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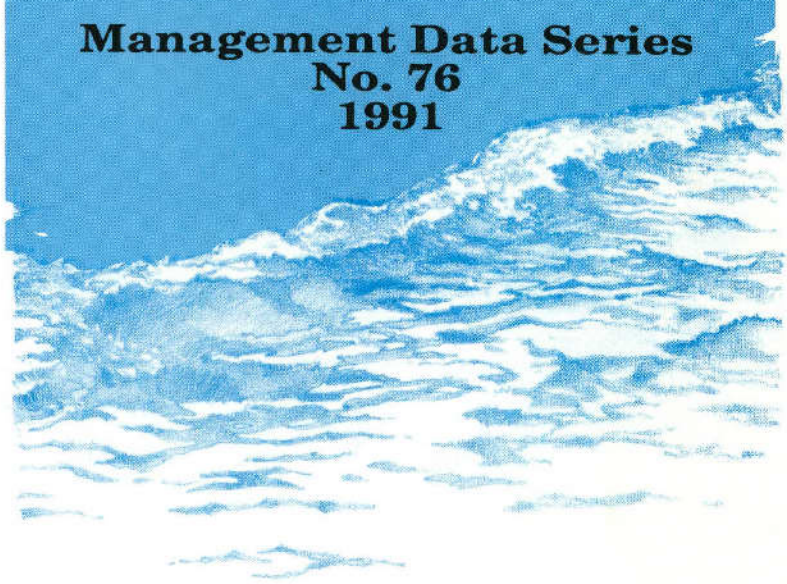

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ABSTRACT

Concern for impacts of exotic (non-indigenous) species on native species in Texas led to their inclusion in Senate Bill 1507 of the 71st Legislature, and subsequent rules implemented by the Texas Parks and Wildlife Commission (TPWC) in 1989. Occurrence of an exotic penaeid shrimp (Penaeus vannamei) in the Brownsville ship channel was reported by area fishermen during spring 1989 and documented by Texas Parks and Wildlife Department (TPWD) personnel during spring 1990.

P. vannamei is potentially harmful to native penaeid shrimp and the fisheries that rely upon them. Of six criteria used for determining potential harm, this species meets at least four: 1) potential for establishing self-sustaining populations, 2) potential for adversely affecting native penaeids and predators that feed on shrimp, 3) disease transmission, and 4) morphological similarity with native and other exotic penaeids (Texas Parks and Wildlife Department Agenda Item 1989).

Recent developments in the aquaculture industry suggest a continued growth in importation, transportation, distribution and culture of P. vannamei in Texas. Increasing popularity of the commercial culture of exotic penaeids, proximity of culture facilities to Texas coastal water and lack of research on impacts of exotic penaeids on native penaeid stocks initiated amendment of existing rules and adoption of additional regulatory measures by the TPWC in December 1990.

INTRODUCTION

Concern for impacts of exotic (non-indigenous) species on native species in Texas led to their inclusion in Senate Bill 1507 of the 71st Texas State Legislature. Provisions set forth by Senate Bill 1507 transferred regulation of fish farming activities from the Texas Parks and Wildlife Department (TPWD) to the Texas Department of Agriculture (TDA). However, regulation of exotic fish, shellfish and aquatic plants to protect indigenous Texas species and aquatic habitats is the responsibility of the TPWD. Rules to meet this responsibility were implemented by the Texas Parks and Wildlife Commission (TPWC) in 1989. Included was a policy requiring examination of potential or realized harm of exotic species whose documented first occurrence in Texas public waters occurs after 11 December 1989.

Occurrence of an exotic penaeid shrimp (P. vannamei) in the Brownsville ship channel was reported by area fishermen during spring 1989 (Hockaday personal communication 1989). Whereas these shrimp were caught before December, their identity was not confirmed until 15 February 1990, when samples were provided to the Coastal Fisheries Branch. The author identified the exotic shrimp using taxonomic keys (Perez-Farfante 1988). Identification was verified by Timothy King at the Perry R. Bass Marine Fisheries Research Station, Palacios, using isoelectric focusing (IEF) techniques.

The objective of the present report is to determine the potential or realized harm of this species and other exotic penaeids in Texas public waters as directed by Senate Bill 1507, Section 134.020(a) of the Agricultural Code (State of Texas 1989a) and Section 66.007(a) of the TPWD Code (State of Texas 1989b).

