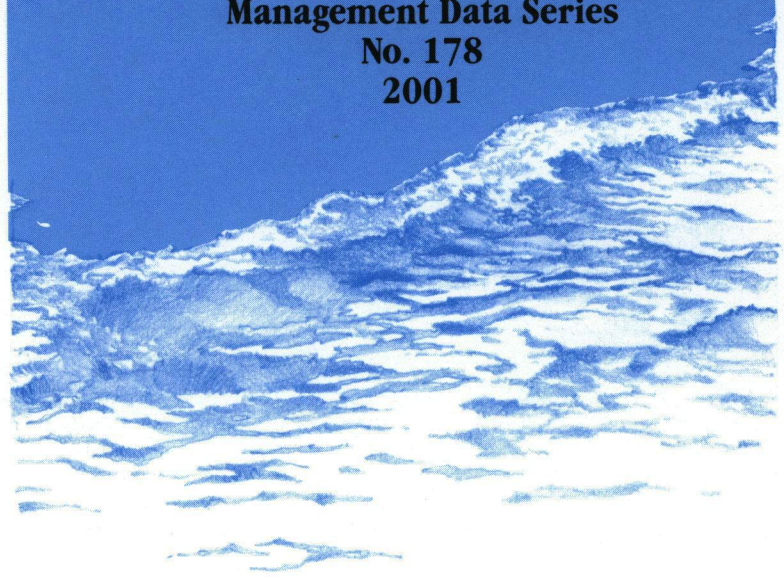
Texas Closure Dates for the 1993-2000 Texas Gulf Shrimping Seasons

by
Billy E. Fuls

Management Data Series
No. 178
2001



TEXAS PARKS & WILDLIFE

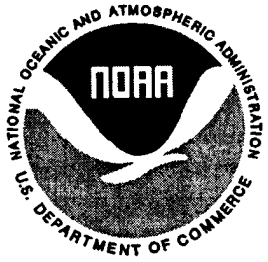
COASTAL FISHERIES DIVISION
4200 Smith School Road
Austin, Texas 78744

TEXAS CLOSURE DATES FOR THE 1993-2000 TEXAS GULF SHRIMPING SEASONS

by

Billy E. Fuls

MANAGEMENT DATA SERIES
No. 178
2001



Texas Parks and Wildlife
Fisheries Division
4200 Smith School Road
Austin, TX 78744

ABSTRACT

Brown shrimp (*Farfantepenaeus aztecus*) were collected with bag seines along shorelines and with trawls in Texas bay and gulf waters (≥ 1 m) to determine closing and opening dates for the Texas Closure during the 1993 through 2000 shrimping seasons within Texas Territorial Sea. The purpose of the Texas closure is to protect small brown shrimp from fishing pressure until they reach a larger, more valuable size (≥ 112 mm TL) and to minimize waste caused by discarding smaller shrimp during gulf harvest. Texas Parks and Wildlife Commission (TPWC) rules, effective 14 May 1990, set the closed season to begin at 30 minutes after sunset on 15 May extending to 30 minutes after sunset on 15 July; dates can be altered by the Texas Parks and Wildlife (TPW) Executive Director using sound biological data. Preset TPWC opening and closure dates for the Texas Closure were altered during 1993, 1994, 1996, 1998 and 2000.

ACKNOWLEDGEMENTS

Thanks are due to each member of the Texas Parks and Wildlife's Coastal Fisheries Division field personnel for their diligent collection of data. Thanks are also due to Southeast Area Monitoring and Assessment Program (SEAMAP) participants. This study was conducted with partial funding from the National Marine Fisheries Service (NMFS) under P. L. 99-659 (Project 2-IJ-34).

INTRODUCTION

In 1997, shrimp had the highest ex-vessel value of all seafood products landed in the United States. Reported shrimp landings were 131.7 million kg (heads-on) with an ex-vessel value of $544 million in 1997 (U. S. Department of Commerce 1998). Texas shrimp landings in 1997 amounted to 29.3 million kg valued at $166 million (Robinson et al. 1998). This is 22% of the weight and 31% of the value of the U. S. shrimp fishery.

Shrimp are the most important commercial seafood product in Texas, annually accounting for over 90% of the value and 80% of the weight of all seafood landings. Brown shrimp (*Farfantepenaeus aztecus*) is the most economically valuable species, and in most years comprises over 75% in both weight and value of Texas annual reported landings.

Brown shrimp spawn in the Gulf of Mexico, progress through several larval stages and enter bays during February-April as post-larvae (Baxter and Renfro 1967, King 1971). They initially seek shallow nursery areas in the bays where they grow rapidly, migrate to the deeper portions of bays and then return to the gulf in late May or early June at a mean size of about 90 mm TL (Copeland 1965, Trent 1967, Parker 1970, King 1971). Movement to the gulf through passes occurs mainly at night near the surface in association with ebb tides during the period of maximum tide duration (Copeland 1965, King 1971). Movement ceases during daylight and during flood tides, with shrimp remaining on the bottom until the next nocturnal ebb tide. In Texas, diurnal tides are mixed, with one low and one high per 24-h period of maximum range and two highs and two lows per 24-h period with a minimum range (Collier and Hedgpeth 1950). During the period of maximum range, tides are at maximum duration.

