NEWSLETTER

of the Introduced Fish Section

July 1989 Paul L. Shafland, Editor **Volume 9, Number 3**

NEWSLETTER CONTENTS

MESSAGE FROM THE PRESIDENT

In the last newsletter, Paul Shafland reprinted excerpts from a number of interesting articles that I hope IFS members found thought provoking. The newsletter is a good place to air controversy and members should feel free to send their own views to the editor. To promote further dialog, I present some of my own views on one of the questions presented: Do conservation-oriented fisheries biologists exaggerate the negative effects of introductions and belittle the positive effects?

My answer to that question is **NO.** If anything, criticisms of introductions have been too muted because a new introduction often seems to have spectacular benefits to fisheries, so the negative effects are downplayed by the agencies responsible for the introductions. The differences in opinions on the effects of introductions are often based on differences in views of the time scale in which the effects are evaluated. A short-term success may be a long-term disaster! I would like to examine two examples presented in the last newsletter in this light: Nile perch in Lake Victoria and brown trout in South Africa.

The excerpt of the paper on the socio-economic effects of the Nile perch introduction states that "the presence of Nile perch in the Lake Victoria fisheries is an exceedingly positive development from the human welfare standpoint" and implies that the extinction of dozens of species of native cichlids and the disruption of the established ecosystem is a price worth paying for an increase in fisheries yields. To me this is a very short-sighted point of view, as the Nile perch fishery has only existed for about 10 years. The perch is a large, easily harvested fish whose population exploded as it consumed the enormous biomass of small cichlids in the lake.

Dietary studies show that once the native cichlids are wiped out in a region, the perch switch to feeding on an introduced cichlid, invertebrates, and their own young. It seems highly unlikely to me that the perch can maintain their present populations on this diet, especially in the face of a major fishery for the perch. Essentially, the fishery is mining the native cichlid biomass that has been converted to Nile perch flesh. A crash in the fishery seems inevitable to me, although this may not occur for another 10-20 years. At the very least, the simplified Lake Victoria ecosystem will support fish populations that are constantly in a boom or bust cycle, driven in part by the fishery. This is the scenario that may be developing in our own Great Lakes, where the alewife populations have been driven to low numbers, apparently through predation by introduced salmonids. Anglers have come to expect the amazing fishery for large salmon that has existed for the past few years in the Great Lakes to continue indefinitely, a fishery which depended on the salmon having a large biomass of alewives to exploit. A number of future scenarios can be envisioned for the salmon fisheries of the Great Lakes but sustained harvests like those that have been experienced recently are not likely to be part of any of them.

It is important that the scientists and economists evaluating the Nile perch situation understand that population booms of species following their introduction into a new, favorable environment are common, and these booms are usually followed by a decline (sometimes a crash) to much lower levels. I am sure that the "success" of Nile perch in Lake Victoria is giving rise to suggestions that the perch also be planted in the other Great Lakes in Africa, which have even more spectacularly diverse species flocks of cichlids than Lake Victoria. I can only hope that any decision-making on this idea will be postponed at least 25 years, so a more realistic evaluation of the socio-economic impact of the Nile perch introduction can be made.

The problems associated with the introduction of brown trout into South Africa present another example of the need to take a long-term perspective. In the last newsletter, Paul Shafland criticized DeMoor and Bruton's monograph on aquatic introductions in South Africa for being too qualitative in evaluating introductions. In particular he disputes claims that brown trout may have been partially responsible for the extinction of a native stream fish because of evidence the two species did coexist for 20 years and that the stream in question was highly degraded. The 20 years of coexistence could simply represent the time it takes for brown trout to deplete the native fish populations through competition and predation to a point where extinction in response to natural or unnatural environmental perturbation becomes more likely. In the absence of brown trout, it is quite possible the species would have been able to persist even in highly degraded environments. I am convinced that many highly altered habitats (e.g. reservoirs) in California would be dominated by native fishes if introduced species had not been brought in. I am sure the situation in South Africa is similar.

Paul states "The bottom line seems to be that we need less rhetoric and more quantitative data and analyses of these very important and complicated biotic and abiotic relationships." I agree completely. However, the agencies and individuals responsible for most introductions rarely collect the necessary data, so evaluations are done after the fact, typically by academics with small budgets (thank goodness for graduate students!). As the Nile perch example illustrates, however, even quantitative studies can be misleading if they are not put in the proper context. An additional problem is timing. It may take years to properly evaluate the effects of an introduction and by that time the effects may be irreversible and the species widely introduced elsewhere. Ballast water introductions, discussed elsewhere in this issue are a case in point. Hard data on their effects are largely lacking, yet can we afford not to take action on preventing further introductions just because we do not know for sure that they will be harmful?

FROM THE EDITOR

Peter's comments above and mine below illustrate that important differences exist among professional fisheries scientists who deal with introduced species. Most of us agree that much of this is caused by myopic rather than open-minded and objective individuals; the disagreement comes when deciding who's myopic and who's open-minded and objective!

Peter's question: Do some "exaggerate the negative effects of introductions and belittle the positive effects" is a case in point. The obvious and correct answer is **YES**, Peter, not **NO**; just as the answer is **YES** to the question 'Do some exaggerate the benefits of introductions and belittle the negative effects?' Individuals on both sides of this issue are guilty of exaggeration. In fact, it is the real and perceived exaggerations of one side that seem to stimulate exaggerations on the other. The lack of constructive communications between these sides and the seemingly orchestrated controversies that sometime surround introduced fishes appear to have become ends unto themselves; like crutches to be held onto even after they have lost their physical usefulness. Unfortunately this situation prevents the development of a cohesive philosophy incorporating the best of all perspectives; without this our fisheries resources will be less wisely managed than they would otherwise be.

Fisheries managers are conscientious and responsible professionals who generally have a different and sometimes opposing philosophy concerning purposeful introductions than the one articulated by some academic and theoretical ecologists. I believe a comprehensive and objective review of the socioeconomic and biological impacts of 'legally' introduced fishes would surprise many by showing that the overwhelming majority of these have had beneficial effects, and that in the vast majority of cases the benefits have exceeded the costs in the opinions of most observers. How many people would 'really' want to go freshwater sportfishing in California if it were not for introduced fishes? Who can forget the salmonids in the Great Lakes, Missouri River and elsewhere? And the list of sportfishing successes goes on: remember striped bass, walleyes and muskies together with their hatchery created hybrids. The undeniable benefits of these introductions are rarely mentioned by critics who apparently do not consider fishing a viable management consideration even though it generates more than $28.1 billion in expenditures by 46.4 million fishermen fishing 976.6 million days per year (1985 National Survey of Fishing, Hunting and Wildlife Recreation)!

Some species introductions have had detrimental socioeconomic and/or ecological impacts. These cannot be ignored, nor should they be the only basis for formulating future programs. Rather, these examples should be considered in a balanced context that includes past beneficial experiences and the confounding impacts of other environmental perturbations. Somehow it seems unrealistic to generically condemn fish introductions by managers when we are draining the swamps and building highrise condominiums and swimming pools in their place.

Preservationism is a fundamental upon which wise fisheries management programs are built but it is not the only fundamental. A broader approach in which socioeconomic and other biological factors are given consideration would provide for more realistic use and assessment of introduced fishes than one based solely on preservationism. Ultimately, more preservation will be accomplished this way than if we adopt the absolute preservationistic approach. If introduced species are as important as we all believe, we must rise above the rhetoric and adversarial nature of this debate, and develop a balanced and objective means of dealing with this issue. Otherwise both sides will simply continue to ignore each other, and what would this gain?

'FREE' IFS MEMBERSHIPS

There are more than 8,500 members in the American Fisheries Society, many of which should be members of the Introduced Fish Section but are not. We now have 215 members so there is a potential to reach more than 8,285 Parent Society members who would only have to pay $3.00 to join our Section! We could double or even triple our membership, if each of us would convince a couple colleagues to join. It seems like this should be easy since introduced aquatic organisms is a topic that touches nearly every AFS member whether their primary area of introduced is diseases, culture, management, education, administration, or whatever.

