Harvesting Wild Species

Implications for Biodiversity Conservation

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THIRTEEN

The Commercial Consumptive Use of the American Alligator (*Alligator mississippiensis*) in Louisiana

Its Effects on Conservation

Ted Joanen, Larry McNease, Ruth M. Elsey, and Mark A. Staton

The commercial consumptive use of some wildlife species, when managed on a sustainable basis, is considered by many to be not only compatible with their conservation but also an effective conservation tool with the potential to benefit a species, its habitat, and associated biodiversity (IUCN/UNEP/WWF 1991; Swanson 1992). However, this view, which is widely held by crocodilian biologists and managers, and most IUCN Crocodile Specialist Group members (e.g., Palmisano et al. 1973; Child 1987; Gorzula 1987; Hines and Abercrombie 1987; Hollands 1987; Jenkins 1987; Joanen and McNease 1987a; Webb et al. 1987a,b; Whitaker 1987; Messel 1991; Thorbjarnarson et al. 1992), is not universal and is under attack in various quarters, including the public media (e.g., Robinson 1993). Much of the argument in this high-profile debate results from emotional and political points of view (e.g., *U.S. News and World Report*, Nov. 15, 1993) rather than objective reviews of biological and socioeconomic data relevant to concerned species and the implications of sustainable use management for conservation.

To evaluate the proposition that sustainable use can provide incentives to conserve a wild species and its supporting ecosystem, we

develop here a case study of the American alligator (*Alligator mississippiensis*) in Louisiana. This species is exemplary because knowledge of trade in alligator products, and the effects of commercial harvests on alligator populations, have been reported for almost two centuries. During this time, commercial use of the Louisiana alligator population evolved from unregulated overexploitation to present-day sustainable use management involving a wild harvest and an extensive egg ranching/farming program. Relevant historical and scientific information affords the opportunity to evaluate objectively the biological suitability of alligators in a sustainable use program, the effects of such use on wetland biodiversity, the efficacy of incentives and controls in the commercial consumptive use of alligators, and the benefits of current use and any alternative use of the species.

The Uses, Markets, and Harvest of Alligators in Louisiana

This section discusses the main alligator products—skins and meat—and the markets for those products. The response of Louisiana alligator populations to the demands of those markets and the development of strategies to protect alligator populations are also reviewed.

Alligator Skins

The commercial value of alligators is derived primarily from their skins. Leather made from the skins of American alligators, along with that of several crocodile species, is considered the "classic" exotic leather. Placed in the hands of skilled designers and leathersmiths, leather made from alligator skins can be crafted into some of the most valuable leather goods available. Although the strength and durability of the leather contribute to its value, the real appeal of alligator leather, compared with common leathers, is akin to that of gold compared to common metals or diamonds compared to semiprecious stones. The beauty is in the eyes of the beholder. Many people do not see any special appeal in alligator leather goods, while others cannot or do not care to pay the prices these products command. Some prefer not to purchase alligator products because it is counter to their personal (animal-welfare-based) beliefs. Others fear that alligators are still endangered or that alligator products are illegal. Nevertheless, there are many people of sufficient means who see an attraction in alligator products—enough

Table 13.1. Markets (Percent) for Louisiana Salted Alligator Skins, Based on the Countries to Which Skins Were Exported in 1992–1993

Country	Wild harvest (25,864)	Farms (125,511)
France	27	44
Italy	16	15
Japan	19	8
Singapore	28	16
Switzerland	8	—
United States	1	17

Source: Louisiana Department of Wildlife and Fisheries.

to create the market for the exclusive leather made from the skins of alligators which are sustainably and legally produced.

The market for Louisiana alligator skins, leather, and leather goods is international in scope. Relatively few skins find a market or end use within Louisiana, and most enter international trade. Ischii (1990) estimated that 70 percent of all classic crocodilian skins found a market in Japan, either as raw skins, tanned skins, or finished leather goods. Thus the largest single market for alligator leather goods are Japanese consumers buying them domestically or abroad. Other major markets are the centers of wealth in Europe, the emerging economies of Asia and Latin America, and the United States. Alligator leather goods are produced throughout these same areas, but manufacturers in Europe are considered to be the most exclusive.

The market for raw (salted) alligator skins is much more limited. Relatively few major tanneries (several dozen) are capable of tanning/finishing alligator skins into the highly valued leather. These are mainly centered in France, Italy, Japan, and Singapore; others are found in other European and Pacific Rim nations, Latin America, and the United States. Most Louisiana alligator skins are tanned and finished in these countries (Table 13.1).

Although leather made from alligator skins is currently assigned a high value, this was not always the case. The earliest record of the use of alligator leather was around 1800 in the manufacture of relatively rough articles of trade such as boots, shoes, and saddles (Stevenson 1904). In the first quarter of the nineteenth century, "many thousands" of alligators were killed for this trade, with obvious destructive effects

on the alligator population (Audubon 1827). Audubon reports that when it was found that the leather was "not sufficiently firm and close grained to prevent water passage or dampness," widespread hunting of alligators stopped.

The following half century saw only sporadic demand for alligator skins, first as a novelty fashion leather around 1855 and later in the Civil War (1860–65) to supply Confederate soldiers with shoe and boot leather. Immediately after the war, alligator skin was again without a use, as trade in regular shoe leather was restored (Stevenson 1904; Joanen and McNease 1991). This proved to be a "lull before the storm" as the modern era of alligator utilization began in the late 1860s, when alligator leather "rose to the top of the fashion scale of all leathers" (Joanen and McNease 1991). Stevenson (1904) wrote that by 1870 the large demand resulted in the slaughter of thousands of alligators per year. Alligator populations were placed under tremendous hunting pressure, and "demand soon exceeded the productive capacity of the U.S. and a large number of skins were imported from Mexico and Central America" (Stevenson 1904).

McIlhenny (1935) estimated that between 3 and 3½ million alligators were taken from Louisiana alone between 1880 and 1933—approximately 60,000/year on average—but with far fewer alligators being taken in the later years of this period. Kellogg (1929), for example, reported 21,885 and 36,041 skins taken in the years 1925 and 1926, respectively. The continued decline of the alligator population is recorded by Louisiana severance tax records (Joanen and McNease 1991), which show that 414,126 skins were sold between 1939 and 1960—down to less than 20,000/year. During this period, the size of alligators taken also decreased, further reflecting excessive pressure on the Louisiana population.

In 1962, Louisiana banned the hunting of alligators, and the state's Department of Wildlife and Fisheries (LDWF) turned its attention to professional management of this valuable wildlife resource, five years before the species was listed in the federal Endangered Species Act in 1967. During a period of total protection in Louisiana (1962–72), extensive research on alligators was conducted, and state and federal laws governing the taking, possession, and transportation of alligators and their products were enacted (Joanen et al. 1983; Joanen and McNease 1991). In 1970, the Louisiana legislature made provisions for a closely regulated, experimental commercial harvest (Palmisano et al.

1973). During this period of total protection, the institutional and political framework for the implementation of a sustainable use program, based on sound scientific information, was developed. The goals of the program were to manage and conserve Louisiana's alligators, as one of many components in the state's vast (more than 2 million hectares [ha]) wetlands ecosystems, to the benefit of the species, its habitat, and associated wildlife (i.e., biodiversity). Inherent in the philosophy of managing the species was to allow and encourage sustainable harvest of alligators to benefit economically the citizens of Louisiana. Since most (approximately 80%) of the state's wetlands are privately owned, this would provide an incentive to landowners, and hunters who lease land, to maintain and enhance the alligator's wetlands habitats (e.g., Joanen and McNease 1973a, 1974, 1975, 1981, 1987a, 1991). Also during this period of total protection, alligator populations rebounded dramatically, to the extent that harvest of some populations was possible. In 1972, a year before the federal Endangered Species Act took effect, the LDWF began modestly to implement its program of sustainable use management. While keeping the conservation of the alligators as the primary objective, the state authorized an experimental hunt, confined to one parish in southwestern Louisiana. A total of 1,350 alligators were taken by 59 hunters. No hunt was allowed in 1974, when declassification of the alligator in Louisiana to the status of "threatened due to similarity of appearance" began. Hunting in three coastal parishes resumed in 1975 and was gradually expanded until 1981, when all Louisiana alligators were reclassified and the season was opened statewide. Presently, about 25,000 wild alligators are currently harvested annually from Louisiana wetlands (Table 13.2).