Brown shrimp management in Texas is designed to accommodate all users (bait, small food shrimp, and large food shrimp fishermen) while protecting the resource and minimizing waste. The supply of large shrimp is ensured by regulating harvest in bays and simultaneously delaying harvest in the gulf until emigrants reach a larger, more valuable size. Prior to 14 May 1990, shrimp were managed by the Texas Legislature through the Shrimp Conservation Act of 1959 (State of Texas 1989). This Act established the Texas Closure, a 45-day closed season in Texas Territorial Sea (TTS) waters ($\leq$16.7 km from shore) from 1 June-15 July each year. In 1975, the Texas Legislature authorized the Texas Parks and Wildlife Commission (TPWC) to adjust closing and opening dates as long as the total closure was $\geq$45 days but $\leq$60 days. In April 1978, the TPWC delegated this authority to the Texas Parks and Wildlife (TPW) Executive Director. Chapter 77, TPW Code, provided the TPWC with the authority to regulate the catching, possession, purchase, and sale of shrimp (1st sales transaction) after a Shrimp Fishery Management Plan developed by the TPW was approved by the TPWC. On 2 November 1989, the Texas Shrimp Fishery Management Plan (Cody et al. 1990) was adopted by the TPWC. Effective 14 May 1990, the TPWC amended Texas Parks and Wildlife Code, Chapter 77, Section 77.061(a)(1), 77.065, and 77.067 to mandate a closure of the TTS beginning 30 minutes after sunset on 15 May to 30 minutes after

sunset on 15 July; however, these dates could be altered by the Executive Director using sound biological data.

The purpose of the annual closure is to protect small brown shrimp from fishing pressure until they reach a larger, more valuable size (≥112 mm mean TL) and to minimize waste caused by discarding smaller shrimp during gulf harvest. Texas has annually closed the TTS during the Texas Closure for over 40 years; the statutory closed season has been adjusted seventeen times (Table 1). The rationale for adjusting closure dates was detailed by Moffett (1967, 1972), Johnson (1976), Bryan (1983, 1985, 1986 and 1988), Procarione and Fuls (1990), Fuls (1990, 1993). Small shrimp were protected in the TTS by closures prior to 1981, but large numbers of small shrimp were still captured and discarded in waters beyond Texas' jurisdiction (Berry and Benton 1969, Baxter 1973, Bryan et al. 1982).

The Gulf of Mexico Fishery Management Council Shrimp Fishery Management Plan was adopted in 1980 and implemented in 1981 (Center for Wetland Resources 1980). Among other options, the plan called for closure of U. S. waters (≥16.7 to 370.6 km) off Texas to complement the traditional Texas Closure. However, during the 1986, 1987, and 1988 closure U. S. waters were closed out to only 27.8 km. During the 1989-2000 closures U. S waters were again closed out to 370.6 km. The combined closure of Texas and U. S. waters has resulted in an increased yield of brown shrimp off Texas during every closure year from 1981-89 (Nichols 1990). However, the July-August catch per unit of effort (CPUE) off Texas was greater (except for 1984) when U. S. waters were closed to 370.6 km during 1981-85 (371-860 kg/d) than during 1986-88 (310-388 kg/d) when waters were closed to only 27.8 km (Klima et al. 1990). July-August CPUE (466 kg/d) again rose above the 1986-88 CPUE. The present report documents procedures used to determine the 1993-2000 closing and opening dates for the Texas Closure.

MATERIALS AND METHODS

Shoreline samples were collected with bag seines to capture post-larval and juvenile shrimp as they were first recruited to the gear. Otter trawls were used in deeper (≥1 m) portions of bays and in the Gulf of Mexico to determine the time and at what sizes shrimp emigrated from the bays.

Samples were collected with bag seines (18.3 m long and 1.8 m deep with 19-mm stretched mesh in the wings and 13-mm stretched mesh in the bag) in Sabine Lake, Galveston, East Matagorda, Matagorda, San Antonio, Aransas and Corpus Christi Bays, and upper and lower Laguna Madre systems. During 1993 through 2000, 20 different shoreline stations were sampled monthly in each bay system; except in East Matagorda Bay where 10 shoreline stations were sampled each month. Detailed descriptions of sample stations and procedures are reported by Hensley and Fuls (1998).

Samples were collected with trawls (6.1 m wide at mouth with 3.8-cm stretched mesh) in the same bay systems listed for bag seines. Detailed descriptions of sample stations, frequency and procedures are reported by Hensley and Fuls (1998).

Trawls, identical to those used in bays, were used in the TTS during June in five gulf areas: 24.1 km either side of each of the Sabine Pass jetties (Sabine), Galveston jetties (Galveston), Matagorda jetties (Port O'Connor), and Aransas Pass jetties (Port Aransas), and 48.2 km north from the Texas-Mexico border (Port Isabel). Detailed descriptions of sample stations, frequency and procedures are reported by Hensley and Fuls (1998). Gulf trawl samples during June were collected in conjunction with the National Marine Fisheries Service (NMFS) Southeast Area Monitoring and Assessment Program (SEAMAP).

For all gears, the sampling week extended from 0.5 h before sunrise Monday through 0.5 h after sunset the following Sunday; all samples were collected during daylight hours. All brown shrimp captured in a sample were counted. Total length (mm; tip of rostrum to tip of telson) was obtained from up to 19 shrimp in bag seine samples and up to 50 in trawl samples.

Catch was expressed as no./ha (bag seines) and no./h (trawls). The coastwide mean catch (number and length) in bag seines was weighted by the shoreline distance in each bay system (Matlock and Ferguson 1982). Bay trawl data were weighted according to the percentage each bay system's surface area in water $\geq$1 m deep contributed to the coastwide area. Gulf trawl data were weighted by the number of sampling grids within each gulf sampling area. Mean shrimp lengths were weighted by the total number caught in each sample. Projected growth rates for combined bays were based on the von Bertalanffy model from Parrack (1979). Sexes were assumed equal since shrimp sex was not determined.