If you think one or more of these AFS members would also make a good IFS member, we will even provide them with a one year complimentary IFS membership just for the opportunity of 'introducing' ourselves to them. All we need is the individual's name and address together with your name. Send these to Dawn Jennings, IFS Secretary/Treasurer, 7920 NW 71st Street, Gainesville, Florida 32606.

NEW AQUACULTURE REGULATIONS IN MARYLAND

Maryland joins the growing list of states that are placing aquaculture under the State Department of Agriculture. Maryland has taken it one step further by making special production and marketing provisions. Maryland excludes fish raised in aquaculture from the definition of species in natural resource. Finfish produced in aquaculture are not subject to size, possession, harvesting, and transportation limits of wild fish.

Striped bass and hybrid striped bass are exempt from the treatened or endangered species law when lawfully purchased or produced by authorized non-tidal aquaculture facilities. Striped bass and hybrid striped bass fingerlings may be purchased from out of state sources for non-tidal aquaculture production on or after June 1, 1989. The bass may be produced and sold from authorized non-tidal aquaculture facilities on or after January 1, 1990.

Although the Maryland law seems to provide exceptional opportunities for the production of striped bass and hybrid striped bass it is not clear how the Lacey Act will impact this legislation. Obviously the time has come to start to eliminate some of the handicaps that aquaculture has faced as the result of laws that did not consider the advent of aquaculture.

--Aquaculture Magazine
May/June 1989, 15(3):3

LACEY ACT HEARING INDECISIVE

David Cochrane who faced some 12 charges of violating the Lacey Act had his day in court. All 12 of the felony charges were dismissed. Cochrane admitted to the actions but denied that the actions were of a violation of the law and pleaded a qualified guilty to a misdemeanor. The Lacey Act prohibits the production and transportation of fish without proper federal permits. Cochrane's contention was that they were domestic animals and did not come under the wildlife provision of the Act.

Cochrane noted that this case highlights some of the difficulties that are being encountered because of the numerous agencies that are involved in administrating laws that effect the aquaculture industry. He feels that the time has come to seek legislative clarification of the conflicts that arise between fish farmers and government agencies.

--Aquaculture Magazine
May/June 1989, 15(3):76

MOVE TO ESTABLISH NATIONAL AQUACULTURE ASSOCIATION

The formation of a national aquaculture association designed as a federation of existing state and national organizations has held several preliminary meetings. A formation committee has been established consisting of Chairman Dave Morehouse of New York, Mike Freeze, President of the American Fish Farmers Association of Arkansas and Tony Schuur, representing the California Aquaculture Association. The preliminary purpose of the organization is to provide for united action in the many fields in which the government impacts aquaculture.

Joe McGraren, Executive Director of the United States Trout Farmers Association, is steering committee chairman. Several meetings will be held this summer with a target of having the first membership meeting at the Fish Farming Expo, New Orleans, Louisiana.

--Aquaculture Magazine
May/June 1989, 15(3):78

OCCURRENCE OF INTRODUCED ANIMALS IN HAWAIIAN FRESHWATERS DURING THE 1980s

William S. Devick, Aquatic Biologist
Hawaii Department of Land and Natural Resources
94-374 Makalu Loop, Mililani Town, Hawaii 96789

At least 46 species of introduced fishes and other aquatic organisms (Table 1), excluding insects, plus 6 amphibians and reptiles (Table 2), have been encountered in freshwater habitats in Hawaii since 1980. Their impact on the limited native fauna (Table 3) has not been defined but is unlikely to be positive.

The total freshwater habitat in Hawaii is more extensive than is generally realized. Over 500 perennial streams and 261 man-made reservoirs exist on the major islands. There are only 5 natural lakes, all very small, but expansive low elevation wetlands, including fresh-to-brackish water marshes, are common.

The reservoirs reflect losses in natural stream habitat attributable to dewatering for agricultural and urbanization purposes. The native species, which evolved in stream environments, are not well adapted to freshwater impoundments. A variety of exotic fishes have been introduced to the reservoir waters, where they provide excellent recreational fisheries (tucunare, largemouth bass, channel catfish in particular). Most of these species are not adapted to Hawaiian stream habitats and do not upset native ecosystems. Their presence in streams tends to be a temporary residual from reservoir overflows. The effects of other exotics which have adapted to stream habitats may not have been so benign.

Past successful aquatic species introductions have primarily been deliberate and have occurred in three waves. The first, in the 1800s, accompanied the immigration of Asian laborers to Hawaii. The second, in the early 1900s, followed development associated with American interests with the importation of species for insect control and for the provision of familiar sport fisheries. The third and most intensive was in the two decades following WWII. Many introductions were made for weed control in reservoir habitats (tilapia), experimental tuna bait production (tilapia, threadfin shad), and aquacultural development (tilapia, prawns, trout). Recreational fisheries introductions included marine and estuarine, in addition to freshwater exotic species for the occupation of presumably open habitats. By the 1970s that wave had disappeared. The only recognized new introduction probably originated from a baitfish experiment.

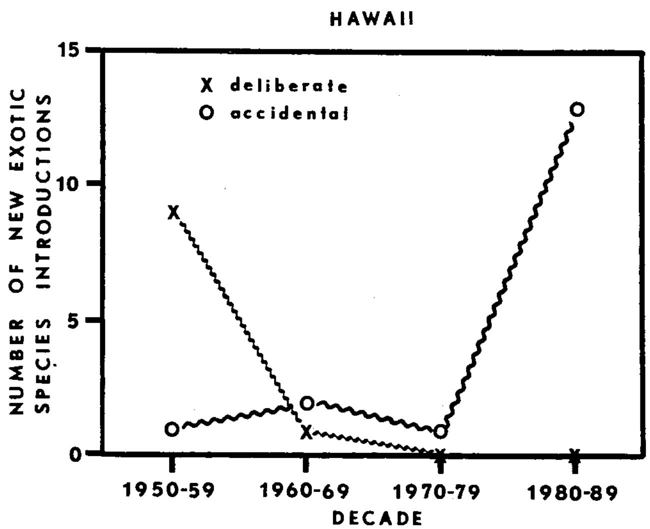

Figure 1. Pattern of appearance of new exotic species in Hawaiian freshwaters since 1950.

In the 1980s we appear to be riding the rising crest of a fourth wave of new introductions (Figure 1) as escapees from the thriving but generally unregulated aquarium fish trade are irrupting ad nauseum. The situation may be worse than depicted. At least two significant parasites, which probably arrived with aquarium fish, have been detected in wild freshwater fish populations in recent years. One of these may have suppressed a native goby population. And unconfirmed reports have included a release of a couple of dozen piranha in 1988.

The present state of knowledge about the distribution, abundance, impact, or even the occurrence of new or old introductions is disorganized and meager at best. Fortunately, a cooperative Hawaii Stream Inventory and Assessment Project has been initiated. It should ultimately provide an information repository and database that can serve as needed reference points for further study.

Table 1. Introduced aquatic macrofauna present in Hawaiian freshwaters after 1980.

