# A Telemetry Study of Striped Bass Emigration from Clifton Court Forebay: Implications for Predator Enumeration and Control

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# Abstract

From July 17, 1995, to June 26, 1996, we monitored the movement of ultrasonic-tagged adult and subadult striped bass in and around Clifton Court Forebay. The movement of these fish was used to assess the validity of mark/recapture methods to estimate adult and subadult (predator-sized) striped bass abundance in Clifton Court Forebay and the feasibility of predator-fish removal as a method to improve entrained fish survival. Tags were applied quarterly to striped bass captured and released in Clifton Court Forebay. About 40 tags were applied each quarter, 180 striped bass were tagged, and 152 tagged striped bass were monitored at automatic tag detection stations. Forty tagged striped bass emigrated from Clifton Court Forebay, and 23 moved out of and back into the forebay; moderate background flux through the radial gates was punctuated with mass emigrations. Results show that Clifton Court Forebay is an open system in which many adult and subadult striped bass move through the radial gates over short periods and confirm these suggestions from previous work at the forebay. Such movement violates two fundamental assumptions of mark/recapture methods to estimate fish abundance (*ie*, no immigration, no emigration). This finding suggests that past Petersen Index striped bass abundance estimates for Clifton Court Forebay were not valid, and efforts to control predation by large-scale predator removal may be offset by rapid movement of adult and subadult striped bass into the forebay. The effectiveness of predator removal as a method to improve entrained fish survival would be difficult to quantify without accurate striped bass abundance estimates.

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# Acknowledgments

The use of firm names in this report does not imply endorsement by the Interagency Ecological Program or its member agencies.

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# Introduction

The objective of this study was to document the short-term movements of adult and subadult striped bass through the radial gates at Clifton Court Forebay (Figure 1). The goal was to provide managers with information to assess the validity of mark/recapture methods to estimate adult and subadult striped bass abundance in Clifton Court Forebay and the feasibility of predator-fish removal as a method to decrease prescreen loss to fish entrained into the forebay. The study was conducted under the Interagency Ecological Program by the Department of Fish and Game, Bay-Delta Division, Fish Facilities Unit, and funded through the Department of Water Resources, Environmental Services Office.

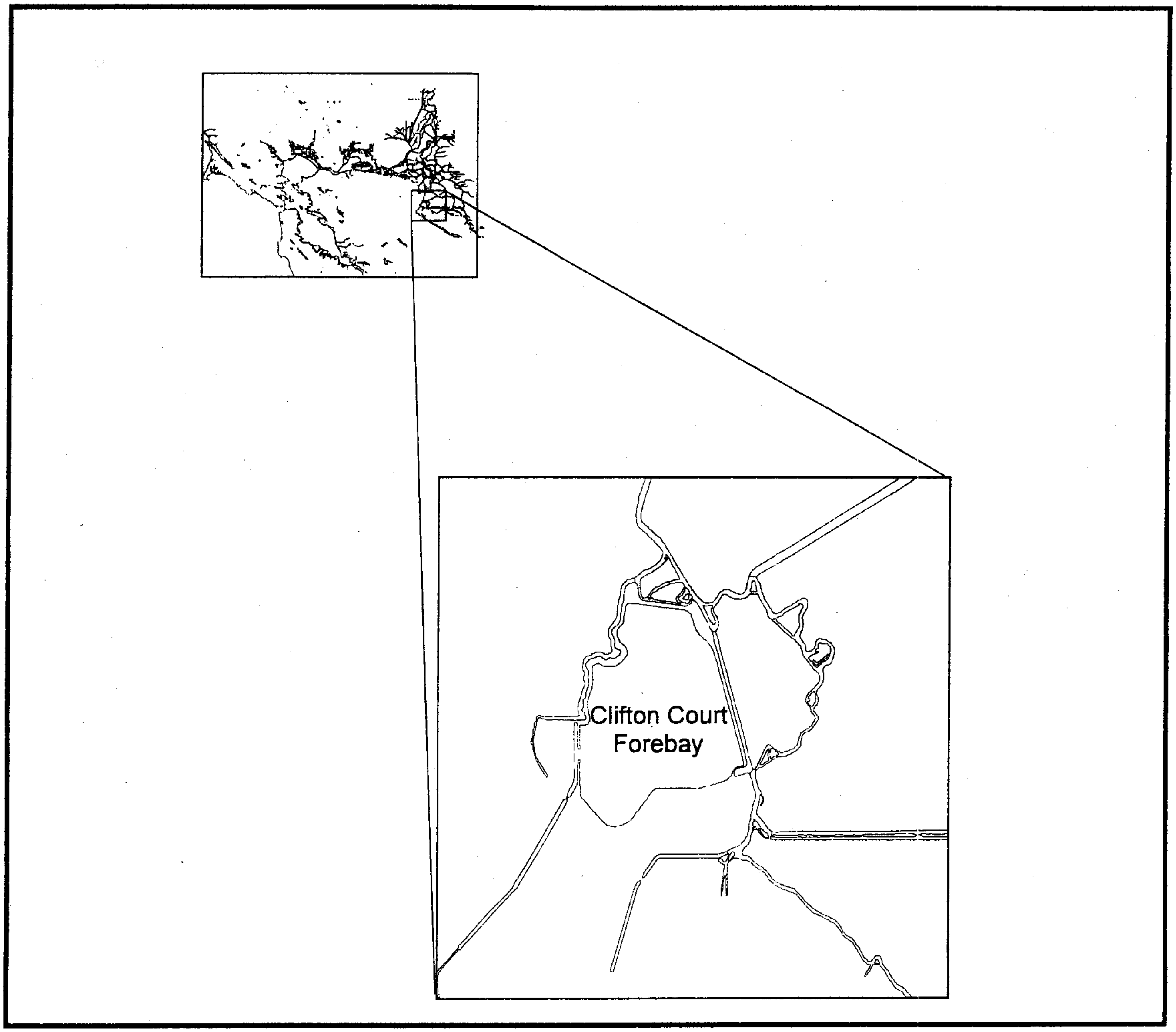


Figure 1
CLIFTON COURT FOREBAY, CALIFORNIA

Large-scale removal of adult and subadult (*ie*, greater than 180mm fork length, predator-sized) striped bass has been one of several methods proposed to reduce predation loss to fish entrained into Clifton Court Forebay. Predator-fish removal is intuitively appealing for several reasons:

- Predation by striped bass is thought to be the largest component of prescreen loss to fish entrained into Clifton Court Forebay.
- Striped bass are presumed to forage on species of special concern. (For food habits of striped bass in the Delta, see Stevens 1966).
- Mark/recapture estimates of predator-sized striped bass suggest they may be abundant in Clifton Court Forebay (*eg*, 223,808 in winter 1992; DFG in prep).

Past work at Clifton Court Forebay has shown that some aspects of predator removal are feasible: striped bass can be caught in large numbers (*eg*, 26,670 in 80 days), successfully trucked to sites throughout the delta, and released (Tillman 1994). Compared with proposed alternatives to reduce prescreen loss (*eg*, screening the intake to Clifton Court Forebay), a program to remove predators might be less expensive in the near term.

Two types of data would be required to attribute any change in prescreen loss to predator removal efforts: accurate estimates of prescreen loss, and accurate estimates of predator abundance. The Interagency Program has completed 10 prescreen loss studies at Clifton Court Forebay (Schaffter 1978; Hall 1980b; Coulston 1992; Tillman 1994). Abundance estimates using mark/recapture techniques have been made since the early 1980s (IEP Annual Reports 1984, 1987, 1994).

While a large-scale predator removal proposal was receiving review, and concurrent to a mark/recapture estimate of predator abundance late in the summer of 1994, DFG conducted a pilot striped bass ultrasonic tagging study at Clifton Court Forebay. During the 1-month study, 14 of 20 tagged striped bass moved out of Clifton Court Forebay through the radial gates. Of the 14, 10 may have moved back into Clifton Court Forebay. Thus, at least one assumption (no emigration) for the mark/recapture study had been violated.

Feasibility of the proposed predator removal study became suspect in two respects:

- Efforts to control predation by large-scale predator removal could be offset by rapid movement of predators into the forebay.
- Effectiveness of predator removal as a means to improve entrained fish survival would be difficult to quantify without accurate predator abundance estimates.

Following the outcome of the pilot tagging study, planning for the large-scale predator removal study was suspended, and planned predator abundance estimates were canceled.

## Tag and Automatic Tag Detection Stations

Ultrasonic tags (Sonotronics models PRG-94 and PRG-94HP) operated on 18 carrier frequencies, 30 kHz through 83 kHz, and were individually identifiable by a unique combination of sound frequency and interval between sound pulses. The cylindrical tags (16 by 60 mm and 18 by 65 mm, respectively) weighed 8 grams in water and were activated by a magnetic switch. Sound output varied from –40 to –70 dB referenced at 1 µBar. Typical tag life was 4 months.

We maintained automatic tag detection stations near Clifton Court Forebay's radial gates, inside and outside the forebay, and at the Skinner Fish Facility trash boom (Figure 2). Each station included a receiver (Sonotronics USR-90), data logger (Hewlett-Packard HP-200 LX), compiled data-logging software (Appendix A), and at least one directional hydrophone (Sonotronics DH-2). Each station monitored for tags around the clock, scanned all tag frequencies used in the study, and logged each tag occurrence to an ASCII data file. Data files from each station were downloaded twice a week. Before leaving each station, station performance was confirmed by reviewing each downloaded data file and logging several records from a test tag.