The following guideline criteria were used to recommend changes in the statutory closing date for the Texas Closure within the TTS during 1993-2000:

1. Mean number of brown shrimp/ha (transformed to Log_{10}) captured coastwide in bag seines during April was compared to the combined mean number $\pm$ 2 mean SE) caught during years when the season was closed 1 June. Relatively large numbers of shrimp captured in April were interpreted as indicating good survival and/or early recruitment of post-larvae and, therefore, a probable earlier than 1 June emigration from bays to the gulf.

2. Percentage of coastwide bag seine samples in which brown shrimp occurred was compared to that observed in previous years. A relatively high percentage of samples containing shrimp was interpreted to mean that shrimp were well distributed along the coast.

3. Mean length of shrimp collected coastwide in bag seines during April was determined. When the number of shrimp in samples indicated early emigration, the von Bertalanffy growth model from Parrack (1979) was used to estimate the date shrimp captured in April would reach a mean length of 90 mm. Growth rate was calculated from 15 April.

4. Periods of maximum duration of ebb tides were determined from NOAA nautical charts for Galveston Channel; Texas coastal tide predictions are in reference to Galveston Channel tides. The date of the period nearest to the date shrimp were projected to reach 90 mm was recommended as the closure date.

The following guideline criteria were used to recommend the opening of the TTS to shrimping during 1993-2000.

1. Mean number of shrimp/ha (transformed to Log_{10}) caught in coastwide bag seines during June was compared to previous years' means. The season could be set for the 60 days authorized if substantial numbers [a mean $\pm$ 2 SE (SD = SE since yearly means are used) greater than average since 1979] of small shrimp were still found along shorelines. This would indicate additional recruitment of small shrimp into the bays, thus later movement towards the gulf. The season could be shortened if the mean number of shrimp were 2 SE less than average for previous years. This would indicate less recruitment of small shrimp into the bays, thus earlier movement towards the gulf.

2. Mean number of shrimp/h (transformed to Log_{10}) caught with coastwide trawls in the deeper ($\geq$1 m) portion of bays in June was compared to previous years' means. These samples reflect those shrimp that will most likely move to the gulf during June-July. If catch rates are similar to or greater than in past years, the date when shrimp are projected to reach a mean length of 112 mm (calculated from 15 June) is recommended to be the reopening date.

3. Coastwide samples in the Gulf of Mexico within the TTS during June were collected to determine if recruitment into the gulf shrimping grounds had occurred. If recruitment to the gulf shrimping grounds has occurred, mean lengths are obtained and growth rates projected to determine the recommendation for the opening date. The criterion is that the majority of brown shrimp on the fishing grounds average $\geq$112 mm when the season opened (Center for Wetland Resources 1980).

In addition to the specific criteria used by the TPW to consider changes to the TPWC amended closure and opening dates of 15 May-15 July for the Texas Closure, the TPW began in 1991 to use a pre-determined date for the opening of the season at the same time as determining the closure date. The pre-determined 1991-93 opening date for

the closure was based on: 1) averaging the date in July when shrimp in TPW coastwide bay trawls during June 1982-92 (corresponding to the first year after the 370.6-km closure was initiated in conjunction with the Texas Closure) would reach 112 mm; and 2) determining an overall average size of shrimp in TPW coastwide June bay trawls for the period 1982-92, and then calculating the date when the resultant overall average size of shrimp would reach 112 mm TL (determined from 15 June). It was determined by the TPW that a predetermined date would meet the objectives of the Texas Shrimp Fishery Management Plan by considering both the biological and socioeconomic aspects of the Texas Closure. However, if TPW data later indicated a much earlier or later opening date would be more appropriate for the fishery (based on normal criteria), then the pre-determined date could be altered. Beginning in 1994, the use of a pre-determined opening date was discontinued, and standard criteria were again used for recommendations for changes to statutory closure and opening dates for the Texas Closure. Additionally, in conjunction with the defined guideline criteria to determined Texas Closure date changes, annual consideration was given to socioeconomic aspects of the closure on the fishery, as well as periods of maximum ebb tide duration close to closure opening dates.

RESULTS

1993 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1993. Mean number of shrimp in April bag seines (1.4 ± 0.3/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.4/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 1993 was 52%, compared to a 6-year mean of 33% for 1 June closures, and a 9-year mean of 60% for early closure years through 1992, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 50 ± 3 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 17 May 1993. Periods of maximum ebb tide duration for Galveston Channel were 8 May-12 May and 22 May-26May. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was not altered, and the Texas Closure began 30 minutes after sunset on 15 May 1993.

Opening Date

During 1993, 6 July was pre-determined for the closure opening date using methods described for pre-determining the date. Average size of brown shrimp collected in TPW June bay trawls was 91 ± 4 mm; at this size shrimp would reach 112 mm (65

tails/lb) close to the date of 6 July 1993 (Table 3). Bag seine catch rates of shrimp during June (2.4 ± 0.2/ha) were not significantly different from the 14-year average (2.1 ± 0.3/ha) of previous years (Table 2). Mean length in bag seines (62 ± 1 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1993 (1.34 ± 0.2/h) was not significantly different from the June 1982-92 average (1.37 ± 0.1/h) (Table 3). Mean length of shrimp collected in bay trawls in June (91 ± 4 mm) would be 112 mm on 8 July as calculated from 15 June.

Although populations were lower than most years (1986-92), catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority of shrimp on the fishing grounds would average ≥112 mm by 6 July 1993. Although brown shrimp remaining in the deeper portion of bays would not reach 112 mm until 8 July 1993, with longest ebb tidal durations predicted for 30 June-2 July, the predetermined Texas Closure opening date of 30 minutes after sunset on 6 July was not altered.

