# Catch per unit effort indices and Effort Time-series for SEDAR 49 Data Limited Species captured in the Gulf of Mexico Recreational Headboat Fishery (1986 – 2015)

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SEDAR49-DW-02

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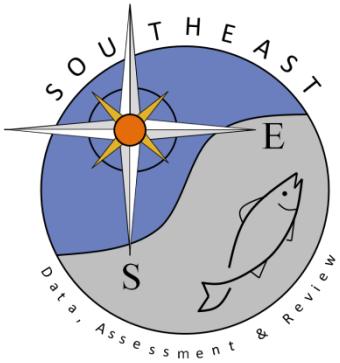

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# Catch per unit effort indices and Effort Timeseries for SEDAR 49 Data Limited Species captured in the Gulf of Mexico Recreational Headboat Fishery (1986 – 2015)

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## Introduction:

The DLM tool kit (Carruthers et al. 2014) employed as the primary assessment modeling framework in SEDAR 49 can accept as input an index of abundance and timeseries of effort for any one fishery dependent or independent fleet. During the data workshop, index selection will be accomplished by initially producing at minimum, nominal indices of abundance from all possible data sources. Candidate indices will then be compared based on the quantity and quality of the data they were derived from as well as the perception that the index trend accurately reflects the actual trend in population abundance. Here, available data from the U.S. Gulf of Mexico Headboat fishery were explored for Lane Snapper, Almaco Jack, Lesser Amberjack, Red Drum, Whenchman, Snowy Grouper, Yellowmouth Grouper, and Speckled Hind with the goal of producing indices of abundance and timeseries of effort for use in the SEDAR 49 data workshop.

## Materials and Methods:

Rod and reel catch and effort data from headboats have been collected and compiled by the NMFS Southeast Zone Headboat Survey since 1986 in the U.S. Gulf of Mexico. At the time of these analyses data were available through 2015. Reported information includes landing date and location, vessel identification, the number of anglers, fishing location, trip duration and type (AM/PM/Both), and catch by species in numbers and weight. Trip duration was reported as a multiple of days fished and for the purpose of CPUE index construction was converted to hours fished based on the following:

- Half day trips = 5 hours
- Three quarter day trips = 7.5 hours
- Full day trips = 10 hours
- Multiple day trips = number of days * 10 hours (e.g., 3 day trip = 30 hours)

Prior to species specific analysis, the headboat data were put through a routine quality control and assurance procedure designed to accomplish the following:

- Calculate effort (angler hours) as the number of anglers times the hours fished
- Correct dates that are incomplete or do not exist (e.g., record indicting trip occurred on Feb 31$^{st}$ of a given year)
- Remove trips with 0 anglers reported
- Remove duplicated data entries

Species specific analysis included:

- Identified regulatory history (i.e., bag/ aggregate/ vessel limits and size regulations) and determine whether or not regulations influenced catch (e.g., bag limit was commonly reached likely censoring the catch data)
- Use either the guild based approach or the Stephens and MacCall (2004) (SMAC) approach to extract a subset of trips for which the species of interest was the target species or was likely to be encountered during the trip
- Calculate standardized indices using a delta log-normal generalized linear model (Lo et al.,1992 )
- Prior to standardization, factors (other than year) were grouped into deterministic variables with a pre-determined number of discrete levels (Table 1)
- Standardizing factors other than year were included in the model based on the results of a forward stepwise regression analysis (i.e., deviance reduction analysis). During each step, a separate GLM was fit using the model from the previous step and one of the remaining candidate factors. The model that resulted in the greatest reduction in deviance was then used as the base model for the next step. This process was repeated until none of the updated models resulted in a reduction of residual deviance greater than or equal to 1%
- Two way interaction terms were not considered due to limited sample sizes
- Variable selection was conducted separately for the proportion positive trips and the log(CPUE) models
- Calculate normalized effort timeseries as the sum of the annual angler hours (# anglers per trip * hours fished) divided by the mean of the timeseries

## Results:

Preliminary data exploration indicated that the headboat data was sufficient for construction of nominal and standardized indices for Lane Snapper and Almaco Jack. The six other species included in SEDAR 49 occurred so rarely in the dataset that nominal indices either could not be constructed at all or were not considered reliable (See Appendix 1 for summary of available data for Red Drum, Speckled Hind, Whenchman, Snowy Grouper, Yellowmouth Grouper, and Lesser Amberjack).