SCIENTIFIC NAME	PROFILE	YEAR OF RELEASE OR DISCOVERY	NATIVE REGION
Bryozoans			
Lophopodella carteri	A,e,r	1987	North America
Plumatella repens	A,e,r	1968	North America
Crustaceans			
*Macrobrachium lar	D,e,s	1957	Guam
*Macrobrachium rosenbergii	I,e,s	1966	Malaysia
Procambarus clarkii	D,e,r	1923	North America
Fishes			
Ancistrus sp.	A,e,r	1985	South America
Astronotus ocellatus	D,e,r	1952	South America
Barbus semifasciolatus	D,e,r	1940	Asia
Carassius auratus	D,e,r	1800s	Asia
Cichla ocellaris	D,e,r	1961	South America
Cichlasoma meeki	D,e,s	1940	Central America
*Cichlasoma nigrofasciatum	A,e,r&s	1983	Central America
Cichlasoma sp.	A,u,r	1988	-----
Clarias fuscus	D,e,r&s	1800s	Southeast Asia
Cyprinus carpio	D,e,r	1800s	Asia
Colossoma macropomum	A,u,r	1987	South America
Dorosoma petenense	D,e,r	1958	North America
Gambusia affinis	D,e,r&s	1905	North America
Hypostomus sp.	A,e,s	1984	South America
Ictalurus punctatus	D,e,r	1953	North America
Lepomis macrochirus	D,e,r	1946	North America
Leporinus sp.	A,u,r	1984	South America
*Micropterus dolomieu	D,e,s	1953	North America
Micropterus salmoides salmoides	D,e,r	1897	North America
Misgurnus anguillicaudatus	D,e,s	1800s	Asia
Monopterus albus (Fluta alba)	D,e,r	1800s	Asia
Oncorhyncus mykiss (Salmo gairdneri)	D,e,s	1920	North America
Ophicephalus striatus	D,e,r	1800s	Southeast Asia
Poecilia (Limia) vittata	A,e,s	Before 1950	Cuba
Poecilia (Mollienesia) latipinna	D,e,s	1905	North America
Poecilia reticulata (Lebistes reticulatus)	D,e,s	1922	South America
Poecilia sp.	A,u,s	1986	------
Pterophyllum sp.	A,u,r	1982	South America
Pterygoplichthys multiradiatus	A,e,r	1986	South America
Strongylura kreffti	A,e,r	1988	New Guinea
Tilapia macrochir	D,e,r	1958	Africa
Tilapia melanopleura	D,u,r	1957	Africa
*Tilapia melanotheron	I,e,r&s	1970	Africa

*Tilapia mossambica	D,e,r&s	1951	Africa
Tilapia zilli	D,e,r	1957	Africa
Tilapia sp.	A,u,r&s	1983	Africa
Xiphophorous hellerii	D,e,s	1922	Central America
Xiphophorous maculatus	D,e,s	1922	Central America
Molluscs			
*Corbicula sp.	A,e,s	1982	Asia
Helisoma sp.	A,e,s	--	North America
Viviparus chinensis	e,s	--	Asia

*Suspected as major hazard to native species based on abundance, predacious nature, observed aggressive behavior, or evident habitat disruption.

A = accidental introduction; D = deliberate introduction; I = escape from aquaculture industry; e = definitely established; u = uncertain status; r = dominant reservoir or pond habitat; s = dominant stream habitat.

Table 2. Introduced herpetofauna present in Hawaiian freshwaters after 1980.

SCIENTIFIC NAME	NATIVE REGION
Frogs	
Rana catesbiana	North America
Rana clamitans	North America
Rana rugosa	Japan
Toad	
Bufo marinus	Central America
Turtles	
Chrysemys (Pseudemys) scripta elegans*	North America
Trionyx sinensis sinensis	Asia

*Accidental introduction that has been rapidly increasing in abundance and distribution.

Table 3. List of native aquatic macrofauna found in Hawaiian freshwaters.

SCIENTIFIC NAME	PRIMARY HABITAT
Crustaceans	
Atyoida (Atya) bisulcata	Entire stream, especially mid reaches.
Macrobrachium grandimanus	Lower stream.
Fishes	
Awaous (Chonophorus) stamineus	Entire stream, especially mid reaches.
Eleotris sandwicensis	Lower stream only.
Kuhlia sandvicensis	Lower stream only to marine.
Lentipes concolor	Entire stream, especially mid to upper reaches.
Mugil cephalus	Lower stream only to marine.
Scyopterus (Sicydium) stimpsoni	Entire stream, especially mid to upper reaches.
Stenogobius (Awaous, Chonophorus) genivittatus	Lower stream only.
Molluscs	
Melanoides (Melania) sp.	Lower stream.
Neritina granosa	Entire stream.
Theodoxus sp.	Lower stream only.
Polychaete	
Namalycastis abiuma (Lycastis hawaiiensis)	Lower stream only.
Sponge	
Heteromyenia baileyi	Upper stream only.

HERE COME THE MUSKIES

The Washington Department of Wildlife has just introduced tiger muskies into Mayfield Lake (Lewis County, Washington). The type of fish introduced into the lake needed to be predacious, adaptable to cold water, unable to reproduce and not able to migrate. The musky fits this description. The musky is a hybrid of the northern pike and muskellunge and native in Ontario and the north central United States. Although introduction has taken place in 29 states, this is the first introduction on the west coast.

--1989. The Tributary--A Newsletter of the Western Division, American Fisheries Society 14(2):8

ILLEGAL UTAH FISH INTRODUCTIONS

During routine fall gillnet surveys at Scofield Reservoir, UDWR biologists captured a four pound walleye. Scofield, the "second best" trout fishery in Utah, is currently managed as a family fishery and stocked with fingerling trout. Walleye, a very successful predator on soft-rayed fishes, have been documented as the dominant species in walleye-trout interactions. Trout populations existing with walleye must therefore be sustained by catchable-size trout introductions. Because of suitable walleye spawning areas in Scofield, walleye could become the dominant species in Schofield within 10 years or less.

Illegal transplants of fish can be disastrous to existing fish populations, both game and non-game species. Utah has recently experienced numerous illegal stockings--many with detrimental results. Options for management after illegal stockings are expensive: stock catchables or chemical treatment. The public should be made more aware of the serious problems illegal transplants create. Better education and more caring attitude by a small group of specialized anglers could save fishery managers a lot of headaches and the public a lot of money and lost fishing opportunities.

--1989. The Tributary--A Newsletter of the Western Division, American Fisheries Society 14(2):3

BALLAST WATER INTRODUCTIONS

A Proposed Environmental Policy Statement for AFS

Peter B. Moyle

A. Issue definition

The recent establishment of an exotic fish, Gymnocephalus cernua, an exotic cladoceran (Bythotrephes cederstroemi), the exotic zebra clam (Oreissena polymorpha), and the Chinese mitten crab (Eriocheir sinensis) in the Laurentian Great Lakes has created an awareness of the growing problem of ballast water introductions. Most large ships use water for ballast and it is carried in separate tanks used just for that purpose. Typically, water is pumped into the tanks when the ship is departing one port and discharged when the ship takes on a cargo at another port. Cargo ships typically carry 6-8 million gallons of water, with the largest vessels carrying up to 40 million gallons. Not surprisingly, local organisms, usually in their planktonic life history stages, are transported with the ballast water. J. Carlton (1989) recently sampled ballast water in 70 ships that came into Coos Bay, Oregon, from Japan. His samples contained over 200 species of zooplankton and phytoplankton. Use of water for ballast is not new; ships have been carrying it for at least 100 years, but its effectiveness in transporting organisms has been greatly enhanced in recent years by the development of separate tanks just for ballast water, the increase in average ship size (and therefore the amount of water transported), the increase in ship speeds, and the increase in ship traffic (Carlton 1985).

Carlton (1985, 1987, in press) presented evidence that hundreds of species of invertebrates and fish have become established in exotic locales after being transported in ballast water. The effects of most of these introductions is unknown, but there is growing evidence that the bay and estuarine faunas of the world are becoming increasingly homogeneous. The ballast water species now in the Great Lakes have the potential to cause ecosystem level changes (e.g., Scavia et al. 1988). Likewise, the sudden invasion of a number of ballast water species into the Sacramento-San Joaquin Estuary in California may have caused a major alteration of the estuary's ecosystem (Carlton 1989). Carlton (1989) noted that an estuarine reserve in Oregon contained 32 species of introduced organisms brought in with ballast water, including some of the most abundant species in the preserve. Presumably the exotic species have replaced native

species in areas designated as estuarine sanctuaries. Unless new introductions are halted, additional alterations of these sancturaries will take place (Carlton 1989).