1994 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1994. Mean number of shrimp in April bag seines (1.6 ± 2/ha) was similar to early closure years, and equal to or greater than the average + 2 mean SE (1.4/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 1994 was 55%, compared to a 6-year mean of 33% for 1 June closures, and a 10-year mean of 60% for early closure years through 1993, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 55 ± 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 14 May 1994. Periods of maximum ebb tide duration for Galveston Channel were 13 May-17 May and 23 May-27 May. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was altered, and the Texas Closure began 30 minutes after sunset on 13 May 1994.

Opening Date

Bag seine catch rates of shrimp during June 1994 (2.2 ± 0.2/ha) were not significantly different from the 15-year average (2.1 ± 0.3/ha) of previous years (Table 2). Mean length in bag seines (67 ± 2 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1994 (1.25 ± 0.2/h) was not significantly different from the June 1982-93 average (1.35 ± 0.1/h) (Table 3). Mean length of shrimp collected in bay trawls in June (94 ± 1 mm) would be 112 mm on 5 July as calculated from 15 June.

Although populations were lower than during 1986-93, catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority portion of shrimp on the fishing grounds would average ≥112 mm by 15 July 1994. Because brown shrimp remaining in the deeper portion of bays would not reach 112 mm until 5 July 1994, and longest ebb tidal durations were predicted for 4 July-6 July, the TPWC preset Texas Closure opening date was altered to 30 minutes after sunset on 7 July.

1995 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1995. Mean number of shrimp in April bag seines (1.8 ± 0.2/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.4/ha) during combined years when the Texas closure began 1 June (Table 2). Percentage of samples containing shrimp in 1995 was 65%, compared to a 6-year mean of 33% for 1 June closures, and an 11-year mean of 59% for early closures through 1994, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 52 ± 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 16 May 1995. Periods of maximum ebb tide duration for Galveston Channel were 6 May-9 May and 19 May-23 May. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was not altered, and the Texas Closure began 30 minutes after sunset on 15 May 1995.

Opening Date

Bag seine catch rates of shrimp during June 1995 (2.0 $\pm$ 0.2/ha) were not significantly different from the 16-year average (2.1 $\pm$ 0.3/ha) of previous years (Table 2). Mean length in bag seines (65 $\pm$ 2 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1995 (1.33 $\pm$ 0.2/h) was not significantly different from the June 1982-94 average (1.34 $\pm$ 0.1/h) (Table 3). Mean length of shrimp collected in bay trawls in June (83 $\pm$ 2 mm) would be 112 mm on 15 July as calculated from 15 June.

Although populations were lower than most years (1986-94), catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority of shrimp on the fishing grounds would average $\geq$112 mm by 15 July 1995. Because brown shrimp remaining in the deeper portion of bays would not reach 112 mm until 15 July 1995, with longest ebb tidal duration's predicted for 14 July-17 July, the TPWC preset Texas Closure opening date of 30 minutes after sunset on 15 July was not altered. Although this opening date would be during major ebb tides, it was determined the best date considering both biological and socioeconomic factors of the fishery.

1996 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April did not indicate an early emigration of brown shrimp to the gulf in 1996. Mean number of shrimp in April bag seines (0.8 $\pm$ 0.2/ha) was similar to 1 June Texas Closures, and considerably lower than during early closure years (Table 2). Percentage of samples containing shrimp in 1996 was 27%, similar to a 6-year mean of 33% for 1 June Texas Closures, and well below a 12-year mean of 60% for early closure years, indicating shrimp were not widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 46 $\pm$ 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 21 May 1996. Periods of maximum ebb tide duration for Galveston Channel were 20 May-25 May and 1 June -7 June. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was altered, and the Texas Closure began 30 minutes after sunset on 1 June 1996.

Opening Date

Bag seine catch rates of shrimp during June 1996 (2.2 $\pm$ 0.3/ha) were not significantly different from the 17-year average (2.1 $\pm$ 0.2/ha) of previous years

(Table 2). Mean length in bag seines (60 ± 1 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1996 (1.48 ± 0.2/h) was higher than the June 1982-95 average (1.34 ± 0.1/h) (Table 3). Mean length of shrimp collected in bay trawls in June (90 ± 5 mm) would be 112 mm on 9 July as calculated from 15 June.

Although populations were lower than most years (1986-95), catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority of shrimp on the fishing grounds would average ≥112 mm by 15 July 1996. Although brown shrimp remaining in the deeper portion of bays would reach 112 mm on or about 9 July 1996, with longest ebb tidal durations predicted for 10 July-15 July, the TPWC preset Texas Closure opening date of 30 minutes after sunset on 15 July was not altered. This date was in accordance with the statutory mandated 45 day Texas Closure.

1997 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1997. Mean number of shrimp in April bag seines (1.5 ± 0.4/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.3/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 1997 was 51%, compared to a 7-year mean of 32% for 1 June closures, and a 12-year mean of 60% for early closure through 1996, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 49 ± 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 17 May 1997. Periods of maximum ebb tide duration for Galveston Channel were 10 May-14 May and 24 May-28 May. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was not altered, and the Texas Closure began 30 minutes after sunset on 15 May 1997.

Opening Date

Bag seine catch rates of shrimp during June 1997 (2.1 $\pm$ 0.3/ha) were not significantly different from the 18-year average (2.1 $\pm$ 0.2/ha) of previous years (Table 2). Mean length in bag seines (65 $\pm$ 2 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1997 (1.12 $\pm$ 0.1/h) was lower than the June 1982-96 average (1.35 $\pm$ 0.1/h)(Table 3). Mean length of shrimp collected in bay trawls in June (90 $\pm$ 5 mm) would be 112 mm on 9 July as calculated from 15 June.