### *Lane Snapper*

- Most commonly occurring of the SEDAR 49 species in the headboat dataset
- Occurred, annually, in 20 – 40% of guild selected trips and between 40 and 70% of trips when SMAC was used to subset (Figure 1)
- SMAC selected as the preferred subsetting routine based on SMAC Diagnostic output and high proportion positive (Figure 2). SMAC subset used for nominal and standardized index calculation as well as effort timeseries calculation
- Regulatory history consisted of inclusion in the 20 fish aggregate bag and being subject to an 8 inch minimum size limit since 1990. Effects of these regulations were not reflected in the data, thus, no actions were taken to account for their presence.

- Year was included as a factor in the binomial portion of the standardization procedure, while year, month, and sub region were included in the log-normal portion of the delta log-normal standardization procedure
- The nominal index and standardized index show similar trends over a large portion of the timeseries with only substantive difference occurring after 2005 when the standardized index indicates a relatively flat trend and the nominal index suggests an increasing trend (Table 2 & Figure 3)
- Effort for trips identified as fishing in areas were Lane Snapper are likely to occur peaked in 1993, declined rapidly to 1999 and has been steadily increasing since. Terminal effort is near timeseries highs (Table 2 & Figure 4)
- Model residuals are approximately normal as demonstrated by QQ-plot and KS test results, demonstrating a high goodness-of-fit of the glm standardizing model to the data

*Almaco Jack*

- Second most commonly occurring SEDAR 49 species in the headboat dataset
- Occurred, annually, in 1 – 10% of guild selected trips and between 5 and 50% of trips when SMAC was used to subset (Figure 5).
- SMAC selected as the preferred subsetting routine based on SMAC Diagnostic output and high proportion positive (Figure 6). SMAC subset used for nominal and standardized index calculation as well as effort timeseries calculation.
- Regulatory history consisted of inclusion in the 20 fish aggregate. No additional data filtering was deemed necessary to account for regulatory history
- Year and trip duration were included as a factor in the binomial portion of the standardization procedure, while year, month, and sub region were included in the log-normal portion of the delta log-normal standardization procedure
- The nominal index and standardized index show similar trends over the entire timeseries and indicate a near term increase in abundance beginning in 2011. The index peaked in 2003 and since then has displayed cyclical fluctuations with a long term flat or possible slightly negative trend (Table 3 & Figure 7).
- Effort for trips identified as fishing in areas were Almaco Jack are likely to occur peaked in 1993, declined rapidly to 1999 and has been steadily increasing since. Terminal effort is the highest in the timeseries (Table 3 & Figure 8)
- Model residuals are approximately normal as demonstrated by QQ-plot and KS test results, demonstrating a high goodness-of-fit of the glm standardizing model to the data

## Discussion:

The results and model diagnostics indicate that the headboat data can be used to develop reliable nominal and standardized indices for Lane Snapper and Almaco Jack. In general the headboat data for Lane Snapper and Almaco Jack have good spatial and temporal coverage as the survey was intended to be census of the headbaot fishing activity. Spatially, the bulk of the records are from fishing trips occurring in the eastern Gulf of Mexico; however, sample sizes from the western Gulf were large enough to warrant inclusion in the analysis (1560 Almaco Jack, 11873 Lane Snapper). Differences in the magnitude of east and west catches was not entirely explained by differences in fishing effort. For both species, model estimated coefficients

for fishing area indicated that CPUE was significantly higher in the Eastern portion of the Gulf suggesting that, among other things, abundance of Lane Snapper and Almaco Jack was likely higher in the eastern Gulf for the years included in the survey. While there remains insufficient data to identify stock structure, below that of the basin level, for either Lane Snapper or Almaco Jack, the results of the headboat index standardization suggest that there is at least some spatial component to how Lane Snapper and Almaco Jack utilize the Gulf of Mexico.

## Literature Cited:

Lo, N.C., Jacobson, L.D., and Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Can. J. Fish. Aquat. Sci.* 49:2515-2526.

Stephens, a. and MacCall, A. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. *Fish. Res.* 70:299-310.