The problems created by such introductions are no doubt much more widespread than these examples indicate and the need to control the spread of organisms by ballast water is urgent. Some introductions may have positive effects; however, in the majority of cases, these introductions will adversely effect existing commercial and recreational fisheries, thereby causing adverse economic impacts to local coastal communities. In addition, the effects of added ecological competition, predation, and new diseases may further exacerbate the condition of estuarine populations--which are already stressed due to dredging, pollution, and general water quality conditions. If such introductions push estuarine organisms to the threatened or endangered status, listing under federal or state endangered species statutes may prevent or protract estuarine development (dredge and fill, and general expansion) sought by many port authorities.

B. Impacts on aquatic ecosystems

Carlton (1985, 1987) reviewed the evidence for ballast water dispersal of marine organisms, including studies in which ballast water biota were monitored on ships in transit. He listed 58 examples of "probable" introductions and another 59 "possible" established introductions. These are certainly minimum numbers as the studies needed to document such introductions are largely lacking and new ballast water introductions appear to be occurring at a rapid rate. Indeed, two of the recent Great Lake introductions are not listed by Carlton, nor are four recent probable ballast water introductions into the Sacramento-San Joaquin Estuary. Carlton (1985) likened the traffic of ships with ballast water to "international biotic conveyor belts." Given the poor state of our knowledge of even which organisms have been or are being transported in ballast water, it is not surprising that the evidence for ecosystem effects is largely speculative.

Scavia et al. (1988) have developed a model of the dynamics of Lake Michigan plankton that predicts that the exotic, predatory cladoceran, Bythotrephes cederstroemi, will cause a decline in a number of grazing zooplankton species in the lake, with concomitant decreases in water clarity and changes in the abundances of plankton-feeding fishes. In the Sacramento-San Joaquin Estuary, the recently (ca. 1986) established Asiatic clam, Potamocorbula amurensis, can live in water of fluctuating salinity that previously lacked permanent clam populations and achieve population densities capable of filtering a high percentage of the phytoplankton from the water column in shallow areas (USGS, unpublished studies). This in turn may reduce zooplankton populations at a time when high densities are vital for the survival of larval fishes. Survival of larval fishes may be further reduced by the abundance of exotic copepods, especially Sinocalanus doerrii, that may be able to avoid predation by larval fishes more effectively than native copepods (J. Orsi, CDFG, personal communication). In the Sacramento-San Joaquin estuary at least five species of Asiatic copepods have become established in recent years; native copepods have declined (Orsi et al. 1983, Ferrari and Orsi 1984).

The transport of organisms in ballast water is contributing to the increased homogenization of bay and estuarine faunas around the world. Presumably local endemic forms are becoming increasingly rare as a consequence, although the nearly universal heavy pollution of such habitats is no doubt also contributing to this loss. It is likely that the organisms that survive successful transport are also those capable of surviving in stressed ecosystems. Ballast water introductions may also cause the mixing of genomes of geographically isolated populations of the same species, with unknown results (Carlton 1985). For example, the known transport in ballast water of European threespine sticklebacks (Gasterosteus aculeatus) to North America (Carlton 1985) may create problems for biologists who study local stickleback populations for evolutionary trends. It is possible that the unexpected establishment of threespine sticklebacks in lakes Huron and Michigan (Stedman and Bowen 1985) may have been the result of ballast water transport.

C. Effects on fisheries

The effects of ballast water introductions on fisheries are undocumented but are of major concern. A press release of the Ontario Natural Resources Agency (1988) discussed the ability of ruffe (Gymnocephalus cernua) to "devastate a fishery," especially that of whitefish (Coregonus spp.) through egg predation and that of yellow perch (Perca flavescens) through competition. The Wisconsin Department of Natural Resources diverted considerable manpower and resources to study the ruffe invasion of Lake Superior (unpublished report, 1988). Likewise, in California, resources are being diverted to study the potential effects of the various invertebrate invaders on striped bass (Morone saxatilis) populations because of the strong possibility that the invaders may permanently depress the striped bass fishery by decreasing survival rates of larval bass (R. Brown, Calif. Dept. Water Resources, personal communication).

D. Needed Actions

Article 196 of the U.N.'s Law of the Sea Convention reads: "States shall take all measures necessary to prevent, reduce and control ... the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto." AFS should support this statement and should work closely and quickly to inform Congress of the problem and solutions to the problem. In addition, the AFS should work with federal and state agencies that have a logical interest in and concern over the general issue--National Marine Fisheries Service, U.S. Fish and Wildlife Service, Environmental Protection Agency, State Fish and Wildlife Agencies, etc. The AFS should also work on an international basis with such organizations as the Food and Agriculture Organization (FAO) and the International Maritime Organization (IMO), both agencies of the United Nations. In addition, the International Council for the Exploration of the Seas should be consulted. Ballast water introductions are a problem in the United States, so they must be a problem elsewhere as well; therefore, it should, to the extent possible, be addressed on a worldwide basis. Perhaps a logical international forum might be to bring up the matter through the IMO and MARPOL Convention that governs matters of marine pollution. There is current a MARPOL annex, which was ratified by the U.S. which governs the dumping of plastics at sea, that could serve as a model for a convention on ballast water introductions.

The principal means that have been proposed to halt the introductions is to either have ships exchange ballast water at sea or treat the ballast water with chlorine or other toxicants. Because of potential pollution problems to

restricted waters of harbors, the former method is preferred. It is assumed that an exchange of coastal water for water of the open ocean would reduce the possibility of suitable species being introduced. Other mechanisms need to be investigated as well, such as filters on pumps and toxic paints.

Carlton (1985) summarizes studies that have been conducted on organisms in ballast water and their survival rates in the tanks. More such studies need to be conducted to determine the effects of transit time and port of origin and port of dumping on the potential for ballast water organisms for becoming established. Procedures need to be developed for monitoring the ballast water of ships coming into North American ports. In places where ballast water species are established and reaching pest status, modeling efforts such as those of Scavia et al. (1988) need to be conducted to predict their long-term effects. If necessary, factors controlling the abundance of the introduced species in their native ecosystems should be studied, to see if "natural" methods of control are possible.

The American Fisheries Society should promote the idea that ballast water introductions are immediate, serious, and ongoing problems for which interim measures are needed to reduce their frequency and for which studies are needed to find ways to halt them on a permanent basis.

E. References

Carlton, J.T. 1985 Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. Oceanogr. Mar. Biol. Ann. Rev. 23:313-371. [Note: this review contains a bibliography of over 250 references.]

Carlton, J.T. 1987. Patterns of transoceanic marine biological invasions in the Pacific Ocean. Bull. Mar. Sci. 31:452-465.

Carlton, J.T. 1989. Man's role in changing the face of the ocean: biological invasions and implications for conservation of near-shore environment. Conserv. Biol. (in press).

Courtenay, W.R. 1989. The invasive fish problem from an international perspective with particular reference to North America. Transactions, Royal Society of South Africa (in press).

Evans, M.S. 1987. Bythotrephes cederstroemi: its new appearance in Lake Michigan. J. Great Lakes Res. 14:234-240.

Ferrari, F.D. and J. Orsi. 1984. Oithona davisae, new species, and Limnoithora sinensis (Copepoda: Ointhonidae) from the Sacramento-San Joaquin Estuary, California. J. Crustacean Biol. 4:106-126.

Orsi, J., T. Bowman, D. Marelli, and A. Hutchinson. 1983. Recent introduction of the plankton calanoid copepod Sinocalanus doerrii (Centropagidae) from the mainland China to the Sacramento-San Joaquin Estuary, California. J. Plankton Res. 5:357-375.

Scavia, D., G.A. Lang, J.F. Kitchell. 1988. Dynamics of Lake Michigan plankton: a model evaluating nutrient loading, competition, and predation. Can. J. Fish. Aquat. Sci. 45:165-177.

Stedman, R.M. and C.A. Bowen. 1985. Introduction and spread of the threespine stickleback (Gasterosteus aculeatus) in Lakes Huron and Michigan. J. Great Lakes Res. 11:508-511.