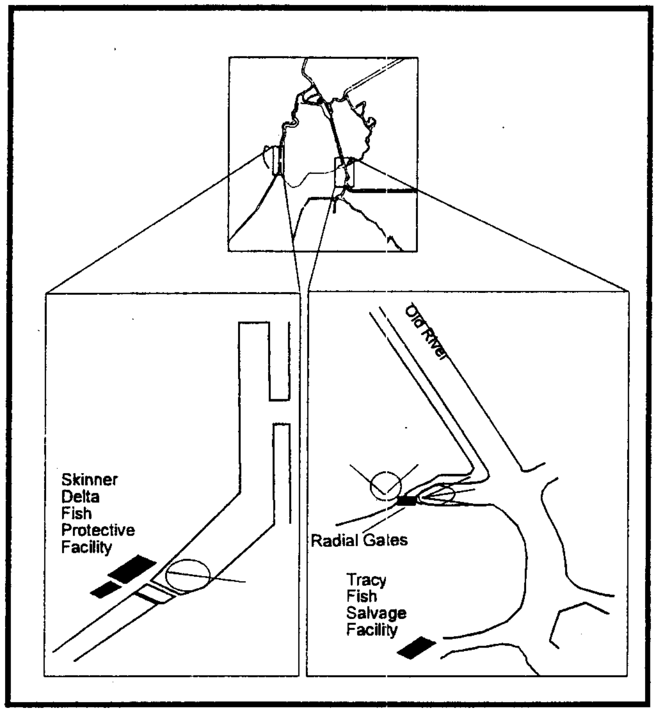


Figure 2
DETAIL OF HYDROPHONE PLACEMENT AND ORIENTATION
Ellipses roughly correspond to areas where tags were detected. Lines through ellipses depict number of hydrophones and the acoustic axis of each hydrophone.

The normal practice of operating Clifton Court Forebay to maintain a large hydraulic head at the radial gates results in abundant aquatic noise from turbulent flow when the gates are open. This noise can mask legitimate tag signals. To increase the probability of detecting tagged striped bass when the gates were open, we used receivers and hydrophones configured to maximize sampling frequency and sensitivity (Appendix B). This practice was effective, although we collected and processed large amounts of redundant, often noisy data.

## Fish Capture and Tagging

Beginning in July and at 3-month intervals, about 40 striped bass were captured in Clifton Court Forebay and fitted with externally mounted ultrasonic tags. Capture gear included Kodiak trawl, gill-net, and angling. Striped bass were captured from around the forebay, but most were captured and tagged near the radial gates. Only vigorous fish, appearing healthy, and longer than 240mm fork length were tagged (Appendix C).

Striped bass selected for tagging were placed in a 378-liter tub, half filled with forebay water. Tag number, fork length (mm), capture gear, and capture area were recorded. External tag attachment was similar to the method described by Gray and Haynes (1979) and Chadwick (1963), although we did not use anesthesia. Two 17-gauge, 3.5-inch-long hypodermic needles were inserted laterally through the dorsal musculature, beneath the spinous dorsal fin. The ends of a stainless steel wire were passed through the tag and then the needles. The needles were removed, leaving the tag firmly against the fish and wire ends protruding opposite the tag. A flexible plastic backing plate was placed over the wire ends, firmly against the fish. The wire ends were joined, wound together, and excess wire removed. The procedure typically took less than 3 minutes. Following tagging, fish condition was evaluated, and vigorous fish were immediately released into the forebay.

## Tagging Effect

To determine if tagging substantially affects striped bass behavior and physiology and to what degree our results might represent untagged fish movement, we held predator-sized striped bass in a common tank (28,000 L) at the Clifton Court Forebay growout facility. Two groups of fish were held, one in late fall (October 17, 1995, to February 6, 1996) and another in spring (April 2, 1996, to May 23, 1996). We placed nonfunctional tags on a fraction of each group and made frequent visual observations of swimming, schooling, and feeding behavior. After the holding period, each fish was sacrificed and these data were recorded: qualitative appraisal of overall condition, weight, fork length, and qualitative appraisal of fat deposition.

## Analysis

We extracted striped bass detection data for 3 months following tag application (Appendix D), although typical tag life was 4 months. This approach made data management and manipulation somewhat more practical and minimized the effects of several possible biases; even with this approach, the complete raw dataset is large (>40 MB).

To report movement on the shortest meaningful temporal scale, we aggregated tagged striped bass movement data by week and used a standardized unit of fish movement defined as $flux_{week} = f/s \times 100$, where $f$ = count of individual fish moving in or out of Clifton Court Forebay through the radial gates and $s$ = count of fish monitored at automatic tag detection stations (a superset of *f*). This unit provides a measure of movement relatively unbiased by tagged fish mortality, emigration, and tag failure. To report movement on a longer temporal scale (*ie,* corresponding roughly to periods in an annual striped bass migration), we aggregated movement data into 10-week periods, dividing the study into five equal parts.

Telemetry work by Bolster (1986) may have documented emigration of striped bass from Clifton Court Forebay. The focus of her work was to establish "habitat selection indices" for areas within Clifton Court Forebay and "activity regions" for individual fish. She radio-tagged and tracked 30 adult and subadult striped bass using mobile tracking techniques and did not attempt to document the emigration of tagged fish from Clifton Court Forebay. Using Bolster's data on tracking duration and expected tag life, we summarized what we suggest is emigration among the radio-tagged striped bass.

## Tagging Effect

Tagged striped bass held at the growout facility swam vigorously, oriented normally, schooled with untagged fish, and fed on live prey-sized American and thread-fin shad. No tags were shed, and irritation at the point of wire insertion was moderate and consistent with a description of irritation to disk-tagged striped bass (Chadwick 1963). Tagged fish appeared healthy after several months, although only untagged fish showed fat deposition on pyloric ceca (Tables 1 and 2).

Table 1
STRIPED BASS HELD IN THE
CLIFTON COURT FOREBAY GROWOUT FACILITY,
OCTOBER 17, 1995, TO FEBRUARY 6, 1996

| Fork Length (mm) | End Weight (grams) | Fat Deposition |
|---|---|---|
| **Tagged** | | |
| 410 | 567.9 | None |
| 411 | 727.0 | None |
| 435 | 855.1 | None |
| 450 | 896.2 | None |
| 491 | 1220.9 | None |
| **Untagged** | | |
| 367 | 640.3 | Moderate |
| 372 | 571.6 | Moderate |
| 420 | 723.5 | None |
| 420 | 842.4 | Abundant |
| 435 | 951.8 | Abundant |
| 440 | 945.1 | Moderate |
| 450 | 1072.2 | Moderate |

Table 2
STRIPED BASS HELD IN THE
CLIFTON COURT FOREBAY GROWOUT FACILITY,
APRIL 2, 1996, TO MAY 23, 1996

| Fork Length (mm) | Change in Weight (grams*) | Fat Deposition |
|---|---|---|
| **Tagged** | | |
| 423 | -86 | None |
| 431 | -199 | None |
| 439 | -57 | None |
| 440 | -114 | None |
| 447 | -114 | None |
| 450 | -57 | None |
| 460 | 29 | None |
| 469 | -114 | None |
| **Untagged** | | |
| 370 | -29 | None |
| 380 | -114 | None |
| 423 | -86 | None |
| 435 | -143 | None |
| 439 | -86 | None |
| 452 | 86 | None |
| 457 | -86 | None |
| 474 | -29 | None |
| 517 | -143 | None |

*Weights were converted from ounces to grams.

## Tagging and Recovery

A total of 180 striped bass were tagged and released, ranging from 246-690 mm FL (mean FL = 431 mm, Figure 3). Automatic tag detection stations recorded 152 tagged fish. Four tags were returned by anglers who captured tagged fish outside the forebay, and five were returned by anonymous sources.

DWR staff observed 18 tagged striped bass impinged on the trash racks at Skinner Fish Facility, including 13 over a 2-day period following a June 11, 1996, application to the forebay of *Komeen* (an herbicide). No impingements were observed following a similar application of *Komeen* on August 22-23, 1995, when surface water temperature averaged 2 degrees cooler. We suspect the mortalities may have been related to an interaction between generally poor water quality, sustained high exports, and decreased swimming stamina caused by external tags (Mellas and Haynes 1985; Hall 1980a).

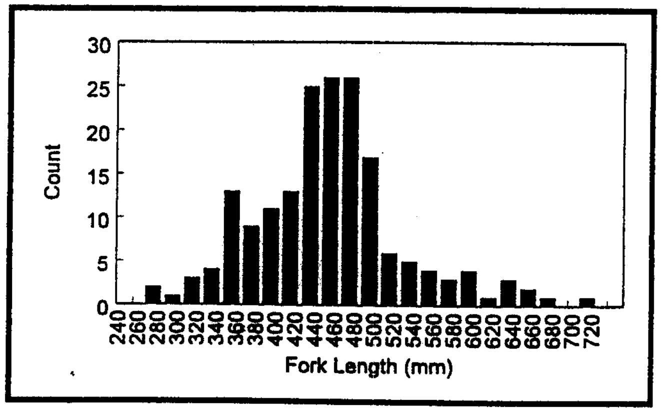


Figure 3
LENGTH DISTRIBUTION OF STRIPED BASS TAGGED DURING TELEMETRY STUDY OF EMIGRATION FROM CLIFTON COURT FOREBAY

## Fish Movement

We documented 133 radial gate transits. Forty tagged striped bass emigrated from Clifton Court Forebay, from 1.4 to 73.7 days after tagging (Figure 4). A summary of these observations shows that emigration occurred an average of 28.9 days after tagging. Twenty-three tagged fish moved out of and back into the forebay but did not emigrate within 3 months of tagging (Table 3).

Due to limitations in our ability to detect tags reliably during high flow, the tide height and flow during each radial gate transit cannot be accurately determined, but movement through the radial gates was constrained to selected tides by State Water Project operators. The SWP rank-order prioritizes gate operations, priority one (of three) is the preferred schedule; radial gates are opened 1 hour after low-high tide, closed 1 hour before high-low tide, opened again 1 hour after high-high tide and closed 2 hours before low-low tide. Priorities two and three draft water into Clifton Court Forebay across more of the tidal cycle.