# Tables

Table1. Factors and factor levels tested for inclusion in the delta lognormal standardization procedure applied to data from the Lane Snapper and Almaco Jack Gulf of Mexico headboat fisheries.

| Factor | Levels | Values |
|---|---|---|
| Year | 30 | 1986 - 2015 |
| Region | 2 | East or West Gulf |
| Season | 4 | Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec |
| Month | 12 | Jan - Dec |
| Trip duration | 4 | 1/2 day, 3/4 day, full day, multiday |
| Multiday | 2 | True, False |
| Anglers (Almaco) | 4 | 2-24, 25-34, 35-44, 44+ |
| Anglers (Lane) | 4 | 1-22, 23-33, 34-48, 48+ |
| Size Limit | 2 | Yes, No (only for Lane Snapper) |

Table 2. U.S. Gulf of Mexico Lane Snapper catch per unit effort (CPUE) indices derived from data collected from the headboat fishery. Prior to index construction, the data were subset based on whether the fishing trip caught fish from the reef fish guild of species (Guild) or based on species association as determined by Stephens and MacCall 2004 (SMAC). The standardized index was generated using the SMAC subset as was the standardized effort timeseries.

| Year | Nominal | | Std. | Std. |
|---|---|---|---|---|
| | Guild | SMAC | SMAC CPUE | Effort |
| 1986 | 0.50 | 0.47 | 0.73 | 0.60 |
| 1987 | 0.36 | 0.39 | 0.86 | 0.72 |
| 1988 | 0.23 | 0.24 | 0.42 | 1.03 |
| 1989 | 0.46 | 0.42 | 0.65 | 0.89 |
| 1990 | 0.74 | 0.72 | 1.04 | 1.18 |
| 1991 | 1.05 | 0.93 | 1.33 | 1.28 |
| 1992 | 1.42 | 1.19 | 1.27 | 1.43 |
| 1993 | 2.08 | 1.87 | 1.57 | 1.54 |
| 1994 | 1.51 | 1.18 | 1.25 | 1.27 |
| 1995 | 1.11 | 0.86 | 0.86 | 1.02 |
| 1996 | 0.85 | 0.55 | 0.66 | 0.86 |
| 1997 | 0.70 | 0.39 | 0.60 | 0.71 |
| 1998 | 0.37 | 0.55 | 0.59 | 0.72 |
| 1999 | 0.23 | 0.25 | 0.51 | 0.69 |
| 2000 | 0.42 | 0.45 | 0.76 | 0.85 |
| 2001 | 0.41 | 0.42 | 0.59 | 0.89 |
| 2002 | 0.57 | 0.64 | 0.88 | 0.91 |
| 2003 | 0.92 | 1.14 | 1.15 | 0.85 |
| 2004 | 0.67 | 0.75 | 1.14 | 1.01 |
| 2005 | 0.99 | 1.16 | 1.52 | 1.02 |
| 2006 | 0.89 | 1.11 | 1.11 | 0.87 |
| 2007 | 0.74 | 0.87 | 1.09 | 0.95 |
| 2008 | 0.91 | 0.89 | 1.23 | 0.95 |
| 2009 | 1.17 | 1.26 | 1.41 | 1.10 |
| 2010 | 0.73 | 1.10 | 1.11 | 0.74 |
| 2011 | 1.28 | 1.38 | 1.05 | 1.06 |
| 2012 | 1.24 | 1.32 | 1.10 | 1.10 |
| 2013 | 1.39 | 1.53 | 1.12 | 1.19 |
| 2014 | 1.48 | 1.49 | 1.13 | 1.26 |
| 2015 | 1.87 | 1.69 | 1.27 | 1.32 |

Table 3. U.S. Gulf of Mexico Almaco Jack catch per unit effort (CPUE) indices derived from data collected from the headboat fishery. Prior to index construction, the data were subset based on whether the fishing trip caught fish from the reef fish guild of species (Guild) or based on species association as determined by Stephens and MacCall 2004 (SMAC). The standardized index was generated using the SMAC subset as was the standardized effort timeseries.