MATERIALS AND METHODS

The first documented occurrence of exotic species in Texas public waters requires the TPWD to evaluate potential or realized harm of these species. The possibility of exotic species causing potential harm depends on: 1) a species' ability to survive and establish self-sustaining populations in Texas' public waters, 2) potential threat to humans, 3) potential threat to native fish, shellfish and aquatic plants, 4) species status as a carrier of disease not found in Texas, 5) potential for impedance of navigation or adversely affecting other water based activities, and 6) similarity among species (Texas Parks and Wildlife Department 1989).

Available scientific literature on P. vannamei physiological tolerances in nature and culture, reproductive biology, potential for disease transfer, similarities to native species, and impact of introduction of exotics into the wild were reviewed. Additional information on P vannamei was collected through personal communication with shellfish culturists and researchers in Texas and South Carolina.

RESULTS

P. vannamei is potentially harmful to native penaeid shrimp and the fisheries that rely upon them. Of the six criteria used for determining potential harm, this species meets at least four: 1) potential for establishing self-sustaining populations, 2) potential for adversely affecting native penaeids and predators that feed on shrimp, 3) disease transmission, and 4) morphological similarity with native and other exotic penaeids. This indicates P. vannamei could become established in Texas and would probably compete with P. setiferus.

P. vannamei could adversely affect fisheries and industries supported by native penaeid shrimp. The potential for establishing self-sustaining populations of P. vannamei is indicated by the documented occurrence in Texas public waters, life history similarity to native penaeids, temperature tolerance range, sexual maturation, and spawning in shrimp farms in Texas. Survival of P. vannamei in Texas public waters has been documented by the capture of this species in the Brownsville Ship Channel. Incidental catch of this species was reported by area bait shrimpers for about 2 years. It is not known if individual shrimp survived throughout this period, however, it appears they were physiologically capable of surviving. P. vannamei have been pond cultured in water from the Laguna Madre during May through October (Chamberlain and Lawrence 1981). They are euryhaline like most penaeids (Perez-Farfante 1969). However, they are susceptible to temperatures below about 5.0 C in nature (Rodriguez de la Cruz 1981) and about 9.0 C in ponds (Hopkins personal communication 1990). Average monthly bottom water temperatures recorded in the lower Laguna Madre and Gulf of Mexico in 1989 ranged from 9.1 to 29.7 C and 15.3 to 26.7 C, respectively (Dailey et al. 1990). Possible survival of non-native species such as P. vannamei in Texas is supported by survival of the exotic species P. monodon in South Carolina and northern Florida, colder climates than south Texas (Smith 1988).

Assuming P. vannamei could survive most Texas winters, they have potential for successfully reproducing. The life cycle of P. vannamei is characteristic of penaeid shrimp. Adults spawn offshore and larvae are carried into estuaries and lagoons by onshore currents. In the wild, P. vannamei are distributed in the eastern Pacific from Sonora, Mexico to northern Peru (Holthuis 1980); they spawn year around with a peak during September-November (Edwards 1978, 1980; Menz and Bowers 1980). Recruitment of juveniles into lagoons appears to be influenced by hydrological factors and occurs in groups during March-April, June-July, and in greatest number during October-November; these periods coincide with peak spawning offshore (Poli and Calderon-Perez 1987). Periods during which recruitment into estuaries and seaward migration occurs coincides with life histories of P. aztecus and P. setiferus (Perez-Farfante 1969, Moffett 1990).

Maturation and reproduction of captive P. vannamei in Texas has been successful utilizing eyestalk ablation and photo-period, temperature and diet regimes (Chamberlain and Lawrence 1981). Ovarian maturation was observed in an unablated female reared in a Corpus Christi, Texas facility (Chamberlain and Lawrence 1981). Natural maturation and reproduction of unablated P.

vannamei was successful at a facility in Tahiti after conditioning periods of 4-12 months (Aquacop 1979). Successful reproductive interaction and establishment of a self-sustaining population depends on the number of individuals present in Texas waters. Introduction of a sufficient number of individuals would subsequently provide for a potentially self-sustaining population. This is supported by the creation of self-sustaining populations of a similar exotic (P. semisulcatus) beyond its native range. Construction of the Suez Canal may have afforded P. semisulcatus the mechanism by which the species extended its range from the Red Sea to the eastern Mediterranean Sea (Holthuis 1980).