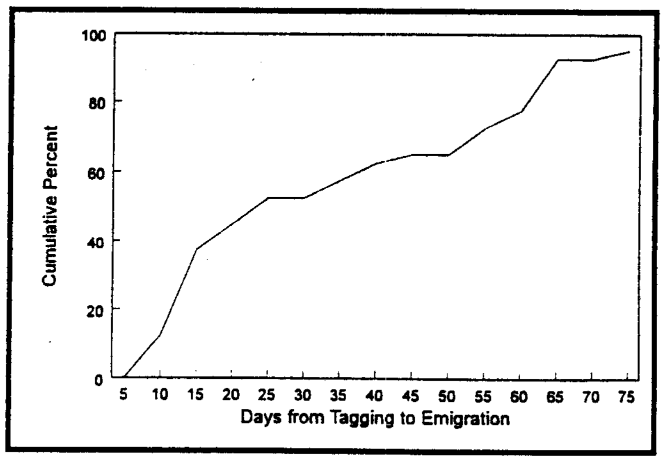


Figure 4
SUMMARY OF
EMIGRATION DATA FROM A TELEMETRY STUDY OF STRIPED BASS TAGGED IN CLIFTON COURT FOREBAY

Table 3
FINAL RADIAL GATE TRANSIT OBSERVATIONS OF ULTRASONIC-TAGGED STRIPED BASS
MOVING IN OR OUT OF CLIFTON COURT FOREBAY

| Tag Number | Fate | Length | Date | Time | Tag Number | Fate | Length | Date | Time |
|---|---|---|---|---|---|---|---|---|---|
| 15 | E | 324 | 09/05/95 | 04:00:42 | 131 | E | 443 | 04/10/96 | 13:56:17 |
| 58 | E | 435 | 12/01/95 | 06:55:20 | 135 | E | 466 | 04/12/96 | 07:25:32 |
| 61 | E | 439 | 10/19/95 | 18:13:10 | 137 | E | 358 | 04/28/96 | 11:26:49 |
| 64 | E | 492 | 10/20/95 | 18:26:07 | 142 | E | 510 | 06/04/96 | 22:12:41 |
| 66 | E | 640 | 10/18/95 | 17:57:38 | 143 | E | 438 | 04/21/96 | 08:16:18 |
| 68 | E | 565 | 10/29/95 | 11:08:08 | 144 | E | 433 | 05/31/96 | 10:56:13 |
| 69 | E | 480 | 10/22/95 | 20:45:06 | 160 | E | 404 | 05/12/96 | 10:20:40 |
| 72 | E | 620 | 11/19/95 | 00:01:46 | 178 | E | 315 | 06/03/96 | 01:19:31 |
| 73 | E | 653 | 10/29/95 | 10:13:04 | 14 | IO | 569 | 10/06/95 | 02:18:52 |
| 74 | E | 548 | 11/02/95 | 06:35:09 | 54 | IO | 380 | 10/17/95 | 14:54:33 |
| 75 | E | 440 | 10/27/95 | 14:06:21 | 56 | IO | 440 | 11/12/95 | 13:21:22 |
| 78 | E | 465 | 10/26/95 | 21:36:44 | 57 | IO | 332 | 10/29/95 | 16:12:53 |
| 85 | E | 452 | 11/03/95 | 08:00:08 | 62 | IO | 405 | 10/19/95 | 11:01:33 |
| 86 | E | 473 | 11/04/95 | 09:01:55 | 63 | IO | 409 | 10/20/95 | 18:56:03 |
| 88 | E | 466 | 11/03/95 | 21:44:23 | 67 | IO | 582 | 12/05/95 | 15:19:55 |
| 89 | E | 524 | 03/17/96 | 06:43:25 | 77 | IO | 445 | 01/09/96 | 15:26:49 |
| 90 | E | 477 | 03/17/96 | 06:26:50 | 99 | IO | 546 | 04/24/96 | 14:23:01 |
| 91 | E | 605 | 03/17/96 | 06:44:24 | 106 | IO | 400 | 02/22/96 | 10:21:59 |
| 92 | E | 477 | 03/17/96 | 06:48:30 | 108 | IO | 414 | 04/07/96 | 08:20:40 |
| 94 | E | 529 | 03/23/96 | 12:31:27 | 109 | IO | 562 | 05/02/96 | 01:32:25 |
| 101 | E | 449 | 04/12/96 | 06:36:29 | 117 | IO | 494 | 04/13/96 | 03:29:26 |
| 103 | E | 508 | 04/09/96 | 14:04:36 | 121 | IO | 535 | 02/20/96 | 14:32:56 |
| 111 | E | 516 | 02/19/96 | 09:38:24 | 122 | IO | 445 | 04/21/96 | 10:55:59 |
| 113 | E | 614 | 03/12/96 | 02:37:37 | 125 | IO | 444 | 04/04/96 | 09:21:02 |
| 114 | E | 415 | 04/07/96 | 12:36:41 | 126 | IO | 455 | 04/14/96 | 08:50:11 |
| 116 | E | 472 | 03/05/96 | 09:56:46 | 127 | IO | 419 | 05/09/96 | 22:29:05 |
| 118 | E | 572 | 03/20/96 | 10:30:39 | 134 | IO | 506 | 05/09/96 | 16:20:14 |
| 119 | E | 690 | 03/18/96 | 07:28:13 | 141 | IO | 460 | 05/20/96 | 16:28:45 |
| 123 | E | 437 | 04/12/96 | 06:36:30 | 148 | IO | 441 | 05/23/96 | 11:33:27 |
| 124 | E | 415 | 02/22/96 | 14:02:24 | 166 | IO | 419 | 06/01/96 | 05:01:32 |
| 129 | E | 437 | 05/23/96 | 13:47:51 | 170 | IO | 369 | 06/09/96 | 10:23:06 |
| 130 | E | 435 | 04/07/96 | 09:25:52 | | | | | |

E = Emigrated from Clifton Court Forebay.
IO= Moved out of and back into Clifton Court Forebay.

Mean fork length was 486mm for tagged striped bass moving through the radial gates and 424mm for those monitored at automatic tag detection stations, and significantly different ($p<0.01$). These mean lengths correspond to 3- to 4-year-old fish (Robinson 1960); these fish are classified as subadults by Orsi (1971). Mean lengths of tagged fish moving out of and back into the forebay and those emigrating from the forebay were not significantly different ($p=0.122$).

$Flux_{week}$ throughout the study ranged from 0 to 100 percent, and averaged 17 percent. To determine if $f/s$ (defined earlier for $flux_{week}$) were equal throughout the study period, we aggregated observations into 10-week periods. There were significant ($X^2$ $p=0.002$) differences in cell proportions, with flux maxima during the second, third, and fourth periods of the study.

Seventy-one tagged striped bass moved repeatedly between the radial gates and the trash boom area; they made a total of 225 across-forebay transits. Many of these fish later emigrated from Clifton Court Forebay.

Final observations of 19 predator-sized striped bass tagged by Bolster (1986) occurred within the minimum expected tag life (90 days). A summary of these observations suggests emigration occurred an average of 43 days after tagging (Figure 5). Other than emigration, possible fates for these fish include unreported angler capture, tag failure, and undetected mortality. There were no known tag failures and only one known mortality and, in light of our results, these alternative fates seem unlikely.

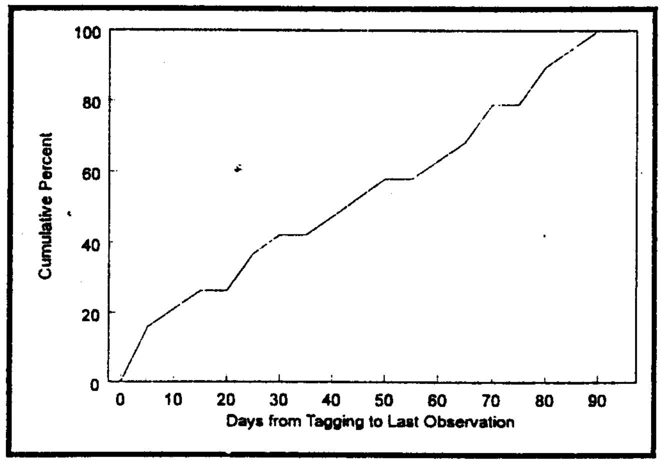


Figure 5
SUMMARY OF FINAL OBSERVATIONS OF RADIO-TAGGED STRIPED BASS IN CLIFTON COURT FOREBAY
As Reported by Bolster (1986)

# Discussion of Predator Enumeration

Much work has been completed on predation issues at Clifton Court Forebay:

- Creel censuses (Mecum 1980).
- Food habits studies (IEP in press; G. Edwards, DFG, personal communication.)
- Prescreen loss estimates (Schaffter 1978; Hall 1980b; Kano 1990; Coulston 1992; Tillman 1994).
- Disk-tag returns (Kano 1990).
- Petersen Index abundance estimates (Kano 1990; Coulston 1992; Tillman 1994; IEP in press; M. Healey, DFG, personal communication).
- Catch per unit effort abundance indices (Kano 1980; Coulston 1992; IEP in press).
- Striped bass removal programs (Coulston 1992; Tillman 1994).
- Telemetry studies (Bolster 1986).

Results from several of these studies speak toward the feasibility of predator enumeration and/or predator control, although no single study has addressed the feasibility of using Petersen indices to estimate striped bass abundance in Clifton Court Forebay.

Before early work on issues of predation at Clifton Court Forebay, the number and age composition of striped bass in Clifton Court Forebay were assumed to reflect entrainment and growth of young-of-the-year striped bass, predation, and salvage. During 1983/1984, DFG conducted the first in a series of predator abundance and composition studies. Kano (1990) reported the estimated number of striped bass >180mm FL varied greatly over the 12-month period — out of proportion to the likely effects of angler harvest, salvage, natural mortality, and predation. Kano also noted that within several years, anglers outside the forebay recaptured several hundred striped bass disk-tagged during the study.[1] To explain the apparent variability in striped bass abundance and the return of disk-tags from outside the forebay, Kano proposed emigration through the radial gates corresponding to the seasonal migrations of adult striped bass throughout the delta.

Over a 1-month period, changes in striped bass catch per unit effort approaching one order of magnitude have been reported (Kano 1990; Tillman 1994). Although CPUE often incorporates bias due to changes in water temperature and fish behavior, CPUE trends at Clifton Court Forebay appear to follow the pattern established for striped bass occurrence in the delta (Chadwick 1967; Orsi 1971), with abundance minima during summer and winter and maxima during spring.

Distinct changes in length frequency distribution of striped bass in Clifton Court Forebay, over both weekly and seasonal time scales, have been reported (Coulston 1992; M. Healey, DFG, personal communication). From 1991 through 1994, seasonal changes in length distribution of striped bass in Clifton Court Forebay and increased abundance of fish greater than 400 mm FL was predictable each spring (M. Healey, DFG, personal communication). During the mark and recapture phases of a Petersen Index striped bass abundance estimate in spring 1992, spanning a 24-day period, Coulston (1992) documented a substantial decrease in abundance of 3-year-old striped bass (*ie,* 300-400mm FL). He suggested that emigration could explain the change in length frequency distributions, expressed uncertainty regarding validity of the abundance estimates, and proposed using telemetry to monitor the movement of striped bass during subsequent abundance estimates.