Catch rates and mean lengths of shrimp during June in the TTS indicated populations were similar to most years from 1986-96, recruitment had occurred, and the majority of shrimp on the fishing grounds would average $\geq$112 mm by 15 July 1997. Although brown shrimp remaining in the deeper portion of bays would reach 112 mm on or about 9 July 1997, with longest ebb tidal durations predicted for 1 July-7 July, the TPWC preset Texas Closure opening date of 30 minutes after sunset on 15 July was not altered. This date helped protect high populations of shrimp found in TPW samples within bays the last two weeks of June.

1998 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1998. Mean number of shrimp in April bag seines (1.5 $\pm$ 0.2/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.3/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 1998 was 62%, compared to a 7-year mean of 32% for 1 June closures, and a 13-year mean of 59% for early closure years through 1997, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 56 $\pm$3 mm. Growth calculated from 15 April indicted mean length would be 90 mm on 13 May 1998. Periods of maximum ebb tide duration for Galveston Channel were 15 May-18 May and 28 May-31 May during 1998. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was not altered, and the Texas Closure began 30 minutes after sunset on 15 May 1998.

Opening Date

Bag seine catch rates of shrimp during June 1998 (2.3 ± 0.2/ha) were not significantly different from the 19-year average (2.1 ± 0.2/ha) of previous years (Table 2). Mean length in bag seines (63± 1 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1998 (1.55 ± 0.2/h) was higher than the June 1982-97 average (1.33 ± 0.1/h)(Table 3). Mean length of shrimp collected in bay trawls in June (86 ± 4 mm) would be 112 mm on 12 July as calculated from 15 June.

Catch rates and mean lengths of shrimp during June in the TTS indicated populations were higher than most years from 1986-97, recruitment had occurred, and the majority of shrimp on the fishing grounds would average ≥112 mm by 15 July 1998. Although brown shrimp remaining in the deeper portion of bays would not reach 112 mm until 12 July 1998, with longest ebb tidal durations predicted for 7 July-12 July, the TPWC preset Texas Closure opening date was altered to 30 minutes after sunset on 8 July. In view of higher than normal populations of shrimp in TTS, it was determined this date would benefit both biological and socio-economic concerns of the fishery.

1999 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 1999. Mean number of shrimp in April bag seines (2.0 ± 0.2/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.3/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 1999 was 71%, compared to a 7-year mean of 32% for 1 June closures, and a 14-year mean of 59% for early closure years through 1998, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 53 ± 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 15 May 1999. Periods of maximum ebb tide duration for Galveston Channel were 2 May-8 May and 15 May-21 May during 1999. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was not altered, and the Texas closure began 30 minutes after sunset on 15 May 1999.

Opening Date

Bag seine catch rates of shrimp during June 1999 (2.2 ± 0.2/ha) were not significantly different from the 20-year average (2.1 ± 0.2/ha) of previous years (Table 2). Mean length in bag seines (58 ± 1 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 1999 (0.90 ± 0.1/h) was lower than the June 1982-98 average (1.35 ± 0.1/h)(Table 3). Mean length of shrimp collected in bay trawls in June (78 ± 4 mm) would be 112 mm on 19 July calculated from 15 June. This catch rate and mean size was the lowest on record for the month of June.

Although populations were lower than most years (1986-98), catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority of shrimp on the fishing grounds would average ≥112 mm by 15 July 1999. Although brown shrimp remaining in the deeper portion of the bays would not reach 112 mm until 19 July 1999, with longest ebb tidal durations predicted for 8 July-15 July, the TPWC preset Texas Closure opening date of 30 minutes after sunset on 15 July was not altered.

2000 Texas Closure

Closure Date

Mean catch rates and sizes of brown shrimp collected in bag seines during April indicated early emigration of brown shrimp to the gulf in 2000. Mean number of shrimp in April bag seines (2.0 ± 0.1/ha) was similar to early closure years, and equal to or greater than the average +2 mean SE (1.3/ha) during combined years when the Texas Closure began 1 June (Table 2). Percentage of samples containing shrimp in 2000 was 78%, compared to a 7-year mean of 32% for 1 June closures, and a 15-year mean of 60% for early closure years through 1999, indicating shrimp were widely distributed along the Texas coast.

Mean length of shrimp in bag seines during April was 54 ± 2 mm. Growth calculated from 15 April indicated mean length would be 90 mm on 15 May 2000. Periods of maximum ebb tide duration for Galveston Channel were 4 May-10 May and 17 May-23 May. Evaluating these data and criteria for Texas Closure dates, the TPWC preset closure date was altered, and the Texas Closure began at 30 minutes after sunset on 11 May 2000.

Opening Date

Bag seine catch rates of shrimp during June 2000 (2.1 ± 0.3/ha) were not significantly different from the 21-year average (2.1 ± 0.2/ha) of previous years

(Table 2). Mean length in bag seines (63 $\pm$ 3 mm) indicated shrimp along bay shorelines in June would not reach 112 mm until at least the end of July or much longer than the authorized Texas Closure.

Mean number of shrimp in the deeper portion of bays in June 2000 (1.32 $\pm$ 0.2/h) was not significantly different from the June 1982-99 average (1.32 $\pm$ 0.2/h) (Table 3). Mean length of shrimp collected in bay trawls in June (92 $\pm$ 2) would be 112 mm on 7 July calculated from 15 June.

Although populations were lower than most years (1986-99), catch rates and mean lengths of shrimp during June in the TTS indicated that recruitment had occurred, and the majority of shrimp on the fishing grounds would average 112 mm by 15 July 2000. Although brown shrimp remaining in the deeper portion of the bays would not reach 112 mm until 7 July 2000, with longest ebb tidal durations predicted for 28 June-5 July, the TPWC preset Texas Closure opening date was altered to 30 minutes after sunset on 5 July.