Provisions in the law were also made for a carefully regulated program of skin production from the farming of alligators originating from captive breeding stock or from eggs harvested from wild populations. The latter source of hatchlings has been the primary source of alligators for the Louisiana "farming" program (known as "egg ranching" in the lexicon of wildlife managers). The egg ranching program began experimentally with eggs harvested from state-owned lands at Rockefeller Refuge, was expanded statewide in 1986, and has grown substantially. In 1972, a total of 35 skins were sold by three of eight licensed farms. By 1992, 85 of 125 licensed farms sold approximately 128,300 skins (Table 13.3).

Table 13.2. Statistics from the September Wild Alligator Harvest in Louisiana, 1973–1993[a]

Year	Commercial hunters	Tags issued[b]	Number taken	Success (%)	Average length (cm)	Average value of skins per 30.5 cm (US$)	Total value of skins (US$)	Area hunted (ha)	Amount meat sold (kg)	Value of meat (US$)
1972	59	1,961	1,350	68.8	211	8.10	75,505	111,254	N/P	N/P
1973	107	3,243	2,921	90.1	213	13.13	268,994	216,513	N/P	N/P
1975	191	4,645	4,420	95.2	229	7.88	258,791	329,144	N/P	N/P
1976	198	4,767	4,389	92.1	216	16.55	512,240	327,038	N/P	N/P
1977	236	5,760	5,474	95.0	224	12.23	488,499	395,645	N/P	N.P
1979	708	17,516	16,300	95.0	211	15.00	1,711,500	1,047,168	45,400[c]	125,000
1980	796	19,134	17,692	92.5	201	13.00	1,609,972	1,313,456	45,400[c]	125,000
1981	913	15,534	14,870	95.7	211	17.50	1,821,575	1,415,394	45,400[c]	125,000
1982	1,184	18,188	17,142	94.2	208	13.50	1,621,633	1,617,408	45,400[c]	125,000
1983	945	17,130	16,154	94.3	211	13.00	1,452,568	1,416,974	45,400[c]	125,000
1984	1,104	18,386	17,389	94.6	213	21.00	2,556,183	1,428,192	45,400[c]	125,000
1985	1,076	17,466	16,691	95.6	216	21.00	2,482,619	1,415,313	68,100[d]	625,000
1986	1,207	23,267	22,429	96.0	211	23.00	3,611,000	1,539,000	140,740[d]	1,395,000
1987	1,370	24,635	23,892	97.0	216	40.00	6,689,760	1,579,500	227,000[d]	2,250,000
1988	1,545	24,111	23,526	98.0	221	48.00	7,905,024	1,741,500	272,400[d]	3,000,000
1989	1,769	25,492	24,846	97.4	221	50.00	9,006,675	1,766,580	339,040[d]	3,000,000
1990	1,921	26,051	25,575	98.2	221	57.00	10,568,869	1,765,800	318,000[d]	3,000,000
1991	1,995	24,532	23,870	97.3	227	32.00	5,686,025	1,766,000	310,310[d]	2,935,000
1992[e]	1,686	25,378	24,000	94.0	221	23.00	4,002,000	1,766,000	312,000[d]	2,951,520
1993	1,690	24,381	23,500	96.4	221	23.00	3,916,410	1,707,000	305,500[d]	2,890,000
Total	20,700	341,577	326,430				66,925,842	24,664,879	2,565,490	22,846,520
Average				95.6	216					

Source: Louisiana Department of Wildlife and Fisheries.
[a]N/P, sale of meat not permitted; Louisiana Health Department regulations first allowed meat sales in 1979.
[b]Does not include Salvador and Marsh Island experimental and farm harvest.
[c]Bone in.
[d]Deboned.
[e]Predicted December 28, 1992.

Table 13.3. Statistics from the Alligator Farming/Ranching Program in Louisiana, 1972–1993

Tag year	Number of farms		Number of skins sold	Average length (cm)	Value of skins (US$)		Value of meat (deboned)[a]	
	Licensed	Sold skins			Average per 30.5 cm	Total	Amount (kg)	Value (US$)
1972	8	3	35	152.4	8.10	1,417	N/P	N/P
1973	8	5	103	193.0	13.13	8,560	N/P	N/P
1975	8	3	83	167.6	7.88	3,597	N/P	N/P
1976	8	3	360	175.3	16.55	34,258	N/P	N/P
1977	8	4	376	160.0	12.23	24,142	N/P	N/P
1980	8	1	191	142.2	13.00	11,595	434	3,342
1981	8	3	360	142.2	17.50	29,421	817	6,300
1982	8	1	113	121.9	13.50	6,102	205	1,582
1983	14	6	1,449	139.7	13.00	86,273	3,290	25,357
1984	12	7	2,836	129.5	21.00	253,113	5,150	39,704
1985	15	12	4,430	129.5	21.00	395,377	8,045	79,740
1986	22	15	5,925	137.2	23.00	613,237	12,105	119,983
1987	30	23	10,670	134.6	24.00	1,131,873	21,800	216,067
1988	47	38	27,749	129.5	36.00	4,245,597	50,392	554,980
1989	83	68	66,737	121.3	32.00	8,499,624	136,477	1,202,362
1990	123	79	88,220	122.9	24.00	8,534,396	180,410	1,786,059
1991[b]	134	93	119,000	126.1	15.00	7,385,400	243,300	2,380,000
1992[c]	125	85	128,300	122.9	12.00	6,206,128	262,310	2,566,000

Source: Louisiana Department of Wildlife and Fisheries.

[a]N/P, sale of meat not permitted; Louisiana Health Department regulations first allowed meat sales in 1979.

[b]Revised October 12, 1992; subject to further revision.

[c]Revised November 15, 1993; subject to further revision; includes the time period September 10, 1992 through September 10, 1993.

In contrast to the supply of alligator skins over the previous century, the renewed availability beginning in the 1970s carried with it the promise of a continued supply of skins resulting from a sustainable use program. Markets reacted with a steady price increase, which continued through most of the 1980s (Tables 13.2 and 13.3) until supply met market demands. Since the late 1980s, the major economies of the world, including that of Japan, have been in recession to one extent or another. Consequently, at the time that the ability of the farming industry to produce skins reached an all-time high (Table 13.3), prices dropped significantly (Tables 13.2 and 13.3). During this time, the

industry has been marked by consolidation of and improvements in the production efficiency. Groups such as the Louisiana Fur and Alligator Advisory Council, the Louisiana Department of Agriculture, the Southern U.S. Trade Association, and the American Alligator Council have engaged in efforts to expand and diversify the markets for alligator skins. These efforts, coupled with a reduction of the backlog of farm and tannery stocks, and economic improvements around the world, led to a 25–40 percent rebound in prices in 1994.

Unlike markets of the past, which were not built around sustainable use programs, the present availability of affordable alligator leather in sustainable quantities has set the stage for market expansion and diversification due to competition. This competition will come primarily from within the alligator industry itself, as there are no true substitutes for alligator skin. Leather pressed with the scale pattern of alligator skin is very popular, reflecting alligator leather's general appeal among people who cannot or will not pay the very high prices of the genuine article. However, this leather belongs to a far less exclusive marketplace and cannot replace genuine alligator leather.

