two pumps, four 20-foot boats, six collection tanks, absorbing material, and 25 workers, certified as counter spill technicians by the US FOSS environmental company (Ortega et al., 1994).

There is a significant difference between the pier located at Cedros Island, operated by ESSA for 44 years, and the pier proposed 25 km to the north of SIL. At Cedros Island, it is necessary to transport, and to store, the diesel fuel used for generating electricity. At SIL, the electricity will be provided by the Mexican Electrical Utility based at Guerrero Negro. There will be no ships carrying fuel to the pier north of SIL, and there will be no fuel storage.

Grey whale

Every winter, grey whales arrive at the coastal lagoons of the Baja California peninsula (Ojo de Liebre, Guerrero Negro, San Ignacio, and Magdalena Bay) for reproductive purposes. Pregnant females give birth and males and nonpregnant females copulate (Maravilla, 1991). This species used to exist as at least three stocks, one in the Atlantic, one in the western Pacific and one in the eastern Pacific, but only the latter has survived in large numbers (Rice and Wolman, 1971). Even this stock was severely endangered because of whale hunting, but international efforts, and especially the protection of the reproductive grounds by the Mexican government (Ortega et al., 1988; 1992) have succeeded in a significant recovery of the eastern Pacific stock (Maravilla, 1991). In the early 1970s, the population size was about 10 000 individuals (Rice and Wolman, 1971; Maravilla, 1991). Their number had increased to 15 600 in 1980 (Reilly et al., 1983) and to more than 20 000 in 1989 (Tershys and Browse, 1991).

Aerial censuses over the Mexican lagoons indicate the arriving population size to be around 1500 individuals, a number that has remained relatively constant for the last decade (Fleisher, 1990). Of these, between 300 to 400 usually use San Ignacio, while more than twice generally prefer OLL (Maravilla, 1991). However, the annual number of whales in each lagoon is variable, with the global environmental fluctuations in temperature and salinity determining whale preferences for northern vs. southern lagoons (Fleisher and Maravilla, 1990).

Most of the data provided here are based on grey literature, which has not been published in peer reviewed journals. Also, the number of the aerial surveys did not account for turnovers within the lagoons during the breeding season. However, these are the only data available to date.

Though both the level and the growth of the grey whale population seem adequate, the grey whale was, and still is considered by some, an endangered species (Aurioles-Gamboa, 1993). Thus, many of the concerns about the SIL
production project relate directly to its potential effects on the whale population (Velasco, 1996; Danemann and Saenz-Arroyo, 1995). One aspect of the ongoing controversy deals with the construction of the dock. There is concern that this 2000-m long structure may be an obstacle for the whales as they move in and out the SIL.

It should be emphasized that only 200 m of the proposed dock could represent a physical barrier for the normal whale transit in this zone, particularly at the local level, and especially to the females with calves who prefer to move closest to the shore. However, study of the movements of 321 whales by Ramírez and Velázquez (1994) at the proposed dock area indicated that whales prefer to move relatively far offshore. Only 12 individuals swam close enough to pass near the projected dock (less than 3 km off the coast). Moreover, only 20 to 30% of the total whale population arriving in México goes to San Ignacio (the remaining 70 to 80% use the other lagoons, mainly OLL, which is located to the north; Figure 1). We can then estimate that less than 1% of the grey whales arriving to Baja California Sur will ever swim near the area of the proposed dock.

We should also consider that the same grey whale population moves along all the Canadian and US west coasts twice during their yearly migration (Maravilla, 1991). Whales reach México after passing by very large Canadian and USA military and commercial port facilities, much larger and more troubled by ship traffic, pollution, and noise than the projected dock at SIL. Their migration path takes them into, out of, and across the normal shipping routes. Even at locations such as those for oil exploitation in the Gulf of Alaska, the evidence of significant impacts on the grey whale remains, at most, unclear (ASA, 1981).

Grey whales do not breed in any of the areas mentioned and no longer breed in San Diego Bay, which has been highly modified. However, as we have noted, most of the Mexican grey whales are born in OLL, located to the north of SIL, and thus will not be affected by the dock building and operation.

Marine bird populations

Because the core of the proposed project is the conversion of 24 000 ha of the Eriales, hypersaline and biologically unproductive soil, into more biologically productive habitat, we expect the marine bird community of this Lagoon to increase its population numbers at the Eriales (Ortega-Rubio et al., 1998). Comparing the number of marine bird species before the OLL salt facilities were built and operating (Bancroft, 1927) with the species number after salt production activities takes place, there has been found a significant increase (Ortega-Rubio et al., 1998). We believe this fact must also be considered, especially since some of these marine birds are either endangered or migratory species, subject to international protective management (Castellanos and Llinas, 1991; Lluch et al., 1993).

The SIL project operation does not include the formation of any new human settlement in the region, which usually represents a source of negative impacts on marine birds (Castellanos and Llinas, 1991). Moreover, the operations of the project imply the control of human access and transit across the area. This control is very important for conservation purposes, since human disturbance is a main problem for birds nesting in the zone (Castellanos and Llinas, 1991; Salinas-Zavala et al., 1991; Lluch et al., 1993). We note the Mexican Government does not have enough economic resources to properly guard this protected area. The access to SIL would be privately regulated by the infrastructure of the salt company, as it is at OLL (Ortega-Rubio et al., 1998). As has been demonstrated at OLL, the controlled access precludes uncontrolled transient human visits to the sensitive zones, such as the breeding islands (Castellanos et al., 1994a; 1994b), but does not preclude ecotourism.