Reproduction of P. vannamei in Texas public waters has not been documented. Lengths of captured individuals in the Brownsville Ship Channel ranged from 82 to 138 mm (mean TL = 100 mm). No specimens <82 mm were reported. No adults or juveniles of this species have been identified in TPWD routine monitoring samples collected before or after the documented February 1990 occurrence.

P. vannamei is a potential threat to native penaeids. Survival in Texas public waters could lead to trophic alteration, spatial and temporal overlap or alteration and in the worst case scenario possible extinction of native species. Adverse competitive interaction for available resources between native and exotic species is possible due to similarities in penaeid life history. Penaeid shrimp are omnivorous and possess similar dietary habits (Perez-Farfante 1975). Similar diel, diurnal activities and substrate preferences of exotics could impact native species. Pond culture of P. vannamei and P. setiferus demonstrated growth and survival of P. vannamei was superior to P. setiferus (Chen et al. 1985). This superior performance in culture demonstrates potential for competition with or replacement of native penaeids. If exotic replacement occurs followed by occasional low (<9 C) water temperatures, penaeid stocks would experience a greater loss than in the absence of P. vannamei. Fisheries which these species support could be adversely impacted to a greater extent than would otherwise occur.

Natural hybridization in the wild between P. vannamei and native penaeids is improbable due to morphological differences of reproductive structures (Perez-Farfante 1975). However, interspecific hybridization of P. setiferus, P. stylirostris and P. schmitti through artificial insemination techniques has produced viable hybrids (Bray et al. 1990).

P. vannamei could possibly transmit at least one of six pathogenic viruses known to infect penaeids as shown by laboratory experiments. Infectious hematopoietic and hypodermal necrosis virus (IHHNV) has been transmitted from P. vannamei to native penaeids in the laboratory (Lightner et al. 1985). IHHNV has not been reported in native Gulf penaeids. Lightner et al. (1985) infected P. japonicus, P. setiferus, P. aztecus, and P. duorarum with IHHNV. IHHNV occurs naturally in P. stylirostris, P. vannamei and P. monodon, three species imported and utilized in U. S. commercial culture. Pathogenicity of this virus on native penaeids was evaluated experimentally with few specimens. Pathogenicity appeared limited but impact of introduction of IHHNV on native stocks under natural conditions has not been determined (Lightner et al. 1985). Five other viruses, Baculovirus penaei (BP), Monodon

type Baculovirus (MBV), Baculoviral midgut gland necrosis (BMN), Hepatopancreatic parvo-like virus (HPV), and reo-like virus (REO) have not been successfully transmitted to native penaeids (Lightner et al. 1985). However, few attempts have been made to transmit these viruses from exotic species to native penaeids.

The probability of P. vannamei transmitting any of the other five viruses is unknown, but the potential exists. Two of these five viruses have been transmitted among other penaeids. MBV, a natural pathogen of P. monodon has been found to infect P. semisulcatus, possibly P. kerathurus in Italy, and cultured P. merguensis, (Lightner et al. 1985). REO, a pathogen responsible for high mortalities in cultured P. japonicus, was discovered in culture facilities in France and Hawaii (Lightner et al. 1985). Pathogenicity of the viral agent appears to be species specific with certain species acting as asymptomatic carriers. Each virus may actually be comprised of multiple strains, some of which are highly pathogenic to some penaeids and of little consequence to others (Lightner et al. In press). BP has been reported in wild Gulf of Mexico penaeids. Pathogenicity of BP on P. vannamei, P. aztecus and P. duorarum usually results in widespread infection similar to an epidemic in humans. P. stylirostris and P. setiferus were also documented as carrying BP but pathogenicity in species was limited (Lightner et al. 1985).

Externally, P. vannamei is similar to P. setiferus with slight variations in coloration (Dore and Frimodt 1987). Morphological differences in female reproductive structures allow for distinction between species, but is not possible in males or immature females. Apparently, coloration of P. vannamei in the Brownsville Ship Channel was sufficiently different from that of native penaeids to be noticed by commercial shrimpers. Bait shrimpers who caught and supplied specimens of P. vannamei from the Brownsville Ship Channel stated the color of the exotic species tails was different from those of native penaeids. Different substrate and diet impart color variation in some penaeid shrimps in the wild and could complicate identification in the future. Distinction of this species from P. setiferus, particularly among juveniles, is difficult to establish accurately.