Other exotic leathers would appear to have the potential to "substitute" for alligator leather through competition in the marketplace. However, the noncrocodilian exotics (e.g., snake, lizard, and ostrich) do not directly compete with crocodilian skins because of price structure and consumer choice (Durland 1990; Yamanaka 1990). The supply of other classic crocodilian leathers, such as from saltwater crocodile (*Crocodylus porosus*), Nile crocodile (*C. niloticus*), and Papua New Guinea freshwater crocodile (*C. n. novaequineae*), is smaller and less reliable, and competition from these sources is of less consequence than that within the alligator industry itself. In recent years, alligator skin production has grown to represent the preponderance of classic crocodilian skins produced worldwide. For example, excluding alligators, the total number of classic crocodilian skins produced in 1990 was estimated at 102,687 skins (R. Luxmore, pers. comm. of data presented at a workshop on trade at the IUCN Crocodile Specialist Group Meeting, August 1992, Victoria Falls, Zimbabwe). In the same year, alligator production in Louisiana alone, excluding nuisance alligators, was 113,795 skins (Tables 13.2 and 13.3). Since that time, alligator production increases in Louisiana (152,681 in 1992) and other states (Florida, Texas) have greatly exceeded gains in production of crocodile species. This contrasts sharply with the situation only a de-

cade earlier. For example, alligators represented no more than 26 percent of the classic crocodilian skins traded worldwide in the period 1983–85 (Luxmore 1990). Despite this decline in market share of other crocodilian exotic leathers, competition from these sources can only serve to improve efficiency in the industry and stimulate markets for all exotic leathers.

Alligator Meat

The alligator industry is based on the sale of skins, but the meat produced is a valuable by-product. The commercial sale of alligator meat has been allowed in Louisiana since 1979, when relevant health department requirements took effect. "Controlled by the Food and Drug Control Unit, Office of Health Services and Environmental Quality of the Department of Health and Human Resources, alligator skinning facilities were licensed and approved for the sale of both farm and wild alligator meat for human consumption under Louisiana Law, Chapter VI of the State Sanitary Code" (Joanen and McNease 1991).

During the period 1979–93, more than 2,500 MT of alligator meat from the wild harvest and more than 900 MT of meat from the ranching/farming program were produced and sold. Current annual production has grown to about 500 tons of alligator meat from the harvest of both wild and farmed alligators (Tables 13.2 and 13.3). Obviously, only a very small portion of the meat produced from Louisiana's sustainable use program is consumed in Louisiana by those who produce it, and it is not important in their diet as might be the case in an underdeveloped nation. Instead, its value comes from its sale into markets for human consumption and the economic benefits conferred on the hunters, ranchers and farmers, and their employees.

During the period 1979–93, approximately US$32 million was generated from the sale of alligator meat within the state, other states, and overseas, including Taiwan, Canada, and several European countries. As supply increased during the period 1979–93, meat prices steadily declined (Tables 13.2 and 13.3).

The nutritional attractiveness—low in fat and cholesterol (Johnson et al. 1983)—and the ease of cooking alligator meat (Moody et al. 1988) ensure that markets for alligator meat will always exist. However, supply of those markets will likely be limited by the demand for skins in the leather markets because alligator meat is essentially pro-

duced as a by-product. In the United States, alligator meat is primarily a "novelty" on restaurant menus. In the Far East, it is consumed as "dragon meat," and many customers eat it because they believe that by doing so their spirit will be imbued with that of the dragon. Because the supply of alligator meat is now significant, steady, and intrinsically limited, and because of alligator meat's unique nature, the stage is set for development of further processed, "value-added" alligator meat products for the retail market. Limited efforts along this line are evidenced by the development of alligator sausages in Louisiana seafood markets and experiments with canning (Moody et al. 1988).

Biological Suitability

This section raises and attempts to answer two important questions: (1) Are alligators in Louisiana, and their wetland habitats, capable of sustaining annual harvests? (2) Is the current Louisiana harvest program well designed and adequately monitored?

It was recognized in the late 1960s and early 1970s that one of the greatest threats to alligators in Louisiana was the potential for unmanaged development of wetlands, with the likelihood of habitat loss to agricultural, commercial, and residential uses. A policy of managing alligator populations as a renewable natural resource on a sustained yield basis to provide an incentive to landowners to "manage wetlands as wetlands," rather than for other commercial purposes, was adopted (Joanen and McNease 1973a, 1974, 1981, 1987a, 1991; Joanen et al. 1983). As a consequence, alligators have been managed under sustainable use programs in Louisiana for more than 20 years (Joanen and McNease 1991). An essential component of this effort was an extensive research program, initiated by the Louisiana Department of Wildlife and Fisheries in 1964, to study the natural history, management, and captive propagation of this species (see reviews in Joanen and McNease 1981, 1987a,b, 1991; Joanen et al. 1983). Over the past 30 years, the state of Louisiana has invested extensive resources into this effort, resulting in steady growth of the alligator population, the development and publication of much scientific information, and —as an unintended benefit—the most highly developed crocodilian industry in the world. Furthermore, the work done by LDWF on the management of alligators, both wild and under farm conditions, has been applied to crocodilian conservation programs throughout the

world (e.g., Webb et al. 1987b). Nevertheless, the goal of the Louisiana program has always been to manage the alligator populations, as a component of the state's wildlife resources, to the benefit of alligators, other species, and the people of Louisiana.

Central to this research program are the exhaustive and ongoing studies on the size, structure, dynamics, and distribution of the alligator population in the vast (more than 2 million ha) Louisiana wetlands, which includes an estimated 1.7 million ha of coastal marsh (Chabreck 1970; Joanen and McNease 1981) and more than 400,000 ha of nonmarsh wetlands (Taylor 1980; Joanen and McNease 1991: LDWF data). Alligators are present in 63 of the 64 parishes in Louisiana and inhabit the entire range of wetland habitats throughout the state.

Coastal marsh habitats in Louisiana are categorized geographically: (1) the Chenier Plain, 560,000 ha east of the Sabine River to Vermilion Bay; (2) the active delta marshes, 97,000 ha of very recent origin near the Mississippi River delta; and (3) subdelta marshes, 1.1 million ha west of the Chenier Plain except the active delta region. Throughout these regions, approximately 404,000 ha are salt or highly brackish marshes and are not considered to be alligator habitat. Most of the approximately 404,000 ha of nonmarsh wetlands are alligator habitat, including 10,925 ha of lake habitat and more than 385,000 ha of cypress-tupelo swamps, which are comprised mostly (64%) of the Atchafalaya Basin (Joanen and McNease 1981, 1991; LDWF data). Thus there are approximately 1.7 million ha of alligator habitat in the state.

Another classification of Louisiana coastal wetlands is that based on salinity and resultant vegetative types (e.g., Chabreck et al. 1968; Joanen and McNease 1972a). The intrusion of saline water, both naturally and as a result of human activities, is the greatest abiotic factor affecting alligator populations. Salinity of the environment is known to affect feeding habits (Chabreck 1972; McNease and Joanen 1977; Lauren 1985), movements (Joanen and McNease 1972b), reproduction (Joanen 1969; Joanen and McNease 1972a; Ruckel and Steele 1985), physiology (Lauren 1985; Dunson and Mazzotti 1988), and growth rates (Mazzotti 1982; Lauren 1985). Prolonged exposure of young alligators to salinities of 3.5 parts per thousand (ppt) results in cessation of feeding and to salinities greater than 5–13 ppt can result in death (Joanen and McNease 1972a; Lauren 1985).

Alligator population densities are consequently related to salinity conditions (Joanen and McNease 1970, 1972a,b, 1978; Table 13.4),

Table 13.4. Tag Allotments in Louisiana in Relation to Alligator and Nest Densities, 1993

Habitat type	Acres per: Alligator[a]	Nest[b]	Tag allotment[c]
Marsh			
Fresh	6.9	146	75–250
Intermediate	5.3	70	75–325
Brackish	10.2	105	100–700
Nonmarsh			
Cypress-tupelo lakes	4.1	N/C	Avg. 125
Cypress-tupelo swamps	6.4	N/C	Avg. 200
Atchafalaya Basin	18.0	N/C	Avg. 1,280

[a]1981 Louisiana Department of Wildlife and Fisheries data.
[b]1988–92 Louisiana Department of Wildlife and Fisheries data. N/C, not compiled.
[c]1993 Louisiana Department of Wildlife and Fisheries data.

being greatest in intermediate marsh (0.5–8.3 ppt salinity), and slightly less in fresh marsh (0.1–3.4 ppt salinity) and brackish marsh (1.0–18.4 ppt salinity). The latter is a band of marsh averaging 13.36 kilometers (km) statewide (Joanen and McNease 1972a) between intermediate and salt marshes (8.17–29.4 ppt salinity). Nesting does not occur on the gulf side of the 10 ppt isohaline line (Joanen and McNease 1972a).