| Year | Nominal | | Std. | Std. |
|---|---|---|---|---|
| | Guild | SMAC | SMAC CPUE | Effort |
| 1986 | 0.41 | 0.16 | 0.22 | 0.52 |
| 1987 | 0.41 | 0.14 | 0.18 | 0.44 |
| 1988 | 0.28 | 0.30 | 0.35 | 0.55 |
| 1989 | 1.38 | 0.46 | 0.49 | 0.72 |
| 1990 | 0.97 | 0.73 | 0.77 | 0.91 |
| 1991 | 0.69 | 0.69 | 0.63 | 1.24 |
| 1992 | 0.41 | 0.48 | 0.57 | 1.43 |
| 1993 | 0.41 | 0.41 | 0.37 | 1.84 |
| 1994 | 0.69 | 0.89 | 0.83 | 1.32 |
| 1995 | 0.97 | 0.94 | 1.01 | 0.84 |
| 1996 | 0.41 | 0.55 | 0.56 | 0.57 |
| 1997 | 0.41 | 0.44 | 0.61 | 0.57 |
| 1998 | 0.28 | 0.18 | 0.11 | 0.58 |
| 1999 | 0.55 | 0.14 | 0.14 | 0.52 |
| 2000 | 0.97 | 1.17 | 0.94 | 0.61 |
| 2001 | 1.94 | 1.88 | 1.68 | 0.92 |
| 2002 | 1.80 | 2.18 | 1.87 | 1.08 |
| 2003 | 2.07 | 3.30 | 2.73 | 0.89 |
| 2004 | 1.11 | 1.70 | 1.64 | 0.82 |
| 2005 | 0.55 | 0.94 | 0.84 | 0.92 |
| 2006 | 0.41 | 0.67 | 0.83 | 0.63 |
| 2007 | 1.11 | 1.88 | 2.03 | 0.65 |
| 2008 | 2.21 | 2.20 | 2.36 | 0.88 |
| 2009 | 1.80 | 1.79 | 1.91 | 1.24 |
| 2010 | 0.41 | 0.62 | 0.69 | 0.88 |
| 2011 | 0.55 | 0.44 | 0.49 | 1.05 |
| 2012 | 1.52 | 1.10 | 1.10 | 1.87 |
| 2013 | 1.52 | 1.15 | 1.19 | 1.74 |
| 2014 | 1.52 | 0.89 | 1.10 | 1.75 |
| 2015 | 2.21 | 1.58 | 1.74 | 2.02 |