DISCUSSION

The source of P. vannamei caught in the Brownsville Ship Channel is unknown. However, two aquaculture facilities permitted to culture P. vannamei are located within 16 km of the capture site.

Establishment of P. vannamei in public water jeopardizes a shrimp industry with an economic impact in Texas of over $580 million. The shrimp fishery in Texas employs about 20,000 fishermen using 7,000 vessels and boats (Cody et al. 1989). Shrimp are harvested by commercial and recreational fishermen and utilized as both food and bait. Shrimp for food are harvested commercially in both the bays and Gulf of Mexico with an ex-vessel value in 1987 of over $229 million (Cody et al. 1989). Commercial bait shrimpers harvested an estimated 1,000,000 kg valued at $6.8 million in 1978 (Cody et al. 1989). Shrimp are a principal source of forage for finfish and are vital

to the health of the Texas sport fishery, an industry with an economic impact of over one billion dollars annually (Texas Parks and Wildlife 1985).

The probability of additional exotic shrimp occurring in Texas public waters is expected to increase. Demand for shrimp is being addressed by increased aquaculture activity in the world and in Texas. Predicted culture area in Texas for 1990 is 193 ha with an estimated production of about 500,000 kg of P. vannamei (Chamberlain and Pettibone 1990).

Recent developments in the Texas aquaculture industry suggest a continued growth in importation, transportation, distribution and culture of P. vannamei. Prior to December 1990, requirements outlined by the TPWD Exotic Shellfish Culture Permit, (Texas Administrative Code Sections 57.111-57.116) provided restrictions regarding 1) importation, 2) disease status of exotic shellfish, 3) source of postlarvae, 4) geographic location of culture facility or stocking area, and 5) strategy for prevention of imminent release of exotic shellfish into public waters (State of Texas 1989b). Furthermore, the previous regulations concerning exotic penaeids were applicable only to those who sold them. In December 1990 the TPWC amended TAC sections 57.111-57.116 and added sections 57.118-57.121, more stringent measures to further prevent inadvertent introduction of exotic penaeids into public waters. The amended regulations place all exotic penaeid species listed in TAC section 57.111 on the harmful or potentially harmful exotic species list, require the culture license holder submit an annual report accounting for disposition of any harmful or potentially harmful species, and provide penalties for violation of any provisions in these rules.

It is impossible to predict how an exotic species will behave in a new environment. Introduction will cause shifts within the host community; the degree of shift may be slight or major and could lead to extinction of one or more species within the host community (Courtenay 1979). Courtenay (1979) further states adverse effects on the host community often do not become apparent for several decades following establishment of exotic species. Ecosystems are highly complex, with dynamics not fully understood, thus complicating prediction of impacts of exotic species on native biota. Introduction of exotic species and associated pathogenic viruses and diseases poses ecological, economic and management implications. Diversification of exotics used in commercial culture supports the possibility for introduction of additional species and associated pathogens and diseases into Texas coastal waters. Similarities in physiological tolerances behavior and growth of exotic penaeids to native species support the potential for survival and possible establishment of self-sustaining populations (Lawrence et al. 1983, 1985; Lawrence and Huner 1987; Solis 1988; Chen et al. 1988; Rojas-Beltran 1981; Seidman and Issar 1988; D'Croz et al. 1979; Aquacop 1975; Rodriguez 1977; Menz and Bowers 1980; Edwards 1978). Similarities in hydrological tolerances, dietary habits, and predatory nature of some exotics also suggest competitive interraction with native species.

Increasing popularity of the commercial culture of exotic penaeids, proximity of many culture facilities to Texas coastal waters and lack of research on impacts of exotic penaeids on native penaeid stocks dictated the need for a more exacting approach in the regulation of exotic penaeid

importation and culture in Texas. Until conclusive research is published regarding the effect of exotic penaeids on native Texas stocks the TPWD will continue to monitor the potential impacts of the culture of these organisms in Texas.

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