Maps of the isohaline lines and associated vegetation of Louisiana are prepared about every 10 years by the LDWF (Chabreck et al. 1968; Chabreck and Linscombe 1978). These maps are used in assessment of populations within each parish by wetland habitat type, including subdivisions by salinity (e.g., Chabreck 1970; Joanen and McNease 1973b; Ensminger and Linscombe 1980; Table 13.4), and resulting management decisions. In addition to salinity, factors such as the amount of open water, cover, water depth, and interspersion, as developed in the alligator habitat suitability index model (Newsom et al. 1987), are considered.

This detailed knowledge of alligator distribution in Louisiana wetlands shows the versatility and adaptability of this species to diverse habitats. Although a notable member of wetlands fauna, the alligator shows no unique association with specific habitats or other species. Alligator populations are densest in intermediate marsh (Table 13.4),

where they feed heavily on nutria (*Myocastor coypus*), an introduced species which also prefers this habitat.

The alligator plays the role of a large top predator throughout the diverse wetland habitats it occupies. Numerous studies on the feeding habits of alligators in Louisiana have been conducted (e.g., Kellogg 1929; Giles and Childs 1949; Chabreck 1972; Valentine et al. 1972; McNease and Joanen 1976; Taylor 1986; Wolfe et al. 1987). Prey species for alligators include insects, amphibians, mollusks, crustaceans, fish, birds, reptiles, and mammals. As McIlhenny (1935) pointed out, alligators are opportunistic feeders, consuming most animals smaller than themselves. The importance of prey species in an alligator's diet depends largely on the relative abundance of the prey, compared with other prey species, in habitat selected by individual alligators.

Based on the extensive published record and experience of LDWF personnel, it is considered unlikely that alligators play a dominant role in the regulation of populations of any of these species. For example, nutria and muskrat are the most important food items for large alligators, but these mammals have reproductive potentials that vastly exceed the ability of alligators to control. For example, the Louisiana nutria population, which produced in excess of 13,500,000 pelts from 1970 to 1979 (Ensminger and Linscombe 1980), started from the accidental release of 13 individuals into a marsh of high alligator density in 1937 (Kinler et al. 1987). Similarly, other common prey such as crustaceans and fish are characterized by almost incalculable biomass and reproductive potential, and any regulation of their populations by alligator predation would be marginal and isolated.

Martin and Hight (1977) provide an unusual example of prey population numbers being regulated by alligators. In ponds at Florida's Loxahatchee National Wildlife Refuge, where other prey species apparently were relatively sparse, alligators fed almost exclusively on apple snails, large aquatic snails important in the diet of the Everglade kite. The number of snails in the ponds was inversely proportional to alligator density. When alligators were excluded from ponds, snail population indexes increased.

Perhaps the only species on which alligator predation has a serious impact is alligators themselves. Alligators of virtually all sizes suffer from intraspecific predation (Nichols et al. 1976b; Hines and Abercrombie 1987; Rootes 1989). Rootes (1989) estimated that cannibalism accounted for 50.2 percent of hatchling mortality and 70.1 per-

cent of mortality of alligators 11 months and older. "Total cannibalism losses were an estimated 2.13 prey alligators per predator size alligator in the standing crop per year" (Rootes 1989). For alligators and other crocodilians, cannibalism is believed to be the major population density-related mortality factor (Nichols et al. 1976b; Polis and Myers 1985).

The only suggestion that alligators play an influential ecosystem role is in southern Florida wetlands (Craighead 1968; Rhoads and Pope 1968; Kushlan 1974, 1979), where, when marshes dry, alligator burrows/dens serve as refuges for fish species and help to maintain fish diversity. Alligator activity at these ponds prevented encroachment of successional vegetation. While alligator holes are present in Louisiana (e.g., McIlhenny 1935; Chabreck 1965), such a benefit is now viewed as minimal in most Louisiana marshes because of active water management by landowners, which is designed to prevent stressful drought conditions, as discussed below.

The Louisiana coastal marsh alligator population has been quantified annually by aerial nesting surveys (Chabreck 1966) along transects in representative habitat since 1970 (LDWF annual survey data; Fig. 13.1; Table 13.5), validated by actual counts along selected transects. Consistent annual growth has led to the conservative estimate (Taylor et al. 1991) of approximately 750,000 alligators in Louisiana wetlands (Table 13.5), including a quadrupling of the coastal marsh alligator population. This growth occurred over a 20-year period when 800,000 alligators were harvested as a result of the wild hunt, the nuisance alligator program, and as part of the egg ranching program (Tables 13.2 and 13.3).

One reason alligators show remarkable population growth numbers is a high reproductive rate. It has been conservatively estimated (Taylor et al. 1991) that nesting females represent 5 percent of the nonhatchling population (Chabreck 1966). Over a four-week period in June and early July, these females build a nest and deposit an average of 39 eggs (Joanen 1969; Joanen and McNease 1976, 1978, 1979, 1980). Thus immediately after nesting there are more eggs in nests than there are alligators in the entire population. Given that alligators are long-lived, that as many as 63 percent of adult females nest each year (Joanen and McNease 1980), and that a relatively small percentage of the adult male population is required to mate each year (adult males can mate with three to five females), the intrinsic capacity of population growth, even under enormous pressures, is considerable.