# Figures

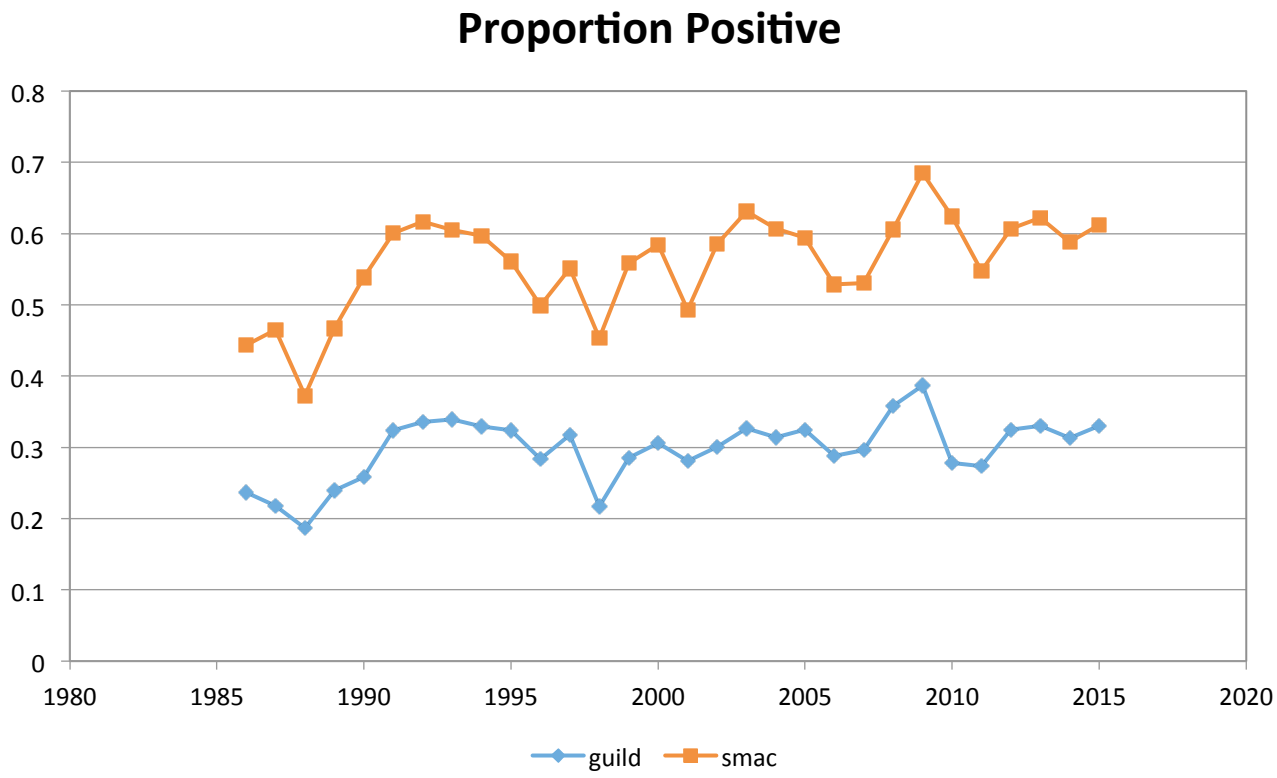


Figure 1. Annual proportion of trips capturing Lane Snapper when data were subset based on the guild approach (guild) and the method of Stephens and MacCall (SMAC).

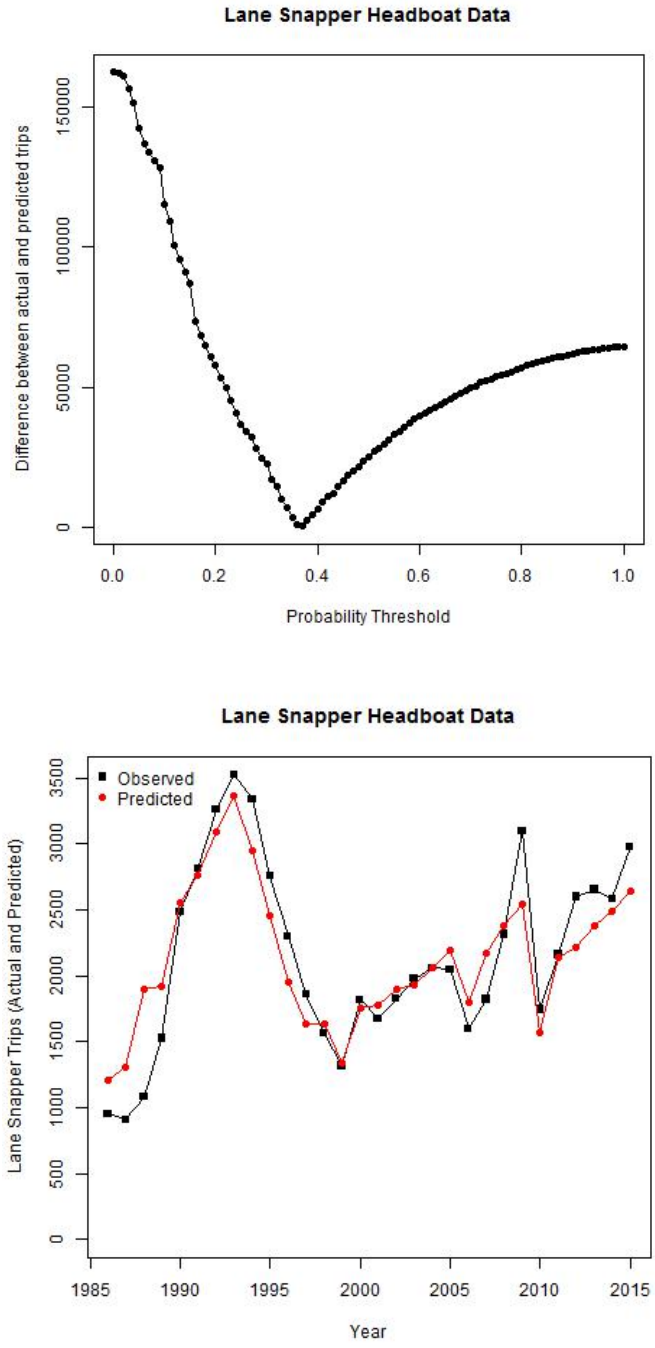


Figure 2. Difference between the number of records in which Lane Snapper are observed and those in which they are predicted to occur for each probabibilty threshold using the Stephens and MacCall (2004) approach (top panel). Difference between the observed number of trips capturing Lane Snapper and the predicted number of trips capturing Lane Snapper when trips are selected using the probability threshold of 0.37 (bottom panel).