1 Previously unreported information on these disk-tag returns shows that 6% were from fish recaptured outside Clifton Court Forebay within 90 days of being tagged, 13% were recaptured outside the forebay within 180 days, and 32% were recaptured outside the forebay within 360 days.

Results of our telemetry study confirm the findings from Kano's disk-tagging study and support suggestions from the work of Bolster, Coulston, Healey, and Tillman: a meaningful amount of predator-sized striped bass flux through the radial gates occurs on very short timescales. The flux maximum we observed during spring (the third and fourth periods of our study) corresponds to the migrational movement of adults reported by Chadwick (1967) and Orsi (1971). We suggest that the flux maximum observed during fall (the second period of our study) corresponds to the typical movement behavior of subadult striped bass (Calhoun 1952).

Measured over both short timescales and year-round, changes in striped bass abundance indices (*ie*, Petersen, CPUE), length-frequency distributions, and measurements of flux are evidence that Clifton Court Forebay is not a closed system with a striped bass population reflecting recruitment and growth of young-of-year, predation, and salvage. Instead, Clifton Court Forebay is open to immigration and emigration of predator-sized striped bass. The fundamental assumptions of mark/recapture methods for abundance estimation (*ie*, negligible immigration and emigration) are not valid when Clifton Court Forebay is operated normally. This finding suggests that past Petersen indices of striped bass abundance in Clifton Court Forebay were not valid.

# Discussion of Predator Control

No single study has addressed the feasibility of predator control at Clifton Court Forebay. The feasibility of predator removal is complicated by the fact that Clifton Court Forebay is an open system; thus efforts to reduce the number of striped bass in Clifton Court Forebay could be offset by rapid movement of predator-sized striped bass into the forebay. Effectiveness of predator removal efforts would also be difficult to quantify without accurate striped bass abundance estimates.

Kano (1990) suggested that methods to increase the exploitation of predator-sized striped bass in Clifton Court Forebay (*eg*, allow boat angling, decrease size limits, and increase take limits) might reduce predation, as could frequent large-scale removal programs. However, by implication he suggested that a reduction in predator opportunity — by constructing a salvage facility at the intake to Clifton Court Forebay — was more feasible in an open system with potentially rapid recruitment. In a system like Clifton Court Forebay, where a large and open population of predators contributes to the loss of entrained salmonids, Hall (1977) suggested that predator removal would be ineffective because removal would affect a small fraction of the likely predator population. Hall (1977) and Odenweller (DFG, personal communication) suggest that predation in such systems is primarily limited by prey availability.

Although predation at Clifton Court Forebay has not been thoroughly modeled, the parameters of a model would likely be similar to those used by Rieman and Beamesderfer (1990) and Beamesderfer *et al* (1990), who modeled the influence of northern squawfish, *Ptychocheilus oregonensis*, on the survival of salmonid smolts in Columbia River reservoirs. They found that moderate to heavy exploitation of squawfish (similar in relative magnitude to proposed predator removal at Clifton Court Forebay) resulted in a dramatic increase in smolt survival. However, the selection of squawfish reproduction model (*ie*, the degree to which squawfish would recruit to the system) resulted in a twofold range in exploitation required to sustain a 50% reduction in predation. Because removal efforts at Clifton Court Forebay would not affect reproduction in the striped bass (predator) population or recruitment to Clifton Court Forebay, logic dictates that the level of exploitation to substantially reduce predation at Clifton Court Forebay would need to be very high.

Notwithstanding the extraordinary effort that predator removal would pose as a means to improve prescreen survival of fish entrained at Clifton Court Forebay, a coordinated program to reduce predation should be expected to yield some degree of positive effect. In this respect, initiating a predator control program may seem attractive; however, in a review of 250 fish control projects, Meronek *et al* (1996) classified most of them as failures. They documented many proximate causes for failure (*eg*, insufficient reduction in numbers) but suggested that unreported "seminal reasons" were more often the cause. Suggested seminal causes of failure were insufficient pre- and post-treatment study and lack of criteria for success. Proposed predator removal activities at Clifton Court Forebay have been delayed in substantial part due to the inability to reach a consensus on criteria to quantify success. Because fundamental assumptions of mark/recapture methods for abundance estimation are not valid when Clifton Court Forebay is operated normally, predator control activities would need to be evaluated without accurate predator abundance estimates. Quantifying any improvement in prescreen survival attributable to predator removal efforts would be difficult.

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## Appendix A

# BASIC Program to Log ASCII Records

BASIC program to log ASCII records from USR-90 ultrasonic receiver to any DOS compatible computer—tailored for Hewlett-Packard 200LX palmtop, with an automatic file naming routine, and data formatted for direct import into dBASE. Write an informative data file header line in an ASCII file, name the file header.ini, and place in the same directory as this program or delete lines 145-180.

```
10   CLS
15   INPUT “Are you using a USR-90 multiplex receiver?(y,n)  ”, multanswer$
20   IF multanswer$ = “y” THEN
25           INPUT “Are you using two hydrophones?(y,n)  ”, hydrophone$
30           IF hydrophone$ = “y” THEN
35                   INPUT “enter code for ‘phone A:  ”, multloca$
40                   INPUT “enter code for ‘phone B:  ”, multlocb$
45                           fileloc$ = multloca$ + multlocb$
50           ELSEIF hydrophone$ = “n” THEN
55                   INPUT “Enter the two digit location code for this site:  ”, location$
60                           fileloc$ = location$
65           ELSEIF hydrophone$ <> “y” OR hydrophone$ <> “n” THEN
70                   GOTO 25
75           END IF
80   ELSEIF multanswer$ = “n” THEN
85           INPUT “Enter the two digit location code for this site:  ”, location$
90                   fileloc$ = location$
95   ELSEIF multanswer$ <> “n” OR multanswer$ <> “y” THEN
100          GOTO 15
105  END IF
110  LOCATE 14, 1
115  PRINT “Make sure at least one record is displayed in the above window BEFORE you leave!”
120  PRINT “Use the answers to the prompts to fill out the log book.”
125  OPEN “com1:1200,n,8,2,ds,cs,asc” FOR INPUT AS #1
130          LOCATE 12, 30
135          PRINT “COM1 is open. The computer is working.”
140          filename$ = MID$(DATE$, 1, 2) + MID$(DATE$, 4, 2) + fileloc$ + “.dat”
145          OPEN filename$ FOR APPEND AS #2
150          OPEN “header.ini” FOR INPUT AS #3
155                  DO WHILE NOT EOF(3)
160                          LINE INPUT #3, fileheader$
165                          PRINT #2, fileheader$
170                  LOOP
175          CLOSE #3
180          CLOSE #2
185  VIEW PRINT 7 TO 9
190  LINE INPUT #1, data$
```

```
195         receivermult$ = MID$(data$, 2, 1)
200         IF receivermult$ = "A" THEN
205                 location$ = multloca$
210         ELSEIF receivermult$ = "B" THEN
215                 location$ = multlocb$
220         END IF
225         IF receivermult$ = "A" OR receivermult$ = "B" THEN
230                 ch$ = MID$(data$, 4, 2)
235                 pi$ = MID$(data$, 7, 4)
240         ELSEIF receivermult$ <> "A" AND receivermult$ <> "B" THEN
245                 ch$ = MID$(data$, 2, 2)
250                 pi$ = MID$(data$, 5, 4)
255         END IF
260                 mo$ = MID$(DATE$,1,2)
265                 day$ = MID$(DATE$, 4, 2)
270                 yr$ = MID$(DATE$, 7, 4)
275                 dbasedate$ =  yr$ + mo$ + day$
280                 format$ = "\     \,\     \,\\,\  \,\\"
285     OPEN filename$ FOR APPEND AS #2
290         PRINT #2, USING format$; dbasedate$; TIME$; ch$; pi$; location$
300         IF multanswer$ = "y" THEN
305                 PRINT DATE$, TIME$, data$
310         ELSEIF multanswer$ = "n" THEN
315                 PRINT DATE$, TIME$, ch$, pi$
320         END IF
325     CLOSE filename
330     CLOSE #2
335     LET n = n + 1
340     PRINT "Number of Records:", n
345     IF NOT EOF(1) THEN GOTO 190
350     END
```

Appendix B

# Automatic Tag Detection Station Configuration and Hardware Criteria

Proper configuration of each automatic tag detection station is essential to ensure that the maximum amount of useful information is recorded. Among the considerations are noise reduction, receiver sensitivity, and sampling frequency. Because a wide range of environmental conditions was expected and only a little was known about striped bass movement, we used redundant systems and several configurations. The configuration of each station is summarized in Table B-1.

Table B-1
AUTOMATIC TAG DETECTION STATION CONFIGURATIONS

| Station | Algorithm | Receiver Type | Number of Hydrophones Used | Sampling Interval | Co-axial Cable |
|---|---|---|---|---|---|
| Out (s) | Slow | S | 2 | 20 secs | RG-58/U |
| Out (f) | Fast | S | 1 | 20 secs | RG-58/U |
| In (g) | Slow | M | 2 | 40 secs | RG-58/U |
| In (l) | Slow | M | 1 | 40 secs | RG-58/U |

Out (s) Hydrophones outside of gates, oriented upstream toward Old River.
Out (f) Hydrophone outside of gates, oriented upstream toward Old River.
In (g) Hydrophones inside of gates, one oriented west and the other oriented north.
In (l) Hydrophone at trash boom of Skinner Fish Facility, oriented across and slightly upstream.
M Multiplexing, two hydrophone input ports.
S Standard, one hydrophone input port.

## Noise Reduction

Noise, in the form of radio frequency (RF) signals, excessive numbers of valid tag records, and aquatic sounds (*eg*, collapsing entrained bubbles and water pumps), was prevalent during our work at Clifton Court Forebay. Minimizing the impact of these sources required specific hardware configurations.