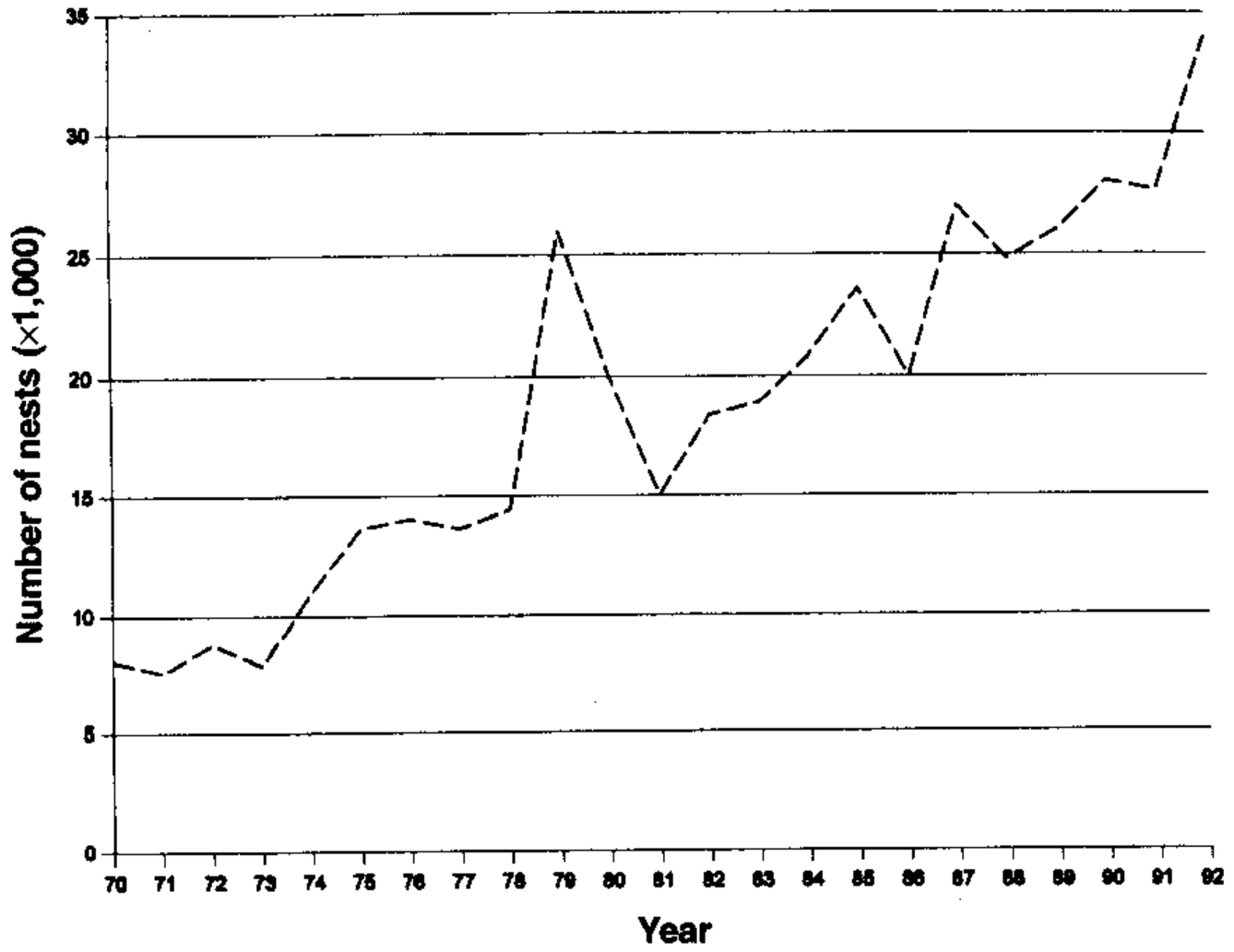

Figure 13.1. Louisiana costal marsh alligator nest projections based on aerial surveys, 1970–92. (*Source:* Louisiana Department of Wildlife and Fisheries data.)

Balancing this reproductive potential is the high natural mortality of alligator eggs and hatchlings (Taylor and Neal 1984). Egg mortality is primarily due to flooding (Joanen et al. 1976) and predation (Fleming et al. 1976; Nichols et al. 1976b). Droughts, desiccation, overheating, and hurricanes (Waldo 1957; Ensminger and Nichols 1958; LDWF data) are influential factors. Predation of hatchlings is maximized under conditions of drought, as suitable habitat is reduced and the ability of predators to find their prey is enhanced (Hines et al. 1968; Fleming et al. 1976). This is particularly damaging because, under drought conditions, many adult females will not nest (Joanen and McNease 1989); as a result, eggs or hatchlings lost to predation are a disproportionately large portion of the population's reproductive output, as compared to the loss of an equal number of eggs or hatchlings in years of normal rainfall and nesting.

Estimates of survivorship, from the time of egg deposition through a hatchling's first years of life, range from 5 to 17 percent (Nichols et

Table 13.5. The Louisiana Alligator Population

Year	Wild[a]						
	Marsh			Non-marsh[b]	Total wild	Farm[c]	State total
	Private	Public	Total				
1970	104,180	67,900	172,080	N/A	172,080	N/C	172,080
1971	77,191	57,218	134,000	N/A	134,000	N/C	134,000
1972	102,460	79,940	182,000	N/A	182,000	N/C	182,000
1973	93,096	60,394	153,000	N/A	153,000	N/C	153,000
1974	121,549	92,445	213,000	N/A	213,000	N/C	213,000
1975	152,773	119,703	272,000	N/A	272,000	N/C	272,000
1976	186,668	95,644	282,000	N/A	282,000	N/C	282,000
1977	182,615	91,733	274,000	N/A	274,000	N/C	274,000
1978	191,520	93,635	285,000	N/A	285,000	N/C	285,000
1979	368,706	150,720	520,000	N/A	520,000	N/C	520,000
1980	295,178	107,760	400,000	N/A	400,000	N/C	400,000
1981	213,940	76,039	289,000	168,000	457,000	N/C	457,000
1982	225,207	136,500	368,000	168,000	368,000	N/C	536,000
1983	256,432	119,560	379,000	168,000	379,000	N/C	547,000
1984	315,712	94,120	410,000	168,000	578,000	N/C	578,000
1985	322,100	146,000	468,000	168,000	636,000	N/C	636,000
1986	299,420	97,500	397,000	168,000	565,000	N/C	565,000
1987	384,078	138,460	523,000	168,000	691,000	46,579	737,579
1988	367,900	115,320	483,000	168,000	651,000	86,446	737,446
1989	372,860	145,200	518,000	168,000	686,000	194,807	880,807
1990	423,500	134,980	558,500	168,000	726,500	325,451	1,051,951
1991	N/C	N/C	550,000	168,000	718,000	318,177	1,036,177
1992	N/C	N/C	690,000	168,000	585,000	291,983	1,149,983
1993	N/C	N/C	566,000	168,000	734,000	258,314	992,314

Source: Louisiana Department of Wildlife and Fisheries.

[a]Does not include hatchlings.
[b]N/A, not available until conservative estimate by Joanen et al. 1981.
[c]N/C, not compiled.

al. 1976a,b; Taylor and Neal 1984; Carbonneau and Chabreck 1990). These represent averages, and in years of either extreme flooding or drought, mortality can reach 100 percent for some populations. For example, in 1985 all nests produced in the Marsh Island population were lost in a hurricane (LDWF data). Alternatively, low mortality for any one cohort of eggs or hatchlings can lead to significant increases in

population numbers. Because of this, the reproductive capacity of alligator populations can be considered to be compensatory.

The management implication is that controlling marsh water levels avoids extremes and decreases mortality of eggs and young. This both stabilizes the recruitment of young into the natural population and makes available a steady supply of eggs for the egg ranching program, which further serves to compensate for extremes in natural mortality.

Both components of the Louisiana alligator harvest target the removal of specific components from the population. In the case of the egg harvest, members of a specific age class (eggs and resulting hatchlings) are removed. In the wild hunt, adult males and nonreproductive females are targeted by way of sex- and size-specific habitat specificity based on telemetry studies (Joanen and McNease 1970, 1972b; McNease and Joanen 1974). The goal is to protect the nesting female segment of the population at a time of nest-tending by breeding females. Hunting takes place in canals, bayous, and lakes—habitats that are avoided by reproductive females during the postnesting period (Giles and Childs 1949; Joanen and McNease 1970). This is important to the success of a year's crop of eggs or hatchlings, which often receive protection by the parental female. Harvest results (Joanen and McNease 1987a) show that adult males routinely comprised 60–80 percent of the total take and 70–85 percent of adults hunted. This trend has not changed. In 1993, for example, males constituted 74 percent of the total take (LDWF data).

The Louisiana alligator ranching program is based on the above-mentioned combination of high reproductive rate and high natural mortality. Under the program, a quota of eggs can be picked up under permit by LDWF, as long as a number of the resulting alligators are subsequently released to the marsh where the eggs were collected. The number to be released is equal to a percentage that would be expected to survive under natural conditions, based on their size and survivorship data (Taylor and Neal 1984). This percentage ranges from 29.6 percent for 91.44-cm alligators, to 9.8 percent for 152.40-cm animals. Published (Elsey et al. 1992a,b) and unpublished data from ongoing LDWF research show that these released alligators eat and grow (and presumably survive and reproduce) as well as their wild counterparts. The ranching program therefore does nothing to restrict the inherent diversity of the wild population. To the contrary, taking a portion of the most fragile part of the population into captivity serves to

"buffer" the Louisiana alligator population during periods of unmanageable habitat stress, for example, hard freezes or hurricanes. The number of eggs harvested annually reached about 275,000 in 1990, and averages about 20 percent of eggs laid. Natural events therefore continue to shape genetic diversity of the vast majority of the wild population.

Alligators are characterized by very low genetic variability; in fact, they are widely recognized as being among the most homogeneous of vertebrate species (Dessauer 1983; Menzies et al. 1979; Adams et al. 1980). There are no recognized subspecies, and systematic studies have shown little intraspecific variation over the range of the species (Ross 1977; Ross and Roberts 1979). None of the periphery of the species' geographical range lies within Louisiana. There are no isolated populations within the state which have differentiated themselves genetically. Because of the widespread distribution of alligators in diverse habitats throughout the state, and the regulation of the harvest according to habitat type, there is no danger that the hunt or egg harvest affects the population by virtue of its being genetically distinct or unique on a geographical basis.