Biosphere reserve

The Vizcaíno Biosphere Reserve was established (Ortega et al., 1988; Ortega-Rubio and Castellanos-Vera, 1994) to promote biological conservation in its core areas, and environmentally sound economic development in the buffer zones (Ortega et al., 1990; 1992). The San Ignacio Eriales surrounding the Lagoon are located in the buffer zones of the Vizcaíno Biosphere Reserve (Tejas et al., 1991).

The presidential decree for the Reserve creation and for both management plans strongly
emphasis the search for economic alternatives for the local inhabitants on a sustainable development basis (Ortega and Arriaga, 1991a). These ecologically plausible productive projects must be developed in the buffer zones of the Reserve, such as the Eriales surrounding the SIL (Tejas et al., 1991; Ortega et al., 1990; 1992).

**Socioeconomic aspects**

It has been stated that the only environmentally sound activities for the local inhabitants surrounding the SIL, are ecotourism and fishery (Aridjis, 1995; Clifford, 1997; Philips, 1996; Velasco, 1996). Although very important abalone and lobster fisheries are on the west coast of the peninsula, the main areas of exploitation are located outside and far from the Lagoon, while fisheries inside are, by comparison, small-scale extraction of other resources such as the pismo clam. Moreover, similar artisanal fishing activities have been going on for many years at OLL and have coexisted with the salt industry for 44 years without any noticeable negative impact. Similarly, whales have coexisted with the salt industry at OLL, and despite year to year variations, the number of whales arriving to this area have increased during the last decades (Ortega-Rubio et al., 1998). No impact on whale-watching tourism is likely to be generated by the new project, particularly since the only activity taking place at the Lagoon would be seawater extraction, as opposed to OLL, where salt transportation inside the Lagoon takes place (Ortega-Rubio et al., 1998).

Neither traditional fisheries nor ecotourism activities are likely to provide future opportunities for economic development within the region. Most of the fisheries in the area are at their maximum production capacity; catches have not increased in any sustained way during the last several years. Yearly catches of abalone and lobster along the northwest Pacific coast of BCS fluctuate between 400 to 600 t. For both fisheries there has been no increase during the last ten years (INEGI, 1991). According to Young (1995), ecotourism has not promoted any significant level of economic development for the local communities. The ecotourism activities at SIL are monopolized by foreign companies, most of them based in the United States (Young, 1995), or owned by American citizens. According to Young (1995), for 1994 approximately $3.3 million were spent by tourists visiting SIL, through tours organized by foreign-based companies. Less than 1% of this ($26 000) was spent on purchases and salaries in the area (Young, 1995). If there were established specific regulations in the area, such as the requirement of visiting the Lagoon using only the boats of the local fishermen, then this unfair use of the scenic resources of the zone by foreigners and by local people would change. However, as far as we can predict, the overall picture of the ecotourism benefits will not change in the visible future.

Other than tourism and fishing, only agriculture and salt production have generated significant economic development in this area. Since agriculture is strongly limited by the lack of fresh water, salt production is the most obvious near-term possibility. All the freshwater of the region is taken from underground reserves (INEGI, 1996). To present, the underground freshwater reserves are overexploited, in the region there is an annual recharge of 40 000 000 m³, and 42 000 000 m³ are annually extracted (INEGI, 1996). Most of this extracted underground water, approximately 86%, is devoted to agriculture. Agriculture is extremely inefficient in the use of the water. It is expected that SIL salt production project operation will consume less than 1% of the total water actually extracted at the zone (Ortega et al., 1994).

An important alternative for economic growth in this area is to use the impermeable soils of the Eriales surrounding SIL to produce salt. This alternative does not preclude fishery and ecotourism, as demonstrated at OLL (Ortega-Rubio et al., 1998). The creation of new jobs is the most important need for the local population (Castellanos and Mendoza, 1991). Because of the aridity and geographic isolation of the zone, the lack of local economic development alternatives have promoted (Castellanos and Mendoza, 1991), and certainly will continue to promote, the migration of the local inhabitants to the USA and mainland México.

**CONCLUSIONS**

Though every effort should be taken to assure that new development will not result in any
negative impact on other activities, it seems clear that both ecotourism and traditional fisheries are unlikely to support the needs of a growing local population, and that salt production has been a major source of economic development for this arid, isolated area. Since sustainable development is one of the main goals of any Biosphere Reserve, we believe that this status regarding Vizcaíno should not be considered as an argument against any sustainable development opportunity, particularly when the proposed project is to take place outside the core areas (the core areas are the only ones intended to be only for conservation purposes). Because there will not be new transient or permanent human settlements produced by this project, it is possible to expect that the effects on local fauna and flora will be limited. Particularly, it is important to emphasize that the project is proposed to be developed inside a huge area (more than 64 000 ha) of Eriales.

It is worthwhile to develop more specific and detailed studies on the potential effects of the SIL proposed project on the ecology of the Lagoon and the Eriales, on the biology of the main species of the zone, and on the socioeconomic effects on the region. However, as far as the available evidence indicates, it is possible to affirm that the SIL salt production project is compatible with the biodiversity conservation of the zone.

The SIL salt production project seems to be one of the best options to attain the, so-called, sustainable use of natural resources of the most arid and isolated zone of all México. As it has been clearly stated by Upreti (1994), the design of appropriate policies and strategies that lead to conservation of the biological diversity, natural ecosystems and the ecologically sustainable development, is not an option but a requirement.

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