Selecting appropriate cable to connect hydrophone and receiver was critical to reduce the effect of RF noise. Certain types of cable will (among other negative consequences) act as RF antennae, thus allowing RF noise to be logged as records. We used solid core, 53.5-ohm, 100% shielded, Belden 8240, RG-58/U coaxial cable. When possible, full-length cables were used to minimize RF noise associated with cable connections. When it was necessary to connect lengths of coaxial cable, we used high-quality crimp-on BNC connectors.

Even with appropriate coaxial cable connecting hydrophone to receiver, some RF noise is transmitted to the receiver. To minimize this noise source, the normal configuration of coaxial cable and receiver included an in-line low-pass filter. These filters exclude signals with frequencies greater than 100kHz.

The DH-2 hydrophone is effectively omni-directional at short ranges (*eg*, <30m), and records from tagged fish in all directions were detected from a single hydrophone. Tagged fish aggregated at the trash boom area and near the radial gates, thus the potential to log excessive and redundant data was great. To reduce the number of valid tag records, we increased the effective directionality of the DH-2 hydrophone. Installing a 50-ohm terminal end resistor (via an in-line BNC "T" connector) reduces the strength of incoming signals; tagged fish on the edges of detection (*eg*, at fairly long range or off the acoustic axis of the hydrophone) are not logged. We increased the directionality of the hydrophone at the trash boom with this technique and reduced the number of records logged.

Ultrasonic tags have specific and predictable acoustic properties (*ie*, frequency, pulse interval, and pulse width), thus valid tag signals can generally be effectively filtered from aquatic noise sources. Two noise filtering algorithms, slow and fast, are available in the USR-90 receiver. The slow algorithm is designed to filter noise signals by measuring two successive pulse intervals (*ie*, ping, interval, ping, interval, ping), as well as pulse-width criteria, before the receiver accepts (or rejects) the signal. We used the slow algorithm inside the forebay, where turbulent noise from the discharge plume at the gates would be abundant and where we expected to detect tagged fish over relatively long periods.

## Receiver Sensitivity

The fast algorithm makes no comparison between successive pulse intervals; therefore, all signals meeting pulse width and pulse interval criteria are accepted. Because the algorithm uses fewer criteria, more noise is accepted. The algorithm runs faster. Anticipating that tagged fish would spend relatively little time in the inlet channel, thus returning relatively few records, and knowing that signals from the inlet channel would be essential in documenting movement to and from the forebay, we used the fast algorithm with station "Out (f)". As expected, this station collected a tremendous amount of noise, but it also logged more records per fish than station "Out (s)".

## Sampling Frequency

The rate at which each of the 18 frequencies are sampled is controlled by two features of the Sonotronics USR-90: the optional use of more than one hydrophone and, to a lesser degree, the choice of noise-filtering algorithm. Either one hydrophone input (standard) or two hydrophone inputs (multiplexing) are scanned on Sonotronics USR-90 receivers with optional hydrophone-multiplexing. In standard configuration, the receiver scans all 18 frequencies in about 20 seconds. When configured to multiplex between two hydrophones, the receiver scans all 18 frequencies from port

"1" then switches to port "2" and scans all frequencies. Cumulative scan time is roughly 40 seconds. We found that tagged fish detection in the outlet channel near the trash boom was very good; individual tagged fish could be expected to log at an excessive rate of every 20 seconds (180/hour) when the receiver was in standard configuration. We reduced the sampling rate in the outlet channel by using multiplexing, but with only one hydrophone attached. This configuration cut the sampling rate (number of records logged) in half.

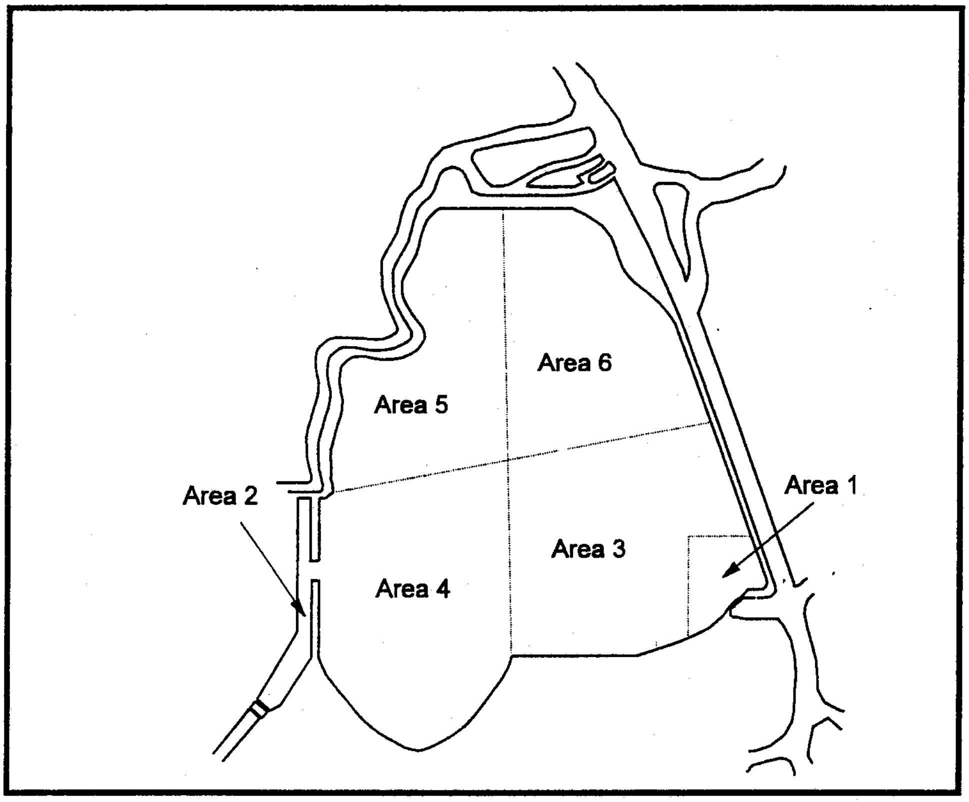
Appendix C

# Capture Data from a Telemetry Study of Striped Bass Emigration from Clifton Court Forebay

| Date | Tag Number | Length | Capture Area | Collection Method |
|---|---|---|---|---|
| 19950717 | 1 | 330 | area 4 | kodiak |
| 19950718 | 2 | 320 | area 2 | angling |
| 19950718 | 3 | 325 | area 2 | angling |
| 19950718 | 4 | 290 | area 2 | angling |
| 19950718 | 5 | 330 | area 2 | angling |
| 19950718 | 6 | 360 | area 2 | angling |
| 19950718 | 7 | 259 | area 1 | gillnet |
| 19950718 | 8 | 271 | area 1 | gillnet |
| 19950718 | 9 | 326 | area 1 | gillnet |
| 19950718 | 10 | 456 | area 1 | gillnet |
| 19950718 | 11 | 330 | area 4 | gillnet |
| 19950719 | 12 | 285 | area 1 | angling |
| 19950719 | 13 | 451 | area 1 | angling |
| 19950719 | 14 | 569 | area 1 | gillnet |
| 19950719 | 15 | 324 | area 5 | kodiak |
| 19950719 | 16 | 295 | area 5 | kodiak |
| 19950719 | 17 | 246 | area 5 | kodiak |
| 19950719 | 18 | 341 | area 5 | kodiak |
| 19950719 | 19 | 324 | area 5 | kodiak |
| 19950719 | 20 | 344 | area 5 | kodiak |
| 19950724 | 21 | 465 | area 1 | angling |
| 19950724 | 22 | 340 | area 1 | angling |
| 19950724 | 23 | 320 | area 1 | angling |
| 19950726 | 24 | 415 | area 1 | gillnet |
| 19950726 | 25 | 515 | area 1 | gillnet |
| 19950726 | 26 | 435 | area 1 | angling |
| 19950801 | 27 | 401 | area 1 | gillnet |
| 19950801 | 28 | 404 | area 1 | gillnet |
| 19950801 | 29 | 465 | area 1 | gillnet |
| 19950802 | 30 | 432 | area 5 | gillnet |
| 19950807 | 31 | 545 | area 1 | gillnet |
| 19950807 | 32 | 402 | area 2 | angling |
| 19950807 | 33 | 410 | area 2 | angling |
| 19950807 | 34 | 381 | area 2 | angling |
| 19950807 | 35 | 359 | area 2 | angling |
| 19950808 | 36 | 340 | area 1 | gillnet |
| 19950808 | 37 | 461 | | gillnet |
| 19950808 | 38 | 452 | area 1 | gillnet |
| 19950808 | 39 | 423 | | gillnet |
| 19950808 | 40 | 395 | area 1 | gillnet |
| 19950808 | 41 | 399 | area 1 | gillnet |
| 19950808 | 42 | 434 | area 1 | gillnet |
| 19950808 | 43 | 495 | area 1 | gillnet |
| 19950808 | 44 | 410 | area 1 | gillnet |
| 19950808 | 45 | 460 | area 1 | gillnet |
| 19950829 | 46 | 460 | area 1 | angling |
| 19950829 | 47 | 420 | area 1 | gillnet |
| 19950829 | 48 | 485 | area 1 | gillnet |
| 19951005 | 49 | 415 | area 3 | gillnet |
| 19951005 | 50 | 330 | area 3 | angling |
| 19951005 | 51 | 418 | area 2 | gillnet |
| 19951005 | 52 | 353 | area 2 | gillnet |
| 19951005 | 53 | 470 | area 4 | angling |
| 19951005 | 54 | 380 | area 4 | gillnet |
| 19951005 | 55 | 339 | area 4 | gillnet |
| 19951005 | 56 | 440 | area 5 | gillnet |
| 19951005 | 57 | 332 | area 5 | gillnet |
| 19951005 | 58 | 435 | area 5 | gillnet |
| 19951005 | 59 | 410 | area 1 | gillnet |
| 19951012 | 60 | 420 | area 6 | gillnet |
| 19951012 | 61 | 439 | area 6 | gillnet |
| 19951012 | 62 | 405 | area 6 | gillnet |
| 19951012 | 63 | 409 | area 6 | gillnet |
| 19951012 | 64 | 492 | area 3 | gillnet |
| 19951012 | 65 | 433 | area 3 | gillnet |
| 19951017 | 66 | 640 | area 1 | gillnet |
| 19951017 | 67 | 582 | area 1 | gillnet |
| 19951017 | 68 | 565 | area 1 | gillnet |
| 19951017 | 69 | 480 | area 1 | gillnet |
| 19951017 | 70 | 531 | area 1 | gillnet |
| 19951017 | 71 | 638 | area 1 | gillnet |
| 19951017 | 72 | 620 | area 1 | gillnet |
| 19951017 | 73 | 653 | area 1 | gillnet |
| 19951017 | 74 | 548 | area 1 | gillnet |
| 19951017 | 75 | 440 | area 1 | gillnet |
| 19951017 | 76 | 458 | area 1 | gillnet |