Research by LDWF on the rate at which populations can be harvested is ongoing. Taylor and Neal (1984) suggested that an 8 percent harvest rate was too liberal. At the Marsh Island Refuge, an experimental hunt conducted periodically since 1986, with few restrictions and a target harvest of 20 percent of the adult female population, has significantly changed the age-class structure, in contrast to the relatively constant average size of alligators hunted statewide (Table 13.6).

In practice, the maximum harvest rate is 5 percent for a population. However, the rate for any given population—managed to habitat type within parish boundaries—takes into consideration the population density and trends in the area, and can therefore be lower (Table 13.4). In marsh habitats, quotas (tag allotments) range from one per 30 ha in the fresh marshes of St. Charles and St. John the Baptist parishes to one per 283 ha in the brackish marshes of St. Bernard and Orleans parishes. In nonmarsh habitats, quotas average one per 50 ha in cypress-tupelo lakes and one per 518 ha in the cypress-tupelo swamps of the Atchafalaya Basin.

Currently, the actual harvest rate is about 3 percent of the state's population (approximately 25,000 alligators harvested from a popu-

Table 13.6. Percentage of Adults and Juveniles in the Statewide Alligator Hunt and the Experimental Hunt at Marsh Island Refuge

Harvest	Year	Percentage of adults	Percentage of juveniles	Sample size
Public hunt	1972	64	36	303
	1973	71	29	843
	1974	87	13	782
	1975	73	27	591
	1976	75	25	281
	1972–76	76	24	2,800
	1972–90	80	20	231,713
Marsh Island	1986	83	17	2,930
	1987	43	57	1,261
	1988	32	68	166

Source: Joanen et al. 1987a (statewide hunt); Louisiana Department of Wildlife and Fisheries (experimental hunt).

lation of approximately 750,000; Tables 13.2 and 13.5). This conservative harvest level provides a hedge against unknown and unpredictable factors, ensuring that the population will not be overharvested. The success of this strategy is validated by the continued growth of the population, by the consistent size of alligators taken in the statewide hunt over the past 22 years (Tables 13.2 and 13.3), and by comparisons of sex and size-class structure from hunted and nonhunted populations. The alligators of Marsh Island were totally protected and unhunted, that is, "preserved" for a period of 24 years between 1962 and 1986. The size-class structure of this population (as reflected in proportion of adults in the first hunt in 1986) and that of the statewide population are very similar (Table 13.6). Over the period 1972–90, approximately 80 percent (Joanen and McNease 1991) of the 231,713 alligators hunted in Louisiana were adults (1.83 m or more in total length), virtually identical to the percentage of adults (83%) taken at Marsh Island in 1986. Therefore, populations hunted under LDWF guidelines are not being excessively harvested, as alligators in unhunted populations died at about the same rate as those from hunted populations.

Not only is the harvest rate low compared to the much higher (20–30%) harvest rates prescribed for species such as rabbit, quail, squirrel, and deer, but the offtake of alligators is also regulated to a

degree rarely seen in wildlife management—to the level of the individual alligator. This is achieved as a result of the tagging requirements developed by the LDWF to regulate effectively the alligator harvest and comply with CITES (Conference on International Trade in Endangered Species) requirements. A locking tag (specific to Louisiana alligators, with unique serial numbers, and monitored under CITES permitting procedures) must be affixed to any alligator skin before it leaves the site on which the animal was killed, whether as a result of the wild harvest or farming. This tagging system is a part of the licensing and hunting regulations developed by LDWF. Any skin not bearing the Louisiana/CITES tag will be confiscated; fines can be imposed and licenses revoked. Furthermore, to conform with and assist CITES, this tag must remain on the skins, whether salted or processed as leather, or traded internationally.

There can be no doubt that the alligator in Louisiana can be managed sustainably without damaging the viability of the resident population. The continued monitoring of the population, the dedication of LDWF to professionally managing the Louisiana population, and the natural resiliency of the species ensure that any indication of overharvest or damage to the population from other factors, even those unknown and unpredictable, will be responded to in such a way as to protect the Louisiana alligator population and ensure its long-term viability.

Impacts on Biodiversity

This section discusses Louisiana's coastal wetlands and the benefits of managing and harvesting alligator populations for the biodiversity of this region. The flora, fauna, habitats, and ecosystems of Louisiana are amply described in the general scientific literature and are the concern of state and federal wildlife and environmental agencies as well as private conservation groups. The Louisiana Natural Heritage Program, and interagency efforts of the LDWF and the state's Department of Natural Resources (LDNR) have described the natural communities (Craig et al. 1987) and listed the plants and animals "of special concern" in the coastal zone of the state (Lester 1988), which is where most alligators are found. Included in this list are two invertebrate species, six reptiles, nine avian species, and five mammal species classified as either threatened or endangered under the federal En-

dangered Species Act. An additional ten plant species, four invertebrates, ten fish species, one reptile, and three birds are considered potential candidates for the list (summarized by Louisiana Department of Culture, Recreation, and Tourism 1988). The species on these various lists show no close association with alligators; nor would it appear that they are in any way dependent on alligators or negatively impacted by their management and harvest per se. To the contrary, efforts to maintain or restore Louisiana's historical wetland diversity benefit the native biodiversity.

Louisiana's wetlands are of national and international importance as part of two important migratory bird routes extending from Canada to South America. For example, Louisiana's coastal zone provides the wintering grounds for 66 percent of the geese in the Mississippi flyway and 20–25 percent of the nation's total puddle duck population (Louisiana Department of Culture, Recreation, and Tourism 1988). The United States government has signed treaties with several other countries to ensure the conservation of migratory bird habitat (Louisiana Department of Culture, Recreation, and Tourism 1988). It is not inconsequential then that waterfowl habitat is also alligator habitat, and that much of this land is privately owned. Louisiana's wetlands are dynamic, productive ecosystems which have historically received significant annual inflow of freshwater, sediments, and nutrients from the Mississippi River and, to a lesser degree, from the Red River. This has led to marsh building or accretion. Operating against this inflow of inland freshwater, sediments, and nutrients is soil erosion and saltwater intrusion from the Gulf of Mexico. Over the past century, historical/natural patterns of sedimentation and hydrology in coastal Louisiana have been altered significantly by the levying of the Mississippi River. This has diverted freshwater and sediments, which under natural conditions would have countered the actions of erosion and saltwater intrusion into the Gulf of Mexico. Furthermore, the past 50 years have seen the construction of ship channels and numerous canals which have facilitated saltwater intrusion into coastal marshes. Also, large-scale pumping from freshwater-bearing sediments have further altered subsurface hydrology (Louisiana Geological Survey 1967). Consequently, coastal marshes have been characterized by salinification, vegetational alteration and losses, subsidence, and both inland and coastal erosion (Beek and Meyer-Arendt 1982), causing significant alteration and loss of habitat for alligators and other coastal zone

species. For example, an estimated 155 km^2 of coastal Louisiana are eroded into the Gulf annually (Templet and Meyer-Arendt 1986). Thus Louisiana's historical wetland diversity cannot merely be "maintained"; it must be "restored."

Throughout geologic history, and particularly over the past century of manmade alterations to wetlands, alligators adapted to the variety of habitats formed. The current policy of LDWF and other state and federal agencies is to attempt to maintain isohaline lines throughout Louisiana wetlands and prevent further habitat loss. The adaptability of alligators, as well as LDWF policies, ensures the viability of the species. However, continued encroachment of saltwater into fresh, intermediate, or brackish marshes puts into question just how much alligator habitat will exist in future years and what its carrying capacity will be.

Alligator managers in Louisiana (Joanen and McNease 1975) and other states (Schortemeyer 1972; Schemnitz 1974; Hines 1979; Potter 1981) realized long ago that the greatest potential problem in managing alligators was that of possible habitat loss to agricultural, commercial, or residential uses. Louisiana adopted the approach of cooperating with landowners to manage alligators as a renewable natural resource. As most alligators in Louisiana are found in the coastal marshes (Table 13.5), alligator habitat management largely means marsh management. The economic value of wildlife—waterfowl, furbearers, crawfish, shrimp, and gamefish, as well as alligators—makes it in the landowners' interests to manage wetlands in such a way as to maintain their integrity and prevent extremes such as flooding, drought, and salinity. With LDWF and Soil and Conservation Service advice, many landowners have taken a multispecies approach to marsh management (e.g., Joanen et al. 1989), investing significantly in resources in hopes of reaping economic benefits. At the same time, wetland habitats have been stabilized or improved, and the native biodiversity has benefited.