DISCUSSION

Techniques used to establish a closed season should be simple because they must be employed in a timely manner. The last possible date for collection of TPW coastwide samples are 30 April and 30 June, respectively. Calculations must be made and results presented and approved by the TPW Executive Director who has delegated authority from the TPWC to set season dates. The law requires 72 and 24 h, respectively, for public notice and news releases to be prepared. The NMFS is notified so that public notice can be provided concerning the closing and opening of U. S. waters (>10-$\leq$ 200 nm). The NMFS must follow their in-house procedure which requires a minimum of three days notice prior to the effective opening/closing date.

Changes in opening and closure dates for the Texas Closure during 1993, 1994, 1996, 1998 and 2000 were made considering TPW coastwide fishery independent sample data, maximization of brown shrimp resources to achieve optimum yield on a continuing basis, and the socio-economic aspects of the closure on the fishery. These factors allow TPW coastal fisheries managers to expediently make responsible Texas closure decisions to best manage shrimp resources.

LITERATURE CITED

Baxter, K. N. 1973. Shrimp discarding by the commercial fishery in the Gulf of Mexico. Marine Fisheries Review. 35(9):26.

Baxter, K. N. and W. C. Renfro. 1967. Seasonal occurrence and size distribution of postlarval brown and white shrimp near Galveston, Texas with notes on species identification. Fishery Bulletin. 66(1):149-158.

Berry, R. J. and R. C. Benton. 1969. Discarding practices in the Gulf of Mexico shrimp fishery. United Nations Food and Agricultural Organization Fishery Report. 57(3):983-999.

Bryan, C. E. 1983. Abundance of brown shrimp (Penaeus aztecus) as related to the 1982 Closure of the Texas territorial sea to shrimping. Management Data Series Number 52. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Bryan, C. E. 1985. Closure dates for the 1984 Texas gulf shrimping season. Management Data Series Number 82. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Bryan, C. E. 1986. Prediction of the closure dates for the 1983 Texas gulf shrimping season. Proceedings of the Shrimp Yield Prediction Workshop. Texas A&M University Sea Grant College. TAMU-SF-86-110.

Bryan, C. E. 1988. Closure dates for the 1985 Texas gulf shrimping season. Management Data Series Number 127. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Bryan, C. E., T. J. Cody, and G. C. Matlock. 1982. Organisms captured by the commercial shrimp fleet on the Texas brown shrimp (Penaeus aztecus) grounds. Technical Series Number 31. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Center for Wetland Resources. 1980. Management plan and final environmental impact statement for the shrimp fishery of the Gulf of Mexico, Unites States waters. Louisiana State University, Baton Rouge, Louisiana.

Cody, T. J., R. P. Campbell, P. C. Hammerschmidt, G. C. Matlock, C. E. Bryan, J. E. Clark, and L. S. Procarione. 1990. Texas shrimp fishery management plan. Source Document. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Collier, A. and J. W. Hedpeth. 1950. An introduction to the hydrography of tidal waters of Texas. Publications of the Institute of Marine Science. 1(2):125-177.

Copeland, B. J. 1965. Fauna of the Aransas Pass Inlet, Texas. I. Emigration as shown by tide trap collections. Publications of the Institute of Marine Science. 10:9-21.

Fuls, B. E. 1990. Closure dates for the 1986 Texas gulf shrimping season. Management Data Series Number 45. Texas Parks and Wildlife Department, Fisheries Division. Coastal Fisheries Branch. Austin, Texas.

Fuls, B. E. 1993. Closure dates for the 1991 and 1992 Texas gulf shrimping seasons. Management Data Series Number 104. Texas Parks and Wildlife Department, Fisheries and Wildlife Division, Coastal Fisheries Branch. Austin, Texas.

Hensley, R. A. and B. E. Fuls. 1998. Trends in relative abundance and size of selected finfishes and shellfishes along the Texas coast: November 1975-December 1996. Management Data Series Number 159. Texas Parks and Wildlife Department, Coastal Fisheries Division. Austin, Texas.

Johnson, R. B., Jr. 1976. A study of Texas shrimp populations, 1976. Coastal Fisheries Project Report 1976. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

King, B. D., III. 1971. Study of migratory patterns of fish and shellfish through a natural pass. Technical Series Number 9. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Klima, E. F., J. M. Nance, E. S. Denton, and S. Nichols. 1990. Executive summary of the 1989 Texas Closure. Draft report to the Gulf of Mexico Fisheries Management Council. Southeast Fisheries Center, Service. Galveston Laboratory. Galveston, Texas.

Matlock, G. C. and M. F. Ferguson. 1982. Shallow-water surface acres and shoreline National Marine Fisheries distances on the Texas coast. Management Data Series Number 37. Texas Parks and wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Moffett, A. W. 1967. A study of commercial shrimp populations in coastal bays of Texas, 1967. Coastal Fisheries Project Report 1967. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Moffett, A. W. 1972. Shrimp populations in Texas, 1972. Coastal Fisheries Project Report 1972. Texas Parks and Wildlife Department, Coastal Fisheries Branch. Austin, Texas.

Nichols, S. 1990. Potential change in yield due to the Texas Closure. Draft report to the Gulf of Mexico Fisheries Management Council. National Marine Fisheries Service. Pascagoula Facility. Pascagoula, Mississippi.

Parker, J. C. 1970. Distribution of juvenile brown shrimp (Penaeus aztecus, Ives) in Galveston Bay, Texas, as related to certain hydrographic features and salinity. Contributions in Marine Science. 15:1-12.