ALIEN FISH AND THE AQUARIUM TRADE IN SOUTH AFRICA

There is no doubt that the keeping of tropical fish is a fascinating and absorbing hobby which provides a wonderful educational tool for demonstrating a number of basic ecological principles to people of all ages. Aquarium enthusiasts are usually people who show a deep interest in nature and animal behaviour. However, few of these enthusiasts realise that their beautiful and interesting pets can provide a real threat to the ecosystem if released into natural waters.

Alien fish worldwide have become a major problem often displacing indigenous species in their natural environment and being implicated in a number of ecological disasters. Who would think that the seemingly harmless little guppies, mollies and swordtails could provide any sort of threat to our local fisheries? And yet if these small fish manage to establish populations in the wild (as is the case in Australia) they would be a major threat to many indigenous species as they often feed on the eggs and young of other fish.

Hundreds of alien fish are imported into South Africa annually through the aquarium trade. While it is unlikely that many of these fish would survive in natural waters, there are some popular aquarium species which could thrive in southern Africa and may have a devastating effect on the environment. Many of these species are not easily recognised by layman but some are quite distinctive. These include the following:

1. The American red-eared terrapin which is known to carry a disease (salmonelliosis) which affects man.
2. Any species of piranha.
3. Any species of freshwater crayfish.

While the trade of the above species is illegal, it is difficult for conservation authorities and customs officials to keep track of all the importations which enter the country and it is possible for some of these "illegals" to slip through. This is where the layman can help in a watchdog role. An appeal is therefore made to the public to be aware of the dangers of alien fish in our natural waters and to keep the following principles in mind:

1. Don't under any circumstances release aquarium fish into natural water.
2. Don't flush them down the toilet. They may survive and later find their way into natural waters.
3. Should any of the above mentioned "banned" species be observed on sale in pet shops, report this to your nearest Nature Conservation Authority.

4. Should you be in possession of a banned species, hand it in at your nearest Nature Conservation Authority.

--Irene de Moor

--Reprinted from ICHTHOS, Newsletter of the Friends of the J.L.B. Smith Institute of Ichthyology, Private Bag 1015, GRAHAMSTOWN, 6140 South Africa.

QUANTITATIVE EFFECTS OF INTRODUCED FISHES

At the last AFS Annual Meeting in Toronto Jim Clugston (1987-88 IFS President) introduced the above titled session with the following remarks which many should find of interest. Jim's address is USFWS, National Fisheries Research Center, 7920 N.W. 71st Street, Gainesville, FL 32606.

This session is sponsored by the Introduced Fish Section and the Genetics Fish Section. The Introduced Fish Section (originally the Exotic Fish Section) has a long list of objectives that were summarized by Section Past-President Jay Stauffer as "-- to promote the understanding of the benefits and risks associated with proposed introductions." Likewise, the Genetics Fish Section has a list of objectives or goals. One -- and the reason for the joint sponsorship of this Session -- is to insure that the stocking of exotic species, hybrids and genetically engineered fishes do not compromise the genetic integrity of natural populations.

Stocking of native and non-native fishes for sport and commercial reasons was one of the first fishery management techniques used in this country. Stocking remains a major tool of fishery managers and recent years has shown the increased use of native hybrids (e.g., white bass x striped bass), exotics (e.g., tilapia, grass carp), sterile exotics (e.g., triploid grass carp), and simply moving particular species from one watershed to another because of possible adaptation for certain water quality parameters (trouts, bass, redfish, etc.). Much is on going to create "improved fish" by gene insertion, hybridization, and other genetic techniques.

Needless to say -- opinions differ on the stocking of different strains of native species in new waters, the spreading of native species to new watersheds, and the introduction of foreign species to North America (exotics). Some authors earlier suggested that managing with exotics is "A game of chance" (Magnuson, 1976) and "Importations are an admission of defeat in managing native populations to meet existing needs" (Giles, 1978). Others believe man has created many new environments -- that won't go away -- such as power plant cooling reservoirs, tailraces, enriched systems, etc. -- and "different" species could be better suited (for man's purposes) than native species (which might not survive).

I just said the term "man's purposes" -- another area for opinion differences. Many agencies (states) are continually striving to maintain or enhance levels of sport or commercial harvest. Others -- such as the National Park Service -- strive to maintain a natural environment (only native species).

I think it is accepted by the scientific community that evaluation of a "new" species must be done prior to its release into open waters. There is, however, considerable differences on what constitutes a proper evaluation. What hoops should an agency go through prior to a release? Numerous protocols have been proposed but only an AFS Position Statement on this subject has been endorsed by any one group -- and it simply recommends general steps to be taken. Although all states have regulations prohibiting or controlling specific introductions -- no enforceable evaluating procedures exist. Regulations that control the introduction of fish into the open water of the U.S. are each state's responsibility (except for walking catfish and all live or dead fish or eggs from the family Salmonidae, etc.). Here in Canada - I think exotic introductions are a Federal responsibility, but -- Federal/Provincial Transplant Committees issue permits for exotic introductions.

Much has been written on the introduction of exotic or non-native plants and animals and the "effects" or "impacts" of these introductions on native communities. However, because of few before- and after-use studies, most results are conjecture and lack conclusive data. Many attempts to document introduction impacts took place after the introduction had been made (usually accidental) and an "effect" noted. As pointed out by the Introduced Fish Section's incoming President Peter Moyle (1986), often introductions occurred during major environmental changes and it is unclear whether "effects" were caused by environmental changes, the introduced organisms, or both working together.

This session was prompted by the apparent lack of good quantitative data on the effects caused by introduced fishes. We--the Sections--hoped to flush-out new quantitative data that is of immediate value to resource managers - to help them assess past introductions and to suggest research needed to evaluate species considered for future introductions.

PEACOCK BASS IN LAKE GATUN, PANAMA: ANOTHER LOOK

Most individuals concerned with exotic fish introductions are familiar with the introduction of peacock bass (Cichla ocellaris) in Lake Gatun, Panama. This introduction first gained prominence following the publication of Zaret and Paine's 1973 paper 'Species Introduction in a Tropical Lake' (Science 182: 449-455). This paper is often cited as a definitive illustration of how introduced species can eliminate native species and otherwise cause 'catastrophic' ecosystem-wide effects. Most persons who cite this paper ignore Zaret and Paine's reference to the significant beneficial effects realized as a result of this introduction: "So far, Cichla has completely lived up to all expectations; its capture has provided entertainment for fishermen, and its taste has pleased many palates. Further, it is the only freshwater fish sold for consumption in this area." Moreover, Zaret and Paine emphasize the

tentativeness their findings by concluding their paper with: "Although at present the Gatun Lake ecosystem is undergoing rapid changes, we anticipate an eventual return to some form of equilibrium. However, it will be some time before we can evaluate the permanence or transience of the many changes produced in the trophic levels by the introduction of a single, top-level predator in this lake system."