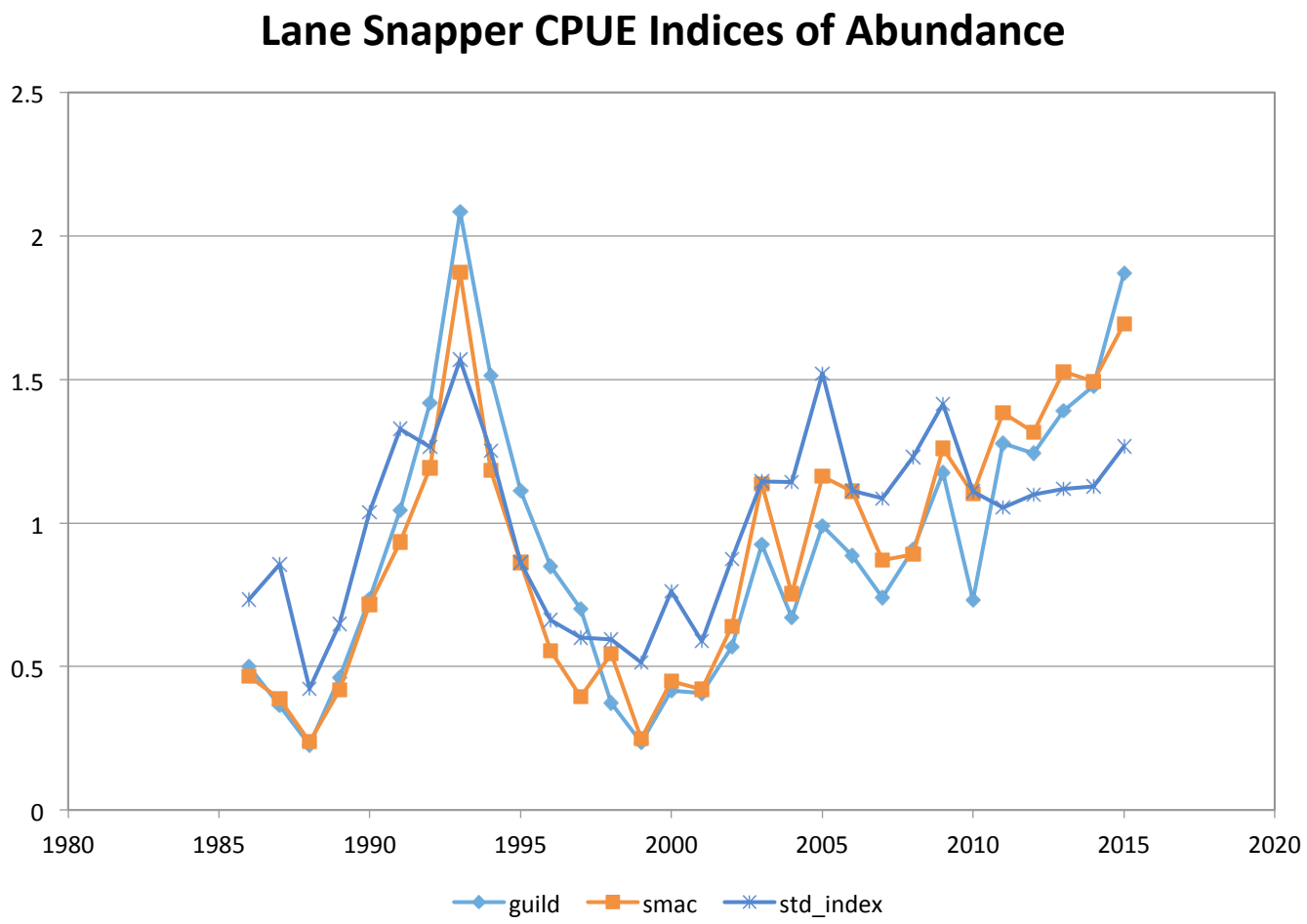


Figure 3. Nominal and standardized indices of abundance for Gulf of Mexico Lane Snapper when surveyed trips were subset based on the guild approach (guild) and the method of Stephens and MacCall (SMAC). Standardized index (std_index) is based on the SMAC data subset.