Parrack, M. L. 1979. Aspects of brown shrimp, Penaeus aztecus, growth in the northern Gulf of Mexico. Fishery Bulletin. 76(4):827-836.

Procarione, L. S. and B. E. Fuls. 1990. Closure dates for the 1986 Texas gulf shrimping season. Management Data Series Number 25. Texas Parks and Wildlife Department, Fisheries Division. Coastal Fisheries Branch. Austin, Texas.

Robinson, L., P. Campbell, and L. Butler. 1998. Trends in Texas commercial fishery landings 1972-1997, Management Data Series Number 158. Texas Parks and Wildlife Department. Coastal Fisheries Division. Austin, Texas.

State of Texas. 1989. Texas Parks and Wildlife Laws. West Publishing Company. St. Paul, Minnesota.

Trent, L. 1967. Size of brown shrimp and time of emigration from the Galveston Bay system, Texas. Proceedings of the Gulf and Caribbean Fisheries Institute. 19:7-26.

U. S. Department of Commerce. 1998. Fisheries of the United States, 1997. Current Fisheries Statistics Number 9700. Washington, District of Columbia.

Table 1. Dates for Texas Closures 1959-2000[a].

Year[b]	Date[c] Closing	Date[c] Opening	Duration days
1959	1 Jun	15 Jul	45
1960	1 Jun	15 Jul	45
1961	1 Jun	15 Jul	45
1962	1 Jun	15 Jul	45
1963	1 Jun	15 Jul	45
1964	1 Jun	15 Jul	45
1965	1 Jun	15 Jul	45
1966	1 Jun	15 Jul	45
1967[d]	17 May	01 Jul	45
1968	1 Jun	15 Jul	45
1969	1 Jun	15 Jul	45
1970	1 Jun	15 Jul	45
1971	1 Jun	15 Jul	45
1972[d]	17 May	01 Jul	45
1973	1 Jun	15 Jul	45
1974	1 Jun	15 Jul	45
1975	1 Jun	15 Jul	45
1976[d]	17 May	16 Jul	60
1977	1 Jun	15 Jul	45
1978	1 Jun	15 Jul	45
1979	1 Jun	15 Jul	45
1980	1 Jun	15 Jul	45
1981[d]	22 May	16 Jul	55
1982[d]	25 May	14 Jul	50
1983[d]	27 May	15 Jul	49
1984[d]	16 May	06 Jul	51
1985[d]	20 May	08 Jul	49
1986[d]	10 May	02 Jul	53
1987	1 Jun	15 Jul	45
1988	1 Jun	15 Jul	45
1989	1 Jun	15 Jul	45
1990[d]	15 May	08 Jul	54
1991[d]	15 May	06 Jul	52
1992[d]	15 May	06 Jul	52
1993[d]	15 May	06 Jul	52

Table 1. (Cont'd.)

Year[b]	Date[c] Closing	Date[c] Opening	Duration days
1994[d]	13 May	07 Jul	53
1995	15 May	15 Jul	60
1996[d]	01 Jun	15 Jul	45
1997	15 May	15 Jul	60
1998[d]	15 May	08 Jul	54
1999	15 May	15 Jul	60
2000[d]	11 May	05 Jul	55

[a]Through 1989 statutory dates for the closed gulf shrimp season were 1 June-15 July. Beginning in 1990 the statutory closed gulf shrimp season was 15 May-15 July.
[b]In 1975 the maximum length of the closed season was increased from 45 days to 60 days.
[c]Through 1981 the season closing and opening times were 12:01 a.m. During 1982-00, the closing and opening times were 30 minutes after sunset.
[d]Modifications to normal closure dates.

Table 2. Coastwide mean catch rate (no./ha + 1 transformed to $Log_{10} \pm 1SE$) and mean length (mm $\pm$ 1SE) of brown shrimp collected with 18.3-m wide bag seines along shorelines in Sabine, Galveston, East Matagorda, San Antonio, Aransas and Corpus Christi Bays, and upper and lower Laguna Madre during April and June 1978-00[a]. ND = no data.

		April			June		
Year	Samples/mo	Mean catch rate (no./ha)[b]	Samples containing shrimp (%)[c]	Mean length	Mean catch rate (no./ha)[d]	Samples containing shrimp (%)	Mean length[e]
1978	42	0.7 ± 0.4	33	48 ± 3	ND	ND	ND
1979	42	0.6 ± 0.4	31	48 ± 2	2.0 ± 0.6	74	62 ± 4
1980	42	0.4 ± 0.2	21	49 ± 3	2.4 ± 0.3	83	63 ± 3
1981	42	2.0 ± 0.5	76	54 ± 3	1.9 ± 0.4	69	60 ± 3
1982	70	1.8 ± 0.3	64	52 ± 2	2.3 ± 0.4	79	68 ± 3
1983	80	1.4 ± 0.4	56	43 ± 2	2.3 ± 0.3	82	63 ± 4
1984	80	1.7 ± 0.4	66	57 ± 4	2.2 ± 0.4	81	69 ± 3
1985	80	1.4 ± 0.5	44	52 ± 2	2.4 ± 0.4	84	64 ± 3
1986	90	2.0 ± 0.2	67	58 ± 3	1.6 ± 0.4	66	69 ± 5
1987	90	1.1 ± 0.3	36	47 ± 3	1.7 ± 0.4	71	65 ± 3
1988	108	0.9 ± 0.2	36	47 ± 4	2.1 ± 0.4	78	71 ± 2
1989	108	1.0 ± 0.2	38	46 ± 3	2.4 ± 0.2	81	59 ± 2
1990	144	1.8 ± 0.3	63	53 ± 2	1.9 ± 0.2	72	65 ± 2
1991	144	1.8 ± 0.3	60	57 ± 3	2.2 ± 0.3	72	66 ± 3
1992	170	1.4 ± 0.3	48	53 ± 2	2.0 ± 0.2	71	58 ± 2
1993	170	1.4 ± 0.3	52	50 ± 3	2.4 ± 0.2	79	62 ± 1
1994	170	1.6 ± 0.2	55	55 ± 2	2.2 ± 0.2	78	67 ± 2
1995	170	1.8 ± 0.2	65	52 ± 2	2.0 ± 0.2	72	65 ± 2
1996	170	0.8 ± 0.1	27	46 ± 2	2.2 ± 0.3	78	60 ± 1
1997	170	1.5 ± 0.4	51	49 ± 2	2.1 ± 0.3	69	65 ± 2

Table 2. (Cont'd.)