Although the methods used were sometimes poorly defined and more qualitative than quantitative, Zaret and Paine (1973) provided important information and analyses on the ecological effects of introducing C. ocellaris into a large, man-made reservoir previously devoid of large piscivores and lacustrine evolved native species. The following commonly cited excerpts from Zaret and Paine's (1973) subsection 'Effect on Native Fishes' depict the introduced C. ocellaris as an ecological disaster:

> As Cichla has spread through the lake, its voracious predatory habits have had a devastating effect on the native fish populations. ... field observations over the past 6 years, illustrate how Cichla has effectively eliminated six of the eight previously common fish species and drastically reduced a seventh.
>
> During the summer of 1972, we attempted to substantiate further the differences in the structure of the fish communities. We made two complete fish collections comparing the Trinidad Arm, where Cichla has not yet invaded, and where the fish community represents the pre-Cichla conditions, with Barro Colorado Island, where the Cichla population has recently peaked. In the Trinidad Arm region, the site we chose was relatively shallow (less than or equal to 5 meters), with dense vegetation, mainly Hydrilla sp. lining the shore. At this site, we made a large semicircle (30 m by 5 m) with a 1.27-cm mesh nylon net. The net was attached to the shore, with the ends 10 m apart, to form the letter "D." The second site, along the shores of Barro Colorado Island, was a comparable cove, depth less than or equal to 5 m, with the same species of dense vegetation lining the banks and choking much of the waters. A 30 m by 5 m nylon net closed off the mouth of the cove, leaving an area approximately 30 m by 25 m. The Barro Colorado Island site had a total surface area, volume, and shoreline several times that of the Trinidad Arm site. A census of the fishes at each site had been taken previously by direct observation.
>
> The Trinidad Arm community is composed of 14 fish species, 11 of which, in terms of their percentage of the biomass, contribute significantly. These are the genera, Melaniris, Astyanax, Compsura, Pseudocheirodon, Roeboides, Aequidens, Cichlasoma, Neetroplus, Gobiomorus, Gambusia, and Poecilia. In contrast, the Barro Colorado Island site shows seven fish species present, but dominated heavily, in terms of percentage of biomass, by Cichla and Cichlasoma. This comparison indicates (excluding Hoplias) that, of the 11 previously important species, Cichla has completely eliminated seven and has reduced the others. One, Cichlasoma, has apparently increased. The increase in Cichlasoma, is probably due to the elimination by Cichla of species that formerly fed on the Cichlasoma fry, thereby seriously

limiting the population. Eleotris, although abundant numerically, is a very small species, most of those we found being less than or equal to 2 cm SL. The role of this fish in the lake is not understood and is omitted from further discussion, although it seems that Cichla's presence is resulting in an increase of this smaller species. The presence of a substantial number of Roeboides came as a surprise because this species was never seen during our numerous diving activities. Roeboides primarily feeds by ingesting scales of other fishes and apparently has survived Cichla by remaining in the midst of the dense aquatic foilage where it must await other fishes darting in for cover. The results from these fish collections basically support the generalizations we made after several year of observing the associations of Cichla with the native fish communities.

****

Some of the effects initially attributed to the presence of C. ocellaris in Lake Gatun by Zaret and Paine (1973) may be less dramatic and more short-term than originally believed. Zaret (1984) hints that some of the 1973 conclusions may have been overstated, and Welcomme (1988) does more than hint. Finally, Maturell and Tapia's (1987) survey of Lake Gatun fishermen clearly demonstrates that fishermen, local fish markets and Panamanian citizens have significantly benefited from the sale of this introduced fish as food. The increased evidence of benefits and reduced evidence of an ecological disaster would seem to argue for more cautious and comprehensive assessments of these events than might otherwise be defensible. Beginning with Zaret (1984):

> A recent occurrence in Gatun Lake can tell something about the effects of man's intervention, and also the ability of lake communities to resist certain types of perturbation. The event was the introduction to Gatun Lake in 1967 of the predatory South American cichlid Cichla ocellaris. I will summarize briefly how the introduction of only sixty fingerlings of a predatory fish was able to create changes at all tropic levels, resulting in a substantially different lake system. By 1974 it had reached the end of the Trinidad Arm and, despite the best efforts of anglers, Cichla caused the local extermination of most of the formerly native fishes. Surprisingly, only in the Rio Chagres, where Cichla was initially introduced, is the original native fish fauna intact. This fish introduction indicates the potentially delicate species balance which exists in lakes, and which can be disrupted so radically and quickly.
>
> Although the changes in the fish community has provided the most spectacular result of the introduction of Cichla, there have been other changes at different trophic levels, resulting because Cichla decimated the populations of the atherinid fish Melaniris, the dominant zooplankton predator. It appears that the atherinids are now returning in somewhat lower but significant numbers as the Cichla population has declined.

> It is difficult to predict the future Gatun Lake community. If left unperturbed, the system would probably return to some low-level equivalent of its previous form. Gatun Lake, however, is located near a large human population center, and one which is presently engaged in the development of natural resources, including fisheries. Even if a new sea-level canal does not eventually erase Gatun Lake from the records permanently, the introduction of Cichla is probably the first of a long line of fish introductions which are likely to occur. Already the Chinese grass carp, Ctenopharyngodon, has been introduced as the miracle cure to alleviate the problems associated with dense stands of the other exotic, Hydrilla verticillata. No doubt there will be other changes and other remedies proposed which involve species introductions. In short, the Gatun Lake of today, a legacy of the ancient Chagres River basin, but already different from that of the 1960s, will be replaced very soon by a new lake. This follows the tradition of the ever-changing tropical lacustrine systems.
>
> --Zaret, T.M. 1984. Central American Limnology and Gatun Lake, Panama in F.B. Taub (ed.) Ecosystems of the World 23, Lakes and Reservoirs, Elsevier Science Publications, Amsterdam.

****

Excerpts below are from Robin Welcomme's 1988 book titled 'International Introductions of Inland Aquatic Species' FAO Fisheries Technical Paper No. 294:(318p):

Cichla ocellaris BLOCH and SCHNEIDER: CICHLIDAE

Native range: Tropical South America

> This large and highly predatory, tropical species is highly valued for the quality of its flesh and its sporting characteristics. As a consequence the tucunare (Portuguese), Pavon (Spanish) or peacock bass has been introduced to other areas of South and Central America lying outside its native range. The species is also being considered for aquaculture but its predatory nature limits its usefulness for this purpose. The results of the introduction of the species to Lake Gatun in Panama were documented by Zaret and Paine (1973) who alleged that Cichla had eliminates six species of native fish from the lake fauna. It now appears that this evaluation may have been overly exaggerated as a new balance is reported between the predator and the native species, many of which persist in refugia in the mouths of inflowing streams. The situation is further complicated by the introduction of other species, including some O. niloticus which provide an alternative prey.

Introduced To: Panama — From: Colombia — Year: 1950

Reason: Sport — Reproducing: Yes

Comments: Initially reduced populations of native fishes in Lakes Gatun, Alajuela and La Yaguada which later recovered to some extent. Excellent for sport and artisanal fisheries. Recent experiments indicate that stocking with carp and tilapia in waters where C. ocellaris are present creates a diversified and productive fishery.

****

And finally a case for C. ocellaris as the PROVIDER from a report by J. Maturell G. and A. Tapia F. 1987. La Pesqueria Del Cichla ocellaris En Lago Gatun, Panama. Departmento De Lagos Y Rios, Dinaac-Mida, Panama (translation by Eileen Garcia, Florida Atlantic University, Boca Raton, FL):

> A recent survey of Lake Gatun sport, commercial and subsistence fishermen concluded that "The fishery of Cichla ocellaris in Lake Gatun, Panama can be considered, by volume of its capture and the activity it generates, the most important fishery in the freshwater bodies of the country."
>
> The harvest of peacocks stabilized after 1985 prior to which it had rapidly increased for several years. The potential peacock bass harvest rate was estimated at 150-300 tons/year. Caution was express that the overharvest of juveniles could ultimately lead to a problem since the harvest was made up mostly of fish less than 300 mm total length.

****

What do you think ... is peacock bass in Lake Gatun an example of an introduced DESTROYER or PROVIDER? It seems that good cases could be made for either choice, if we look at only selected aspects such as economics, human welfare or effects on native fish. If an introduction can be judged as good from one point of view and bad from another, should comprehensive conclusions of introductions be simply characterized as good or bad? Or are the socioeconomic and biological affects associated with introductions too complex for them to be evaluated in simplistic, black and white terms?

Although peacock bass have been introduced elsewhere (see next 2 articles), the Lake Gatun introduction offers ecologists, managers and others an unique opportunity to test several possible hypotheses and scenarios. One hypothesis that will be tested in this large, man-made reservoir is: Will peacock bass ultimately eliminate the riverine originating native fishes which had not previously been exposed to predation by a resident top-level predator. Another scenario to be tested: Can the valuable commercial, subsistence and sportfisheries that have developed for peacock bass be maintained without eliminating any native species. These and other hypothesis and opinions commonly associated with introduced fish will be time-tested in this unique situation which will ultimately contribute much to our understanding of these events.