Of prime importance in the multispecies approach to marsh management is the control of water levels and associated habitat, with the use of water control structures such as weirs, levees, and impoundments. It may be argued that some species are dependent on habitat extremes and that their interests are not served by marsh management. However, as discussed above, modifications to Louisiana's wetlands, vis-à-vis historical wetland diversity, are extreme, and there is abundant habitat for such species. Furthermore, these species benefit from

periodic "draw downs" practiced as part of good marsh management. Nevertheless, control of flooding, drought, and salinity serve to stabilize marsh habitats to the advantage of the vast majority of wetlands species.

Waterfowl species inhabiting Louisiana marshes provide excellent examples of the benefits of a multispecies approach to marsh management. Duck populations at Rockefeller Refuge grew from 75,000 to 500,000 over a period of several decades of concentrated marsh management (Joanen 1982; LDWF data). Alligator populations also benefited from the water control measures, which created an abundance of nesting sites and food supply for alligators (Chabreck 1960). Waterfowl that use Louisiana wetlands to overwinter before migrating to summer breeding grounds in Canada provide another good example. Their reproductive success in summer is related to their feeding success at winter sites in Louisiana's coastal marsh managed for their benefit as well as for alligators (Williams and Chabreck 1986; Chabreck et al. 1989).

Alligator habitats are not manipulated in an unnatural manner in order to meet harvest objectives. Instead, the harvest of alligators is improved by increasing the quantity and quality of wetlands habitat available, that is, restoring and maintaining historical wetlands diversity. Following the pre-1962 depletion of many alligator populations, stocking was conducted in the 1960s and early 1970s to reestablish and replenish those populations (LDWF data). This augmentation of the population was conducted as a conservation measure, with no consideration for eventual harvests. Although it has been noted that the alligator productivity of marshes could be increased by systematic egg collection and subsequent restocking to minimize high natural mortality of juveniles (Nichols et al. 1976a,b), such measures have not been taken.

Marsh management recommendations allow for sustainable harvests of some species (e.g., otters, raccoons, large predatory fish) that prey upon alligator eggs or young. Direct benefits (e.g., lowered predation rates) to alligator populations are, however, probably minimal. Any such benefits are probably negated by a reduction in food supply to the adult alligator population.

Louisiana is known as the "Sportsman's Paradise," and wetlands throughout the state are regularly traversed by hunters, trappers, and fishermen throughout the year. Alligator hunting and egg gathering

are only a small percentage of the human activity in the species' habitat, and cannot be considered intrusive or damaging to it. The harvest of alligators is species-specific, and the incidental taking of other species occurs only rarely. For example, turtles occasionally take baits intended for alligators.

Perry et al. (1993) have shown how a restored, well-managed marsh can reap approximately twice the economic return of a degraded marsh, as well as provide better habitat for wildlife. Thus fauna and flora native to Louisiana's wetlands can benefit from the economic incentive provided by sustainable use of alligators and other wildlife. The maintenance and restoration of the area's wetlands and associated biodiversity can obviously be served by economic forces associated with the wildlife inhabiting them. However, management of Louisiana's expansive marshlands is expensive and could not be undertaken on a large-scale basis without a way to pay for the various professional and capital requirements.

Incentives and Controls

Substantial investments in personnel, equipment, and land management are required to enhance alligator habitat. Rather than being mandated, these investments are made willingly because of the promise of economic return. This incentive, however, must be balanced by careful monitoring in order to prevent overexploitation.

Most large landowners in the Louisiana coastal zone receive royalties from oil and gas production on their land. However, oil and gas are nonrenewable natural resources, and this source of income is both finite and in decline. The reduction in this revenue base adds emphasis to the need to encourage investment in wetlands management schemes that enhance habitat for alligators and other wildlife. Many landowners have responded positively to LDWF efforts and guidance, and, within the above-discussed limitations imposed by considerable modifications to marsh formation and salinity profiles of the state's wetlands, the results are generally well-managed wetlands thriving with populations of alligators and other wildlife.

Although landowners benefit from the sustainable use of alligators and other wetlands species with economic value, the impacts—economic and cultural—are perhaps even greater for the community at large. Approximately fifteen hundred alligator trappers, one hun-

dred alligator farmers, and five thousand furbearer trappers derive a significant portion of their livelihood from what is essentially a subsistence economy. These people and others living in the communities where they live receive most of the economic benefit generated by various components (wild hunt, egg harvest, farming, skin and meat sales, and so on) of the alligator harvest. Direct industry sales, which have grown to as much as US$25 million per year, account for the equivalent of 231 full-time jobs (Brannan et al. 1991; Tables 13.2 and 13.3). Economic modeling shows that an additional US$13 million in goods and services and 172 full-time jobs are indirectly created by the Louisiana alligator industry (Brannan et al. 1991). This economic activity provides tax revenues to underwrite state and local government services.

Though the total value of skins and meat shown in Table 13.2 results in a return of US$4–$6 per ha hunted (not including eggs), it is important to understand that the alligator is only one of several species that are harvested and provide economic value for wetlands in Louisiana. For example, Perry et al. (1993) estimated that waterfowl hunting (guide fees and leasing), muskrat and nutria trapping, shrimp and crab harvests, and alligator hunting and egg collecting in a restored brackish marsh in Louisiana could yield approximately US$48 per ha. Revenues from alligators represented 11 percent of this total.

Beyond economic considerations, alligators and other wildlife native to Louisiana's swamps, marshes, bayous, rivers, and lakes are integral to the centuries-old cultural heritage of Louisianians inhabiting these areas (e.g., Glasgow 1991). Louisiana was pioneered by trappers, resulting in the establishment of the city of New Orleans as a fur trading center (Ensminger and Linscombe 1980). The prominence of alligators in local culture, reflecting the heritage of subsistence living and "closeness to the land," continues today despite the system of land tenureship that has evolved in Louisiana. Although control of the land lies in the hands of relatively few landowners, actual use of the land and associated wildlife remains with the descendants of generations of trappers and hunters, perpetuating the subsistence economy of Louisiana's wetlands. By and large, these hunters willingly adhere to LDWF regulations in order to prevent overharvesting, ensuring their take in the future. Furthermore, they frequently act as agents for the landowners, watching over and protecting the land and the alligators they anticipate hunting. In some cases, they are paid for these efforts,

but generally they are acting out of self-interest in maintaining the alligator population and the suitability of its habitat.

The influence of alligators on the culture of Louisiana is formalized at many local fairs and festivals, such as the Alligator Festival in Boutte, the Alligator Harvest Festival in Grand Chenier, and the International Alligator Festival in Franklin (Glasgow 1991). Alligator skinning is commonly displayed at these events, and alligator meat is cooked in a variety of ways. Furthermore, numerous alligator meat recipes and cookbooks have been published (Glasgow 1991; Moody et al. 1988), and alligator meat is a favorite item in restaurants catering to both tourists and the local population.

Thus the association between man and alligators, which began almost seven hundred years ago and led to the depletion of the state's alligator population, continues today in the form of a sustainable harvest. The stewardship of most of the estimated 1.7 million ha of alligator habitat in Louisiana, upon which alligators ultimately depend, lies with landowners. However, the use of alligators is regulated by and managed under state laws, federal laws, and international convention (CITES).