| Date | Tag Number | Length | Capture Area | Collection Method |
|---|---|---|---|---|
| 19951017 | 77 | 445 | area 1 | gillnet |
| 19951019 | 78 | 465 | area 1 | gillnet |
| 19951019 | 79 | 455 | area 1 | gillnet |
| 19951019 | 80 | 450 | area 1 | gillnet |
| 19951019 | 81 | 440 | area 1 | gillnet |
| 19951026 | 82 | 433 | area 1 | angling |
| 19951026 | 83 | 410 | area 1 | angling |
| 19951026 | 84 | 430 | area 1 | gillnet |
| 19951026 | 85 | 452 | area 1 | gillnet |
| 19951026 | 86 | 473 | area 1 | gillnet |
| 19951026 | 87 | 434 | area 1 | gillnet |
| 19951026 | 88 | 466 | area 1 | gillnet |
| 19960117 | 89 | 524 | area 1 | gillnet |
| 19960117 | 90 | 477 | area 1 | gillnet |
| 19960117 | 91 | 605 | area 1 | gillnet |
| 19960117 | 92 | 477 | area 1 | gillnet |
| 19960117 | 93 | 450 | area 1 | gillnet |
| 19960117 | 94 | 529 | area 1 | gillnet |
| 19960117 | 95 | 473 | area 2 | gillnet |
| 19960117 | 96 | 367 | area 2 | gillnet |
| 19960117 | 97 | 427 | area 2 | gillnet |
| 19960117 | 98 | 499 | area 2 | angling |
| 19960129 | 99 | 546 | center | gillnet |
| 19960129 | 100 | 372 | area 2 | angling |
| 19960129 | 101 | 449 | area 5 | angling |
| 19960130 | 102 | 415 | center | angling |
| 19960130 | 103 | 508 | center | gillnet |
| 19960130 | 104 | 397 | center | gillnet |
| 19960130 | 105 | 350 | center | gillnet |
| 19960201 | 106 | 400 | center | angling |
| 19960201 | 107 | 367 | center | gillnet |
| 19960201 | 108 | 414 | center | angling |
| 19960214 | 109 | 562 | | angling |
| 19960214 | 110 | 398 | | gillnet |
| 19960214 | 111 | 516 | | angling |
| 19960214 | 112 | 363 | | angling |
| 19960214 | 113 | 614 | | angling |
| 19960214 | 114 | 415 | | angling |
| 19960214 | 115 | 380 | | gillnet |
| 19960214 | 116 | 472 | | angling |
| 19960213 | 117 | 494 | area 1 | angling |
| 19960213 | 118 | 572 | area 1 | angling |
| 19960213 | 119 | 690 | area 1 | angling |
| 19960213 | 120 | 461 | area 1 | angling |
| 19960213 | 121 | 535 | area 1 | angling |
| 19960213 | 122 | 445 | area 1 | gillnet |
| 19960213 | 123 | 437 | area 1 | gillnet |
| 19960213 | 124 | 415 | area 1 | gillnet |
| 19960213 | 125 | 444 | area 1 | angling |
| 19960213 | 126 | 455 | area 1 | angling |
| 19960213 | 127 | 419 | area 1 | angling |
| 19960213 | 128 | 440 | area 1 | angling |
| 19960402 | 129 | 437 | | angling |
| 19960402 | 130 | 435 | | angling |
| 19960402 | 131 | 443 | | angling |
| 19960402 | 132 | 419 | | angling |
| 19960402 | 133 | 478 | | angling |
| 19960402 | 134 | 506 | | angling |
| 19960402 | 135 | 466 | | angling |
| 19960402 | 136 | 407 | | angling |
| 19960402 | 137 | 358 | | angling |
| 19960402 | 138 | 374 | | angling |
| 19960416 | 139 | 435 | area 1 | angling |
| 19960416 | 140 | 397 | area 1 | gillnet |
| 19960416 | 141 | 460 | area 1 | gillnet |
| 19960416 | 142 | 510 | area 1 | gillnet |
| 19960416 | 143 | 438 | area 1 | gillnet |
| 19960416 | 144 | 433 | area 1 | gillnet |
| 19960416 | 145 | 445 | area 1 | gillnet |
| 19960416 | 146 | 449 | area 1 | gillnet |
| 19960416 | 147 | 355 | area 2 | angling |
| 19960416 | 148 | 441 | area 1 | gillnet |
| 19960416 | 149 | 423 | area 1 | gillnet |
| 19960416 | 150 | 397 | area 1 | gillnet |
| 19960423 | 151 | 436 | area 1 | angling |
| 19960423 | 152 | 430 | area 1 | angling |
| 19960423 | 153 | 439 | area 1 | angling |
| 19960423 | 154 | 449 | area 1 | angling |
| 19960423 | 155 | 493 | area 1 | angling |
| 19960423 | 156 | 419 | area 1 | angling |
| 19960423 | 157 | 411 | area 1 | angling |
| 19960423 | 158 | 452 | area 2 | angling |
| 19960423 | 159 | 442 | area 1 | angling |
| 19960423 | 160 | 404 | area 2 | angling |
| 19960507 | 161 | 316 | area 2 | angling |
| 19960507 | 162 | 400 | area 2 | angling |
| 19960507 | 163 | 365 | area 2 | angling |
| 19960507 | 164 | 375 | area 2 | angling |
| 19960507 | 165 | 340 | area 2 | angling |
| 19960507 | 166 | 419 | area 2 | angling |
| 19960507 | 167 | 445 | area 2 | angling |
| 19960507 | 168 | 476 | area 2 | angling |
| 19960507 | 169 | 394 | area 2 | angling |
| 19960507 | 170 | 369 | area 2 | angling |
| 19960530 | 171 | 467 | area 2 | angling |
| 19960530 | 172 | 345 | area 2 | angling |

| Date | Tag Number | Length | Capture Area | Collection Method | Date | Tag Number | Length | Capture Area | Collection Method |
|---|---|---|---|---|---|---|---|---|---|
| 19960530 | 173 | 459 | area 2 | angling | 19960530 | 177 | 455 | area 5 | angling |
| 19960530 | 174 | 368 | area 5 | angling | 19960530 | 178 | 315 | area 2 | angling |
| 19960530 | 175 | 395 | area 2 | angling | 19960530 | 179 | 399 | area 2 | angling |
| 19960530 | 176 | 396 | area 2 | angling | 19960530 | 180 | 435 | area 2 | angling |




STRIPED BASS CAPTURE AREAS DURING TELEMETRY STUDY OF EMIGRATION FROM CLIFTON COURT FOREBAY

Appendix D

# Algorithm Used to Assign Tag Numbers to Data Collected at the Automatic Tag Detection Stations

Tag numbers are assigned to frequency (channel) and pulse interval (pi) combinations corresponding to per/tag specifications established by the manufacturer and confirmed during laboratory testing of tags prior to field application.

tagnum 01 is channel = 04 and pi >= 843 and pi <= 845 and date >= 07/17/95 and date <= 10/17/95

tagnum 02 is channel = 13 and pi >= 925 and pi <= 927 and date >= 07/18/95 and date <= 10/18/95

tagnum 03 is channel = 16 and pi >= 916 and pi <= 918 and date >= 07/18/95 and date <= 10/18/95

tagnum 04 is channel = 17 and pi >= 930 and pi <= 931 and date >= 07/18/95 and date <= 10/18/95

tagnum 05 is channel = 14 and pi >= 996 and pi <= 998 and date >= 07/18/95 and date <= 10/18/95

tagnum 06 is channel = 14 and pi >= 913 and pi <= 915 and date >= 07/18/95 and date <= 10/18/95

tagnum 07 is channel = 15 and pi >= 901 and pi <= 903 and date >= 07/18/95 and date <= 10/18/95

tagnum 08 is channel = 12 and pi >= 910 and pi <= 912 and date >= 07/18/95 and date <= 10/18/95

tagnum 09 is channel = 15 and pi >= 873 and pi <= 875 and date >= 07/18/95 and date <= 10/18/95

tagnum 10 is channel = 03 and pi >= 995 and pi <= 997 and date >= 07/18/95 and date <= 10/18/95

tagnum 11 is channel = 04 and pi >= 873 and pi <= 875 and date >= 07/18/95 and date <= 10/18/95

tagnum 12 is channel = 10 and pi >= 921 and pi <= 923 and date >= 07/19/95 and date <= 10/19/95

tagnum 13 is channel = 18 and pi >= 986 and pi <= 988 and date >= 07/19/95 and date <= 10/19/95

tagnum 14 is channel = 12 and pi >= 938 and pi <= 940 and date >= 07/19/95 and date <= 10/19/95

tagnum 15 is channel = 11 and pi >= 955 and pi <= 957 and date >= 07/19/95 and date <= 10/19/95

tagnum 16 is channel = 17 and pi >= 984 and pi <= 986 and date >= 07/19/95 and date <= 10/19/95

tagnum 17 is channel = 04 and pi >= 903 and pi <= 905 and date >= 07/19/95 and date <= 10/19/95

tagnum 18 is channel = 18 and pi >= 912 and pi <= 914 and date >= 07/19/95 and date <= 10/19/95

tagnum 19 is channel = 13 and pi >= 983 and pi <= 985 and date >= 07/19/95 and date <= 10/19/95

tagnum 20 is channel = 16 and pi >= 970 and pi <= 972 and date >= 07/19/95 and date <= 10/19/95

tagnum 21 is channel = 03 and pi >= 964 and pi <= 966 and date >= 07/24/95 and date <= 10/25/95