OBSERVATIONS ON THE IMPACT OF TUCUNARE (CICHLA OCELLARIS) IN HAWAII

William S. Devick
Hawaii Department of Land and Natural Resources

Tucunare (Cichla ocellaris) were imported to Hawaii in 1961 as part of a program to improve recreational fishing opportunities in freshwater habitats and are now widespread in impoundments on the islands of Oahu, Kauai, and Hawaii. Although the nomenclature for Cichla spp. is somewhat confused, C. ocellaris, is well defined. The Hawaiian import supposedly originated from the Orinoco River region but is identical in coloration to Cichla that are abundant in Guyana. It is the same species in both appearance and nomenclature as the peacock bass depicted as "the destroyer" in Panama's Lake Gatun (Zaret, T.M. and R.T. Paine. 1973. Species introduction in a tropical lake. Science 182:449-455) and as the fish recently introduced to man-made canals in Florida. All tucunare in Hawaii have originated from a single spawn by one adult pair.

Tucunare joined the largemouth bass, (Micropterus salmoides salmoides), channel catfish (Ictalurus punctatus), pongee (Ophicephalus striatus), and oscar (Astronotus ocellatus) as primary game fish in reservoir waters where the typical forage and pan fish include tilapia (mostly Tilapia mossambica and increasingly T. melanotheron), bluegill (Lepomis macrochirus), threadfin shad (Dorosoma petenense), Chinese catfish (Clarias fuscus), and mosquito fish (Gambusia affinis). Smallmouth bass (Micropterus dolomieu) are a component of some of these fisheries where reproducing populations in cooler upstream waters replenish the reservoir stock.

Several peculiarities of this unique combination are worthy of note. Pongee are not officially classified as game fish but are equivalent top level predators with feeding habits similar to those of largemouth bass and can exceed 4 ft in length. They are popular, both as strong fighters and as good food fish, with bass fishermen, who frequently release bass (and tucunare) as a conservation measure in part because they have the option of keeping the pongee for food. The Chinese catfish is selectively preyed upon by largemouth bass and pongee but is utterly rejected by tucunare. Where tilapia and bluegill occur together, bluegill do not fare well and are invariably stunted. Population imbalance exemplified by gross overpopulations of tilapia and threadfin shad is characteristic under eutrophic conditions even in the presence of all of these predators, which are subject to heavy, selective fishing pressure. In at least two impoundments, where spawning substrate suitable for tilapia is limited, the establishment of tucunare has substantially reduced the relative proportion of tilapia.

Tucunare, along with largemouth bass, are the freshwater game fishes most prized by anglers in Hawaii. The Hawaii Freshwater Fishing Association gives equal weight to both species in its monthly tournaments but chose the tucunare for its symbol in 1968. Most local anglers agree that of the two species, which exhibit a similar size frequency distribution, the tucunare is a harder fighter, more colorful, and better eating. Largemouth bass fishermen are a bit elitist, however, because the tucunare can readily be taken by shore fishermen and is in their opinion too easy to catch when it is spawning or schooling. Control of poaching on tucunare has in fact proven to be a difficult enforcement problem.

There are indications that selection pressure attributable to intensive poaching on the highly visible spawners is yielding a population of tucunare that is becoming markedly less aggressive in protection of its eggs and young.

The tucunare is well adapted to lower elevation reservoir habitats, where it spawns readily during March to October unless water levels fluctuate too rapidly. The upper temperature-controlled elevation for successful spawning (the water temperatures should cycle above 80 degrees F) is about 1,200 ft. Temperature tolerance tests on juvenile tucunare in Hawaii have shown a lower threshold of 60 degrees F, at which point total mortality abruptly occurs. At 1,100 ft near surface water temperatures invariably remain above 64 degrees even during winter periods of destratification. Successful spawning has been observed at the highest water temperatures, in the low 90s, that may be encountered during the year.

No diseased tucunare have ever been found in reservoir waters, even when red-sore disease (caused by a stalked ciliated protozoan, Epistylis sp.) has been epizootic in largemouth bass and other species and where a variety of parasitic, fungal, and probably bacterial diseases have been identified in other fishes. However, when tucunare have been collected from these waters and confined in an aquarium without prophylactic treatment, "ich" (Ichthyopthirius multifilis) has almost invariably irrupted with subsequent mortality of the fish. Inoculation of confined tucunare with a bacterial pathogen, Aeromonas salmonicida, produced symptoms of furunculosis, but again such symptoms have not been observed in wild reservoir populations.

The tucunare is exclusively piscivorous and is highly selective even within that mode. It prefers torpedo-shaped prey such as mosquito fish but also feeds significantly on the more readily available threadfin shad and juvenile tilapia. Under conditions of satisfactory population balance or overabundance of forage, there is no evidence of either significant predation upon other top level predators or cannibalism. Extensive cannibalism was observed in one reservoir with a low nutrient base and a high ratio of predator (solely tucunare) to forage fish. Tucunare in that location grew much more slowly than elsewhere and were in relatively poor condition (weight per unit length). Dark-colored bottom dwellers such as catfish tend to be ignored even when food is in short supply. The increase in Eleotris in Lake Gatun reported by Zaret and Paine might reflect this selectivity.

Introduction of the tucunare has had no negative impact on native Hawaiian freshwater species or ecosystems largely because the fish is effectively isolated in reservoir habitats, which are both artificial and unsuited to native species, and can not adapt to stream habitats. Its piscivorous habit excludes native shrimps, snails, and insects, and its associated selectivity excludes the amphidromous gobies, which may migrate through some reservoirs, and endemic eleotrids, which are abundant in lower streams. Salinity tests have shown that the tucunare can not survive in even slightly brackish waters. When tucunare do occur in streams below reservoirs, after freshets and spillway overflows, they develop a reddish tinge in coloration, lose weight and disappear. Examinations of stomach contents from these escaped fish have found only accidental exotic introductions such as swordtails, even when small gobies (hinana) and endemic shrimps are also present in the stream.

The fact that the tucunare has provided a highly beneficial addition to the recreational freshwater sport fishery without significant consequences for native stream ecosystems is to an extent fortuitous. At the time of its importation little was known about its habits, and even less concern was directed at the preservation or understanding of native ecosystems. Given the present knowledge base about its life history and habitat requirements, however, it would have been clear that the species could be safely introduced to Hawaii.

--Bill has been studying Cichla ocellaris and other freshwater fishes in Hawaii since 1968. His address is 94-374 Makalu Loop, Mililani Town, Hawaii 96789.

FLORIDA'S PEACOCK BASS PROGRAM

Paul L. Shafland
Florida Game and Fresh Water Fish Commission

Preface--What follows is a thumbnail sketch of the Florida Game and Fresh Water Fish Commission's on-going peacock bass (Cichla spp.) study. It is intended to provide some factual background information, as well as an update on the status of these fish in Florida. Hopefully, this report will reduce the amount of misinformation that occasionally surrounds such efforts. Based on our current data, observations, and the situation existing before butterfly peacocks (C. ocellaris) were introduced, this introduction is considered to have been highly successful.

The introduction of peacock bass represents an attempt to increase the recreational value of underutilized exotic forage fishes in a highly urbanized man-made environment. This introduction represents the culmination of many years of research and analyses, initiated and conducted without preconceptions as to its ultimate conclusions and recommendations. This is important since our program and its success may provide a precedence for others to judiciously consider exotic introductions as a management alternative.

Background--The primary peacock bass study area is restricted to the coastal, man-made canal system of eastern Dade County (= Miami area). Peacock bass are incapable of tolerating water temperatures less than 15°C, and winter temperatures in natural Florida waters nearly always drop below 15°C except in ground water springs. The deep, man-made canals of urban Dade County were primarily constructed for drainage and flood control purposes. These canals are cut into the Biscayne Aquifer which is a surficial water table aquifer that has extreme transmissivity. The combination of the box-cut canal morphometry (depths to 5 m common, widths generally less than 40 m, typical shoreline wind breaks of buildings and trees) and inflow of groundwater from the aquifer provide the most receptive habitat imaginable for many resident exotic fishes that have been illegally introduced from the tropical areas of Central and South America, Africa and Southeast Asia. Since 1982 the minimum water temperature recorded in one of these canals has been 17.5°C.