The 1970 Louisiana legislature established LDWF as the state regulatory agency with principal responsibility for managing the wild population, controlling the harvest, and the ranching/farming program. The state regulations are embodied in Title 56 of Louisiana Public Law. The stated policies and plans regarding the management and harvest of alligators, as described throughout this chapter, have been published (e.g., Palmisano et al. 1973; Joanen et al. 1983; Joanen and McNease 1987a, 1991). Louisiana gained federal authority to manage alligators with the approval of Louisiana's Alligator Management Plan. The state's performance under this management plan is reviewed annually by way of the nondetriment statements filed with the U.S. Fish and Wildlife Service (USFWS) acting as the CITES authority in the United States. Shipments of alligator products are permitted and inspected by LDWF officials, who work in tandem with USFWS to enforce CITES inspection and permitting requirements on shipments entering international trade. Other agencies involved with alligators are the Louisiana Department of Agriculture, which is active in marketing (e.g., Louisiana Department of Agriculture 1989) and the Louisiana Department of Human and Health Services, which regulates the production of meat in slaughterhouses.

In addition to actions taken by the landowner with guidance from LDWF, the management of alligator habitat rests with a host of other state and federal agencies, including the Louisiana Department of Natural Resources, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Marine and Fisheries Service, and the U.S. Corps of Engineers. The controlling law influencing Louisiana wetlands is the U.S. Clean Water Act. Section 404 of this law has made it difficult and expensive for owners of wetlands in Louisiana to commercially develop their land in any way, especially for pursuits other than those based on agricultural or wildlife use. Wetlands management, in general, is receiving much attention statewide and nationally in terms of research, funding, and legislation, and is beyond the scope of this report.

While federal and state agencies address the problems associated with channelization, hydrology, and sedimentation in Louisiana's coastal marsh (e.g., Louisiana Department of Natural Resources 1991, 1992, 1993), many practical actions to restore Louisiana's historical wetland diversity will have to be taken by landowners acting out of self-interest. The revenues derived from the harvest of alligators help landowners in this effort. Discussions with landowners point to a willingness to invest in wetlands in amounts, at a minimum, commensurate with the economic return that can be expected from the use of alligators and other wildlife species. Some landowners would invest more, out of a sense of responsibility toward land stewardship. Landowners who have not taken active measures to maintain and improve their marshes point to the cumbersome, expensive, and time-consuming permit requirements under Section 404 of the Clean Water Act as the primary impediment. Large land companies, with land management staff wholly or partially funded from revenues generated by wildlife use are able to meet and afford these permitting requirements and in some cases procure private and public funds to improve wetlands habitat. Unfortunately, this is beyond the means of small and even medium-sized landowners.

The income derived by landowners from the alligator harvests makes the difference between profitability and financial loss for some land companies. Income and expenses associated with alligators are carefully budgeted. Operating decisions—such as when to schedule construction activities or to permit seismic or mineral exploration activities —are often taken only after consideration of potential impacts on the

biology of alligators or other wildlife species and how revenues could be affected.

The financial incentives made available to landowners, hunters, farmers, and others directly associated with the alligator industry have obviously been sufficient to engender a sense of responsibility toward the resource. They recognize that they are essentially cropping a renewable natural resource and want to do so within the ability of the resource to renew itself. The vast majority willingly work within the limits set by LDWF to prevent overexploitation and maintain healthy, dynamic wetlands. This ethic is consistent with the heritage of wetlands utilization predominant in the culture of many rural Louisianians. A major difference in the present consumptive use of alligators, as contrasted with the pre-1962 years, is the guidance available to the public. The knowledge gleaned from the extensive monitoring and research conducted by LDWF is embodied in management policy and state law.

To ensure that alligator use is under professional control and management, all important aspects of the harvest of alligators and alligator eggs are regulated under state law. Harvests are highly organized and restricted in time in order to maximize the ability of LDWF to monitor the various activities involved. The statewide alligator hunt is conducted in September when the impact on the reproductive output of the population is minimal. Eggs are gathered by or for farmers with the permission (at a price ranging from US$2–$10/egg) of the landowner to whom the permit is issued. Eggs may be gathered only during the established egg collection season, between sunrise and sunset. Furthermore, eggs must be transported so as to maximize survival of eggs, and permits are not issued to any alligator farmer who fails to hatch at least 70 percent of viable eggs for two consecutive years.

LDWF regulations govern the taking, possession, selling, raising, and propagation of alligators in the wild and in captivity. Alligators may be hunted only after hunters complete orientation in the procedures to be followed, and obtain required licenses and tags. Tags are allotted to landowners and are then issued to hunters in exchange for an amount that customarily equals 25–40 percent of the value of the alligator. Approved wild harvest methods include hook and line, long bow and barbed arrow, and firearms. Alligators may be taken only during the hours between official sunrise and official sunset. Alligator hunters are required to inspect any hooks and lines they are utilizing

on a daily basis. They are not allowed to cut alligators loose from hooks and lines for the purpose of selecting larger (more valuable) animals. In the event that an alligator is hooked and the hunter's quota has been reached, the hunter must release the alligator in the most humane way possible.

The ongoing alligator research and monitoring programs conducted by the LDWF are integrated into the department's alligator management efforts and constitute an important part of the controls needed to ensure sustainability of the harvests. The conservative rate (less than 5%) at which alligators are being harvested is based solely on scientific and monitoring information, not on any harvest goals. Harvest details and the results of the monitoring are reviewed annually by the USFWS, acting as the CITES management authority in the United States, by way of nondetriment submissions by LDWF. Despite the economic and cultural benefits of the alligator industry, political considerations bear no influence on decision making in the management of alligators and the biodiversity of their wetlands habitat. This has been LDWF's position over the last 30 years, beginning with the initial decision to take strong and effective measures to safeguard the depleted alligator population even before federal protection was enacted.

Legislative and regulatory safeguards established to protect alligators, their habitat, and associated wildlife communities from overexploitation are enforced by more than four hundred LDWF enforcement agents. There are no exceptions made in the strict enforcement of these laws. Aside from the coercive force of laws and enforcement agencies, the policy of sustainable, multispecies land use promoted by LDWF generates even more effective protection of alligators and wetland habitats by landowners and hunters acting in their own self-interest. Without such cooperation, it is doubtful the state could afford all the law enforcement capabilities required to prevent poaching and unnecessary killing of alligators.

Given that the alligator population is still growing, a cessation of all harvesting for several years would increase their occurrence around dwellings, and the nuisance alligator program would have new and growing demands placed on it. The law enforcement capabilities of the LDWF would be severely stressed. Funds required for the LDWF to manage alligators—which today are generated almost entirely by a US$4 tag fee on each alligator skin harvested in the state—would be

lost and have to be found elsewhere in a state budget that is already running at a deficit. The 30-year investment by LDWF in its alligator programs, which have cost a minimum of US$10 million in operating expenses, would be jeopardized. Personnel and infrastructure important in the sustainable use of alligators, as it exists today, would be lost and difficult to replace.

Loss of an economic incentive to landowners to manage marshes would be highly detrimental to habitat and to alligators and other wildlife. Pressure for other uses of the land, for example, agricultural or residential use, would increase. Large-scale agricultural use of marshes would require their drainage and would result in significant loss of habitat. Management of land as wetlands would decrease. The carrying capacity for most, if not all, species would decrease. Some areas would in all likelihood be developed, but in ways disadvantageous to alligator habitat.

Perhaps the most profound influence would be the loss in income to the many Louisiana residents partially or totally dependent on the alligator industry. There would be less sentiment on the part of local people and public officials to protect alligators or their habitats. Poaching would increase. Protection of alligators by hunters who adhere to LDWF regulations would be lost. Such problems would be greatly magnified under a more prolonged (five years or more) cessation of the alligator harvest. The fallback conservation position is one of pure regulation and law enforcement. Without the cooperation of landowners and the public at large, this would be extremely expensive and much less effective. In the courts, cases involving alligators or their habitat would be less likely to be ruled in favor of the interest of alligator populations. Alligators would lose fear of humans, and attacks on humans could well increase. In Florida, for example, where dense human and alligator populations coexist, a number of alligator attacks on people, including fatalities, have occurred in recent years. Irate citizens have threatened to kill alligators, and on numerous occasions have done so (T. C. Hines, pers. comm. 1994). Under similar circumstances in Louisiana, political pressure against alligators would increase, and courts may not act to protect them. In Florida, more than ten thousand nuisance alligator responses per year have been recorded (Hines 1990), and wildlife officials have spent as much as 50 percent of their time answering nuisance alligator calls (T. C. Hines, pers.