tagnum 22 is channel = 18 and pi >= 962 and pi <= 964 and date >= 07/24/95 and date <= 10/25/95

tagnum 23 is channel = 05 and pi >= 994 and pi <= 996 and date >= 07/24/95 and date <= 10/25/95

tagnum 24 is channel = 09 and pi >= 972 and pi <= 974 and date >= 07/26/95 and date <= 10/26/95

tagnum 25 is channel = 09 and pi >= 947 and pi <= 949 and date >= 07/26/95 and date <= 10/26/95

tagnum 26 is channel = 15 and pi >= 955 and pi <= 957 and date >= 07/26/95 and date <= 10/26/95

tagnum 27 is channel = 09 and pi >= 998 and pi<=1000 and date >= 08/01/95 and date <= 11/01/95

tagnum 28 is channel = 16 and pi >= 997 and pi <= 999 and date >= 08/01/95 and date <= 11/01/95

tagnum 29 is channel = 14 and pi >= 940 and pi <= 942 and date >= 08/01/95 and date <= 11/01/95

tagnum 30 is channel = 17 and pi >= 957 and pi <= 959 and date >= 08/02/95 and date <= 11/02/95

tagnum 31 is channel = 05 and pi >= 877 and pi <= 879 and date >= 08/07/95 and date <= 11/07/95

tagnum 32 is channel = 04 and pi >= 933 and pi <= 935 and date >= 08/07/95 and date <= 11/07/95

tagnum 33 is channel = 05 and pi >= 906 and pi <= 908 and date >= 08/07/95 and date <= 11/07/95

tagnum 34 is channel = 09 and pi >= 931 and pi <= 933 and date >= 08/07/95 and date <= 11/07/95

tagnum 35 is channel = 10 and pi >= 962 and pi <= 964 and date >= 08/07/95 and date <= 11/07/95

tagnum 36 is channel = 03 and pi >= 979 and pi <= 981 and date >= 08/08/95 and date <= 11/08/95

tagnum 37 is channel = 11 and pi >= 938 and pi <= 940 and date >= 08/08/95 and date <= 11/08/95
tagnum 38 is channel = 05 and pi >= 965 and pi <= 967 and date >= 08/08/95 and date <= 11/08/95
tagnum 39 is channel = 12 and pi >= 995 and pi <= 997 and date >= 08/08/95 and date <= 11/08/95
tagnum 40 is channel = 18 and pi >= 937 and pi <= 939 and date >= 08/08/95 and date <= 11/08/95
tagnum 41 is channel = 13 and pi >= 897 and pi <= 899 and date >= 08/08/95 and date <= 11/08/95
tagnum 42 is channel = 15 and pi >= 983 and pi <= 985 and date >= 08/08/95 and date <= 11/08/95
tagnum 43 is channel = 11 and pi >= 989 and pi <= 991 and date >= 08/08/95 and date <= 11/08/95
tagnum 44 is channel = 10 and pi >= 983 and pi <= 985 and date >= 08/08/95 and date <= 11/08/95
tagnum 45 is channel = 13 and pi >= 981 and pi <= 983 and date >= 08/08/95 and date <= 11/08/95
tagnum 46 is channel = 05 and pi >= 936 and pi <= 938 and date >= 08/29/95 and date <= 11/29/95
tagnum 47 is channel = 07 and pi >= 996 and pi <= 998 and date >= 08/29/95 and date <= 11/29/95
tagnum 48 is channel = 16 and pi >= 943 and pi <= 945 and date >= 08/29/95 and date <= 11/29/95
tagnum 49 is channel = 02 and pi >= 944 and pi <= 946 and date >= 10/05/95 and date <= 01/05/96
tagnum 50 is channel = 17 and pi >= 744 and pi <= 746 and date >= 10/05/95 and date <= 01/05/96
tagnum 51 is channel = 08 and pi >= 943 and pi <= 945 and date >= 10/05/95 and date <= 01/05/96
tagnum 52 is channel = 01 and pi >= 972 and pi <= 974 and date >= 10/05/95 and date <= 01/05/96
tagnum 53 is channel = 13 and pi >= 813 and pi <= 815 and date >= 10/05/95 and date <= 01/05/96
tagnum 54 is channel = 15 and pi >= 737 and pi <= 739 and date >= 10/05/95 and date <= 01/05/96
tagnum 55 is channel = 06 and pi >= 995 and pi <= 997 and date >= 10/05/95 and date <= 01/05/96
tagnum 56 is channel = 17 and pi >= 718 and pi <= 720 and date >= 10/05/95 and date <= 01/05/96
tagnum 57 is channel = 14 and pi >= 802 and pi <= 804 and date >= 10/05/95 and date <= 01/05/96
tagnum 58 is channel = 13 and pi >= 785 and pi <= 787 and date >= 10/05/95 and date <= 01/05/96
tagnum 59 is channel = 06 and pi >= 938 and pi <= 940 and date >= 10/05/95 and date <= 01/05/96
tagnum 60 is channel = 02 and pi >= 992 and pi <= 994 and date >= 10/12/95 and date <= 01/12/96
tagnum 61 is channel = 15 and pi >= 709 and pi <= 711 and date >= 10/12/95 and date <= 01/12/96
tagnum 62 is channel = 16 and pi >= 808 and pi <= 810 and date >= 10/12/95 and date <= 01/12/96
tagnum 63 is channel = 17 and pi >= 797 and pi <= 799 and date >= 10/12/95 and date <= 01/12/96
tagnum 64 is channel = 17 and pi >= 851 and pi <= 853 and date >= 10/12/95 and date <= 01/12/96
tagnum 65 is channel = 13 and pi>=1290 and pi<=1292 and date >= 10/12/95 and date <= 01/12/95
tagnum 66 is channel = 15 and pi >= 764 and pi <= 766 and date >= 10/17/95 and date <= 01/17/96
tagnum 67 is channel = 13 and pi >= 757 and pi <= 759 and date >= 10/17/95 and date <= 01/17/96
tagnum 68 is channel = 16 and pi >= 781 and pi <= 783 and date >= 10/17/95 and date <= 01/17/96
tagnum 69 is channel = 16 and pi >= 754 and pi <= 756 and date >= 10/17/95 and date <= 01/17/96
tagnum 70 is channel = 14 and pi >= 747 and pi <= 749 and date >= 10/17/95 and date <= 01/17/96
tagnum 71 is channel = 15 and pi >= 791 and pi <= 793 and date >= 10/17/95 and date <= 01/17/96
tagnum 72 is channel = 16 and pi >= 727 and pi <= 729 and date >= 10/17/95 and date <= 01/17/96
tagnum 73 is channel = 17 and pi >= 771 and pi <= 773 and date >= 10/17/95 and date <= 01/17/96
tagnum 74 is channel = 14 and pi >= 719 and pi <= 721 and date >= 10/17/95 and date <= 01/17/96
tagnum 75 is channel = 14 and pi >= 774 and pi <= 776 and date >= 10/17/95 and date <= 01/17/96
tagnum 76 is channel = 02 and pi >= 912 and pi <= 914 and date >= 10/17/95 and date <= 01/17/96
tagnum 77 is channel = 10 and pi >= 901 and pi <= 903 and date >= 10/17/95 and date <= 01/17/96
tagnum 78 is channel = 18 and pi >= 888 and pi <= 900 and date >= 10/19/95 and date <= 01/19/96
tagnum 79 is channel = 06 and pi >= 824 and pi <= 826 and date >= 10/19/95 and date <= 01/19/96
tagnum 80 is channel = 01 and pi >= 955 and pi <= 957 and date >= 10/19/95 and date <= 01/19/96
tagnum 81 is channel = 10 and pi >= 942 and pi <= 944 and date >= 10/19/95 and date <= 01/19/96
tagnum 82 is channel = 14 and pi >= 747 and pi <= 749 and date >= 10/26/95 and date <= 01/26/96
tagnum 83 is channel = 17 and pi >= 904 and pi <= 906 and date >= 10/26/95 and date <= 01/26/96
tagnum 84 is channel = 14 and pi >= 885 and pi <= 887 and date >= 10/26/95 and date <= 01/26/96
tagnum 85 is channel = 07 and pi >= 802 and pi <= 804 and date >= 10/26/95 and date <= 01/26/96
tagnum 86 is channel = 14 and pi >= 857 and pi <= 861 and date >= 10/26/95 and date <= 01/26/96