Thirty-two eastern Dade County canal blocknet samples taken prior to introducing peacock bass yielded 10 exotic fish species: 7 cichlids and one each clariid, loricariid and poeciliid. The average fish population estimate was 229 kg/ha and 17,790 fish/ha, of which 38% by weight and 24% by number were made up of exotic species. Spotted tilapia (Tilapia mariae) dominated these fish populations averaging more than 25% by weight and number of all the fishes collected, and they made up as much as 71% by weight (267 kg/ha) and 74% by number (26,090 fish/ha) of the fish taken in individual samples. The ratio of forage biomass to predator biomass averaged 12.4, indicating that these canals could support more predators.

In a separate study one Dade County canal was sampled extensively during a 5 year period. Biomass estimates exceeded 200 kg/ha of fish in each of the 4 major habitats sampled. Of the 39 species of fish collected, 11 were exotic, 9 of which were established and 3 were abundant. The latter species dominated the fish community representing more than 60% by number and weight of the fishes collected in quantitative samples. Spotted tilapia was by far the most abundant fish making up greater than 50% of the fish community estimates both by weight and number. Number and size of largemouth bass were comparable for Florida populations in less disturbed habitats, and thus they were considered to be in good overall condition. Total weight of forage relative to piscivorous species, however, was greater than 10.0 in each of the 4 major habitats sampled, indicating this fish community had too few predators and that food was not a limiting factor for largemouth bass.

Based on these and other evaluations, it was recommended that peacock bass be considered as a possible purposeful introduction with the objective of converting the abundant exotic forage fishes into a desirable sportfishery. Initially, the emphasis would be focused on the butterfly peacock (C. ocellaris) which matures faster but grows to a smaller maximum size than the speckled peacock (C. temensis). Prior to making a final decision, however, a comprehensive review of the literature, extensive personal communications and a proposal was prepared and distributed to many fisheries professionals representing a variety of philosophical perspectives.

Just so no one could accuse us of distributing this proposal selectively to individuals likely to concur with our position, 4 Past-Presidents of the AFS Introduced Fish Section were asked to provide their written reviews. One of these, who might have been expected to object to this introduction, wrote:

> "Dear Paul: I have reviewed 'A Proposal for Introducing Peacock Bass in Black Creek Canal.' Instead of the usual myopic, target-oriented proposal that often appears where an introduction is contemplated, it is clear that you did your 'homework' on the potential environmental consequences of this proposed introduction. Particularly because there is extremely little likelihood that Cichla could survive beyond the canals of southeastern Dade County, I am not in a position to object to this introduction. Moreover, those canals are so heavily infested with other exotics that there is nothing to lose and perhaps something to gain from this introduction.
>
> As you know, I am preparing a paper entitled 'Reducing risks of introduced fishes in North America' for presentation at a symposium of the American Fisheries Society next week. Your proposal fits into a very low risk category with the system I am using: that is, you are working with a fish that is thermally restricted and will be used in what one could consider an essentially contained, research-style manner. Sincerely, Walter R. Courtenay, Jr."

The Florida Game and Fresh Water Fish Commission's decision to introduce peacock bass was approved only after receiving general concurrence from an overwhelming majority of reviewers.

Preliminary Results--Stomachs from 378 butterfly peacocks collected in April and May 1989 were examined, and 127 were found to contain identifiable fish remains; one had a shrimp and another had fish eggs (tilapia?) in their stomachs. Butterfly peacocks fed nearly exclusively on fish, and spotted tilapia was the dominant food item consumed. Over 80% of the stomachs containing identifiable fish remains (104 of 127) contained spotted tilapia, and 255 of 339 (75%) of the identified fishes found in stomachs were spotted tilapia. Individual peacock bass contained as many as 13 spotted tilapia.

Of 351 butterfly peacocks electrofished from the primary peacock bass study canal in early 1989, more than 60% were 254 mm total length (TL) or longer (= harvestable size). Of the 225 harvestable sized fish collected 46% were 254-299 mm TL, 31% were 300-349 mm TL and 23% were greater than 350 mm TL. The largest butterfly peacock collected was a 555 mm TL, 3.07 kg male.

A 30 day roving clerk creel survey of the primary peacock bass study canal using non-uniform probability was conducted in July 1988. These preliminary data yielded a fisherman catch rate of 0.91 peacocks and 0.48 largemouth per hour. The hours spent fishing for largemouth, peacocks and all fish combined were 13.6, 9.1 and 8.5 hrs/ha for the 28 day period, respectively. Fishing pressure for peacocks was higher than expected since fishing for peacocks was discouraged at this time. It is conceivable that largemouth bass may benefit from less fishing pressure as anglers redirect a portion of their effort towards peacocks. A 12 month continuous creel was begun in January 1989.

Current Status--Butterfly peacocks have overwintered and reproduced successfully in Dade County canals since they were first introduced in October 1984. Reproduction of the slower maturing speckled peacocks has not been confirmed. Standing crop estimates of butterfly peacocks in the primary study canal last year reached 9.20 kg/ha and 872 fish/ha, of which 3.84 kg/ha and 822 fish/ha were contributed from a single school of fingerlings that were still being guarded by both adults. Peacock bass were introduced in southeast Florida canals to create urban sportfisheries in systems dominated by exotic forage species. Fishermen's responses have been overwhelmingly positive, and the presence of butterfly peacocks has improved these fish communities by reducing the forage to carnivore biomass ratios.

Beginning 1 July 1989, the Commission set a legal bag limit of two butterfly peacocks per fisherman per day but only one of these could be greater than 17 inches. A catch and release philosophy will continue to be strongly encouraged. Speckled peacocks remain illegal to keep, and if caught must be immediately released.

Prior to 1 July 1989 peacock bass caught by fishermen had to be released because they were illegal to possess. Enforcement of fishing regulations is especially difficult in the hundreds of miles of interconnected urban canals where peacock bass are now established. Numerous peacocks have been illegally kept as evidenced by the more than 35 citations officers issued last year for their illegal possession. There is even evidence that some peacock bass were caught and sold to local fish markets who in turn sold them to the public. Such problems were anticipated, as any fisheries enhancement program in urban situations have to withstand a higher than normal amount of illegal activity.

The Florida Game and Fresh Water Fish Commission is committed to a long-term, objective and balanced evaluation of peacock bass. The initial 5 year study has been extended to 10 years, at which time it will likely be extended again.

Based on these data, observations, fishermen responses and given the objectives and situation existing before peacocks were introduced, the introduction of butterfly peacocks is judged to have been highly successful. It is important to keep this and other successful introductions in perspective, however, and to consider them only with utmost care and forethought.

****

1988-89 IFS OFFICERS

President: Peter B. Moyle, Department of Wildlife and Fisheries Biology, University of California, Davis, CA 95616 (916-752-6355).

President-Elect: Paul L. Shafland, Florida Game and Fresh Water Fish Commission, 801 N.W. 40th Street, Boca Raton, FL 33431 (407-391-6409).

Secretary-Treasurer: Dawn Jennings, USFWS, 7920 N.W. 71st Street, Gainesville, FL 32606 (904-378-8181).

Past-President: Nick C. Parker, Texas Cooperative Fish and Wildlife Unit, Department of Wildlife Sciences, Texas Tech University, Lubbock, Texas 79401 (806-742-2851).

July 1989

Non Profit Organization
U.S. POSTAGE
PAID
Gainesville, FL
Permit No. 596

Introduced Fish Section
American Fisheries Society
7920 N.W. 71st Street
Gainesville, Florida 32606

01835 A
JAMES D WILLIAMS
USFWS-NATL FISHERY RES LAB
7920 NW 71ST ST
GAINESVILLE FL 32606