Year	Samples/mo	April			June		
		Mean catch rate (no./ha)[b]	Samples containing shrimp (%)[c]	Mean length	Mean catch rate (no./ha)[d]	Samples containing shrimp (%)	Mean length[e]
1998	170	1.5 ± 0.2	62	56 ± 3	2.3 ± 0.2	80	63 ± 1
1999	170	2.0 ± 0.2	71	53 ± 2	2.2 ± 0.2	79	58 ± 1
2000	170	2.0 ± 0.1	78	54 ± 2	2.1 ± 0.3	75	63 ± 3

[a]Differences in bag seine statistics in this report compared to previous reports are due to updating the data base.
[b]Mean no./ha ± 2SE for 1978-80, 1987-89 and 1996 = 1.3/ha; years when there was a 1 June closure.
[c]Percentage of samples containing shrimp; mean for years 1978-80; 1987-89 and 1996 = 32%
[d]Mean no./ha ± 1SE 1979-99 = 2.1 ± 0.2
[e]Mean length (mm) ± 1SE 1979-99 = 64 ± 4

Table 3. Coastwide mean catch rate (no./h + 1 transformed to $\log_{10} \pm$ 1SE) and mean length (mm $\pm$ 1SE) of brown shrimp collected with 6.1-m wide otter trawls in the deeper ($\geq$1 m) water of Sabine, Galveston, East Matagorda, Matagorda, San Antonio, Aransas and Corpus Christi Bays and the upper and lower Laguna Madre during June 1982-00[a].

Year	No./h[b]	Mean length (mm)[c]	Date shrimp = 112 mm (calculated from 15 June)
1982	1.4 $\pm$ 0.2	92 $\pm$ 2	07 Jul
1983	1.3 $\pm$ 0.2	96 $\pm$ 2	02 Jul
1984	1.5 $\pm$ 0.2	101 $\pm$ 3	27 Jun
1985	1.4 $\pm$ 0.2	91 $\pm$ 2	08 Jul
1986	1.3 $\pm$ 0.2	96 $\pm$ 2	02 Jul
1987	1.5 $\pm$ 0.2	90 $\pm$ 4	09 Jul
1988	1.3 $\pm$ 0.2	91 $\pm$ 2	08 Jul
1989	1.4 $\pm$ 0.2	86 $\pm$ 2	12 Jul
1990	1.2 $\pm$ 0.2	97 $\pm$ 2	01 Jul
1991	1.2 $\pm$ 0.2	90 $\pm$ 2	10 Jul
1992	1.3 $\pm$ 0.2	83 $\pm$ 5	15 Jul
1993	1.3 $\pm$ 0.2	91 $\pm$ 4	08 Jul
1994	1.2 $\pm$ 0.2	94 $\pm$ 1	05 Jul
1995	1.3 $\pm$ 0.2	83 $\pm$ 2	15 Jul
1996	1.5 $\pm$ 0.2	90 $\pm$ 5	09 Jul
1997	1.1 $\pm$ 0.2	90 $\pm$ 5	09 Jul
1998	1.6 $\pm$ 0.2	86 $\pm$ 4	12 Jul
1999	0.9 $\pm$ 0.1	78 $\pm$ 4	19 Jul
2000	1.3 $\pm$ 0.2	92 $\pm$ 2	07 Jul

[a]Differences in bay trawl statistics in this report compared to previous reports are due to updating the data base.
[b]Mean no./h + SE 1982-99 = 1.3 $\pm$ 0.1.
[c]Overall mean length 1982-99 = 90.2

Table 4. Coastwide mean catch rate (no./h + 1 transformed to $\log_{10} \pm$ 1SE) and mean length (mm $\pm$ 1SE) of brown shrimp collected in five areas of the TTS in the Gulf of Mexico with 6.1 m trawls during June 1986-00[a].

Year	Mean no./h	Mean length (mm)	Mean length (mm) adjusted to 6/30 (calculated from 15 June)
1986	0.7 ± 0.2	107 ± 3	120
1987	1.0 ± 0.2	104 ± 2	117
1988	1.3 ± 0.2	105 ± 3	119
1989	1.9 ± 0.3	99 ± 3	113
1990	1.0 ± 0.2	108 ± 2	120
1991	1.0 ± 0.1	97 ± 6	111
1992	0.6 ± 0.1	92 ± 5	105
1993	0.7 ± 0.2	101 ± 3	114
1994	0.4 ± 0.1	100 ± 3	113
1995	0.9 ± 0.3	99 ± 4	113
1996	0.7 ± 0.1	98 ± 3	112
1997	0.9 ± 0.2	95 ± 3	108
1998	1.4 ± 0.3	99 ± 5	113
1999	0.8 ± 0.2	96 ± 2	110
2000	1.1 ± 0.3	102 ± 3	115

[a]Differences in gulf trawl statistics in this report compared to previous reports are due to updating the data base.

PWD RP V3400-705 (4/01)