tagnum 87 is channel = 03 and pi >= 948 and pi <= 950 and date >= 10/26/95 and date <= 01/26/96
tagnum 88 is channel = 16 and pi >= 835 and pi <= 837 and date >= 10/26/95 and date <= 01/26/96
tagnum 89 is channel = 14 and pi >= 982 and pi <= 984 and date >= 01/17/96 and date <= 04/17/96
tagnum 90 is channel = 12 and pi >= 989 and pi <= 991 and date >= 01/17/96 and date <= 04/17/96
tagnum 91 is channel = 07 and pi >= 830 and pi <= 832 and date >= 01/17/96 and date <= 04/17/96
tagnum 92 is channel = 02 and pi>=1005 and pi<=1009 and date >= 01/17/96 and date <= 04/17/96
tagnum 93 is channel = 12 and pi >= 960 and pi <= 962 and date >= 01/17/96 and date <= 04/17/96
tagnum 94 is channel = 17 and pi >= 877 and pi <= 880 and date >= 01/17/96 and date <= 04/17/96
tagnum 95 is channel = 13 and pi >= 996 and pi <= 998 and date >= 01/17/96 and date <= 04/17/96
tagnum 96 is channel = 12 and pi >= 967 and pi <= 968 and date >= 01/17/96 and date <= 04/17/96
tagnum 97 is channel = 15 and pi >= 997 and pi <= 999 and date >= 01/17/96 and date <= 04/17/96
tagnum 98 is channel = 15 and pi >= 989 and pi <= 991 and date >= 01/17/96 and date <= 04/17/96
tagnum 99 is channel = 14 and pi >= 989 and pi <= 991 and date >= 01/29/96 and date <= 04/29/96
tagnum 100 is channel = 16 and pi >= 983 and pi <= 989 and date >= 01/29/96 and date <= 04/29/96
tagnum 101 is channel = 17 and pi >= 991 and pi <= 993 and date >= 01/29/96 and date <= 04/29/96
tagnum 102 is channel = 16 and pi >= 990 and pi <= 992 and date >= 01/30/96 and date <= 04/03/96
tagnum 103 is channel = 15 and pi >= 971 and pi <= 979 and date >= 01/30/96 and date <= 04/30/96
tagnum 104 is channel = 12 and pi >= 949 and pi <= 957 and date >= 01/30/96 and date <= 04/30/96
tagnum 105 is channel = 17 and pi >= 997 and pi <= 999 and date >= 01/30/96 and date <= 04/30/96
tagnum 106 is channel = 13 and pi >= 968 and pi <= 970 and date >= 02/01/96 and date <= 05/01/96
tagnum 107 is channel = 14 and pi >= 962 and pi <= 964 and date >= 02/01/96 and date <= 05/01/96
tagnum 108 is channel = 13 and pi >= 989 and pi <= 991 and date >= 02/01/96 and date <= 05/01/96
tagnum 109 is channel = 10 and pi >= 886 and pi <= 888 and date >= 02/14/96 and date <= 05/14/96
tagnum 110 is channel = 15 and pi >= 833 and pi <= 834 and date >= 02/14/96 and date <= 05/14/96
tagnum 111 is channel = 18 and pi >= 888 and pi <= 889 and date >= 02/14/96 and date <= 05/14/96
tagnum 112 is channel = 09 and pi >= 858 and pi <= 860 and date >= 02/14/96 and date <= 05/14/96
tagnum 113 is channel = 11 and pi >= 887 and pi <= 889 and date >= 02/14/96 and date <= 05/14/96
tagnum 114 is channel = 18 and pi >= 864 and pi <= 865 and date >= 02/14/96 and date <= 05/14/96
tagnum 115 is channel = 16 and pi >= 809 and pi <= 810 and date >= 02/14/96 and date <= 04/03/96
tagnum 116 is channel = 10 and pi >= 855 and pi <= 857 and date >= 02/14/96 and date <= 05/14/96
tagnum 117 is channel = 09 and pi >= 883 and pi <= 886 and date >= 02/13/96 and date <= 05/13/96
tagnum 118 is channel = 11 and pi >= 870 and pi <= 872 and date >= 02/13/96 and date <= 05/13/96
tagnum 119 is channel = 18 and pi >= 876 and pi <= 876 and date >= 02/13/96 and date <= 05/13/96
tagnum 120 is channel = 13 and pi >= 975 and pi <= 977 and date >= 02/13/96 and date <= 05/13/96
tagnum 121 is channel = 10 and pi >= 865 and pi <= 868 and date >= 02/13/96 and date <= 05/13/96
tagnum 122 is channel = 14 and pi >= 976 and pi <= 981 and date >= 02/13/96 and date <= 05/13/96
tagnum 123 is channel = 18 and pi >= 851 and pi <= 853 and date >= 02/13/96 and date <= 05/13/96
tagnum 124 is channel = 11 and pi >= 836 and pi <= 839 and date >= 02/13/96 and date <= 05/13/96
tagnum 125 is channel = 09 and pi >= 870 and pi <= 873 and date >= 02/13/96 and date <= 05/13/96
tagnum 126 is channel = 10 and pi >= 876 and pi <= 877 and date >= 02/13/96 and date <= 05/13/96
tagnum 127 is channel = 12 and pi >= 996 and pi <= 998 and date >= 02/13/96 and date <= 05/13/96
tagnum 128 is channel = 07 and pi >= 774 and pi <= 776 and date >= 02/13/96 and date <= 05/13/96
tagnum 129 is channel = 17 and pi >= 890 and pi <= 893 and date >= 04/02/96 and date <= 07/02/96
tagnum 130 is channel = 11 and pi >= 852 and pi <= 855 and date >= 04/02/96 and date <= 05/13/96
tagnum 131 is channel = 16 and pi >= 774 and pi <= 777 and date >= 04/02/96 and date <= 07/02/96
tagnum 132 is channel = 04 and pi >= 783 and pi <= 785 and date >= 04/02/96 and date <= 07/02/96
tagnum 133 is channel = 06 and pi >= 853 and pi <= 855 and date >= 04/02/96 and date <= 04/03/96
tagnum 134 is channel = 04 and pi >= 963 and pi <= 965 and date >= 04/02/96 and date <= 07/02/96
tagnum 135 is channel = 04 and pi >= 813 and pi <= 815 and date >= 04/02/96 and date <= 07/02/96
tagnum 136 is channel = 13 and pi >= 841 and pi <= 843 and date >= 04/02/96 and date <= 07/02/96

tagnum 137 is channel = 12 and pi >= 881 and pi <= 883 and date >= 04/02/96 and date <= 07/02/96
tagnum 138 is channel = 09 and pi >= 844 and pi <= 847 and date >= 04/02/96 and date <= 07/02/96
tagnum 139 is channel = 07 and pi >= 976 and pi <= 978 and date >= 04/16/96 and date <= 07/16/96
tagnum 140 is channel = 08 and pi >= 972 and pi <= 974 and date >= 04/16/96 and date <= 07/16/96
tagnum 141 is channel = 08 and pi >= 985 and pi <= 987 and date >= 04/16/96 and date <= 05/28/96
tagnum 142 is channel = 18 and pi >= 961 and pi <= 964 and date >= 04/16/96 and date <= 07/16/96
tagnum 143 is channel = 07 and pi >= 962 and pi <= 965 and date >= 04/16/96 and date <= 07/16/96
tagnum 144 is channel = 15 and pi >= 942 and pi <= 944 and date >= 04/16/96 and date <= 07/16/96
tagnum 145 is channel = 06 and pi >= 768 and pi <= 772 and date >= 04/16/96 and date <= 07/16/96
tagnum 146 is channel = 18 and pi >= 937 and pi <= 939 and date >= 04/16/96 and date <= 05/28/96
tagnum 147 is channel = 09 and pi >= 959 and pi <= 963 and date >= 04/16/96 and date <= 07/16/96
tagnum 148 is channel = 09 and pi >= 972 and pi <= 976 and date >= 04/16/96 and date <= 07/16/96
tagnum 149 is channel = 15 and pi >= 914 and pi <= 916 and date >= 04/16/96 and date <= 07/16/96
tagnum 150 is channel = 02 and pi >= 864 and pi <= 867 and date >= 04/16/96 and date <= 07/16/96
tagnum 151 is channel = 09 and pi >= 946 and pi <= 950 and date >= 04/23/96 and date <= 05/28/96
tagnum 152 is channel = 08 and pi >= 997 and pi<=1000 and date >= 04/23/96 and date <= 05/28/96
tagnum 153 is channel = 07 and pi >= 948 and pi <= 951 and date >= 04/23/96 and date <= 06/10/96
tagnum 154 is channel = 18 and pi >= 924 and pi <= 927 and date >= 04/23/96 and date <= 07/23/96
tagnum 155 is channel = 08 and pi >= 958 and pi <= 961 and date >= 04/23/96 and date <= 07/23/96
tagnum 156 is channel = 18 and pi >= 949 and pi <= 952 and date >= 04/23/96 and date <= 07/23/96
tagnum 157 is channel = 15 and pi >= 928 and pi <= 931 and date >= 04/23/96 and date <= 07/23/96
tagnum 158 is channel = 09 and pi >= 985 and pi <= 989 and date >= 04/23/96 and date <= 07/23/96
tagnum 159 is channel = 15 and pi >= 955 and pi <= 957 and date >= 04/23/96 and date <= 05/28/96
tagnum 160 is channel = 07 and pi >= 991 and pi <= 993 and date >= 04/23/96 and date <= 07/23/96
tagnum 161 is channel = 03 and pi >= 936 and pi <= 942 and date >= 05/07/96 and date <= 08/07/96
tagnum 162 is channel = 04 and pi >= 948 and pi <= 952 and date >= 05/07/96 and date <= 08/07/96
tagnum 163 is channel = 06 and pi >= 952 and pi <= 955 and date >= 05/07/96 and date <= 08/07/96
tagnum 164 is channel = 05 and pi >= 972 and pi <= 976 and date >= 05/07/96 and date <= 05/28/96
tagnum 165 is channel = 05 and pi >= 943 and pi <= 947 and date >= 05/07/96 and date <= 08/07/96
tagnum 166 is channel = 03 and pi >= 982 and pi <= 989 and date >= 05/07/96 and date <= 08/07/96
tagnum 167 is channel = 06 and pi >= 995 and pi <= 999 and date >= 05/07/96 and date <= 08/07/96
tagnum 168 is channel = 04 and pi >= 978 and pi <= 982 and date >= 05/07/96 and date <= 08/07/96
tagnum 169 is channel = 02 and pi >= 991 and pi <= 995 and date >= 05/07/96 and date <= 08/07/96
tagnum 170 is channel = 02 and pi >= 959 and pi <= 964 and date >= 05/07/96 and date <= 08/07/96
tagnum 171 is channel = 05 and pi >= 986 and pi <= 991 and date >= 05/30/96 and date <= 08/30/96
tagnum 172 is channel = 06 and pi >= 980 and pi <= 984 and date >= 05/30/96 and date <= 08/30/96
tagnum 173 is channel = 03 and pi >= 951 and pi <= 958 and date >= 05/30/96 and date <= 08/30/96
tagnum 174 is channel = 04 and pi >= 963 and pi <= 967 and date >= 05/30/96 and date <= 08/30/96
tagnum 175 is channel = 02 and pi >= 943 and pi <= 947 and date >= 05/30/96 and date <= 08/30/96
tagnum 176 is channel = 02 and pi >= 975 and pi <= 981 and date >= 05/30/96 and date <= 08/30/96
tagnum 177 is channel = 06 and pi >= 966 and pi <= 970 and date >= 05/30/96 and date <= 08/30/96
tagnum 178 is channel = 05 and pi >= 960 and pi <= 962 and date >= 05/30/96 and date <= 08/30/96
tagnum 179 is channel = 04 and pi >= 993 and pi <= 997 and date >= 05/30/96 and date <= 08/30/96
tagnum 180 is channel = 03 and pi >= 967 and pi <= 973 and date >= 05/30/96 and date <= 08/30/96