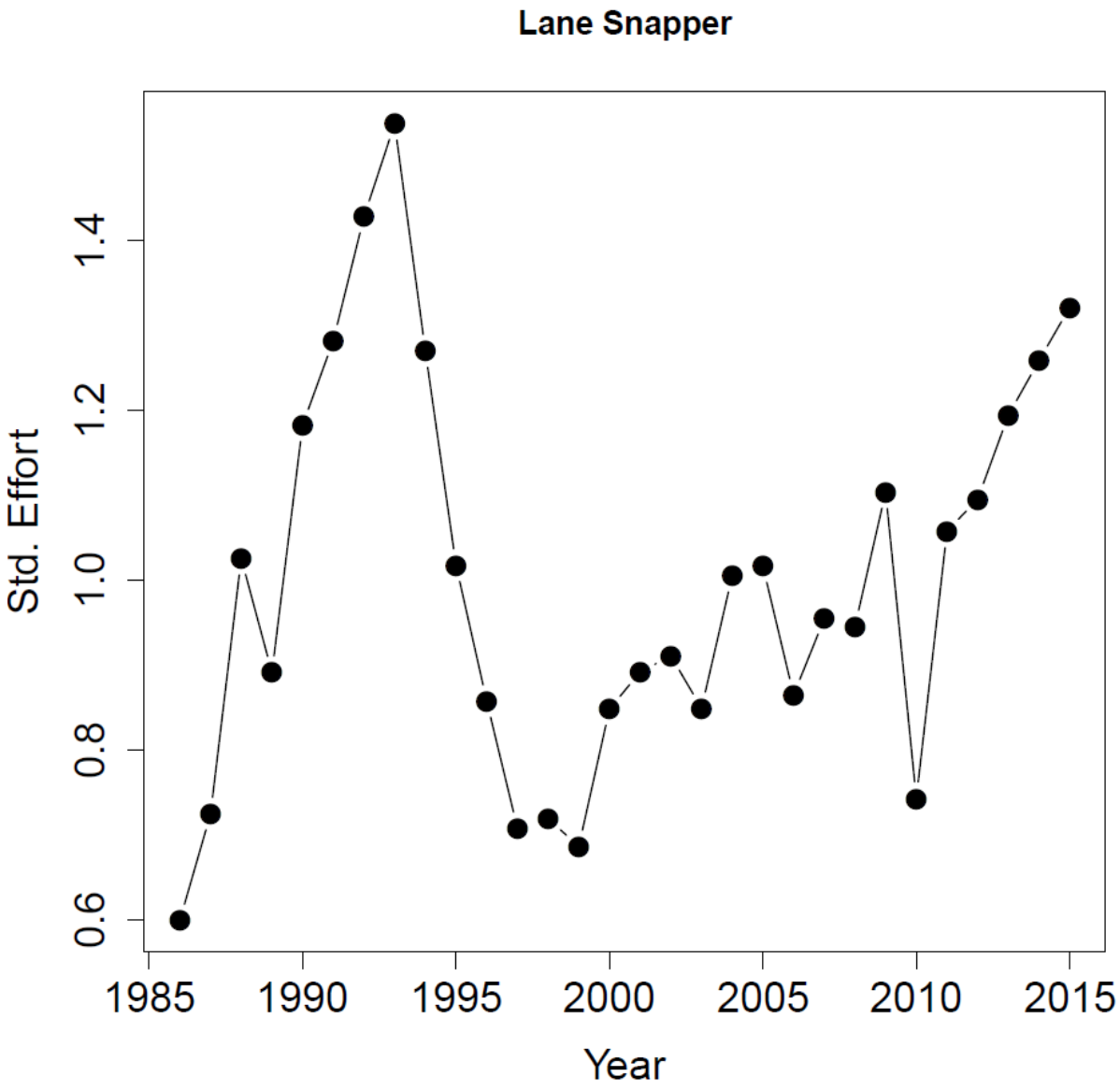


Figure 4. Timeseries of fishing effort for Lane Snapper from the Gulf of Mexico headboat fishery standardized by mean timeseries effort. Annual effort was calculated from the SMAC data subset implying that only effort from trips that caught Lane Snapper or species commonly associated with Lane Snapper were included.

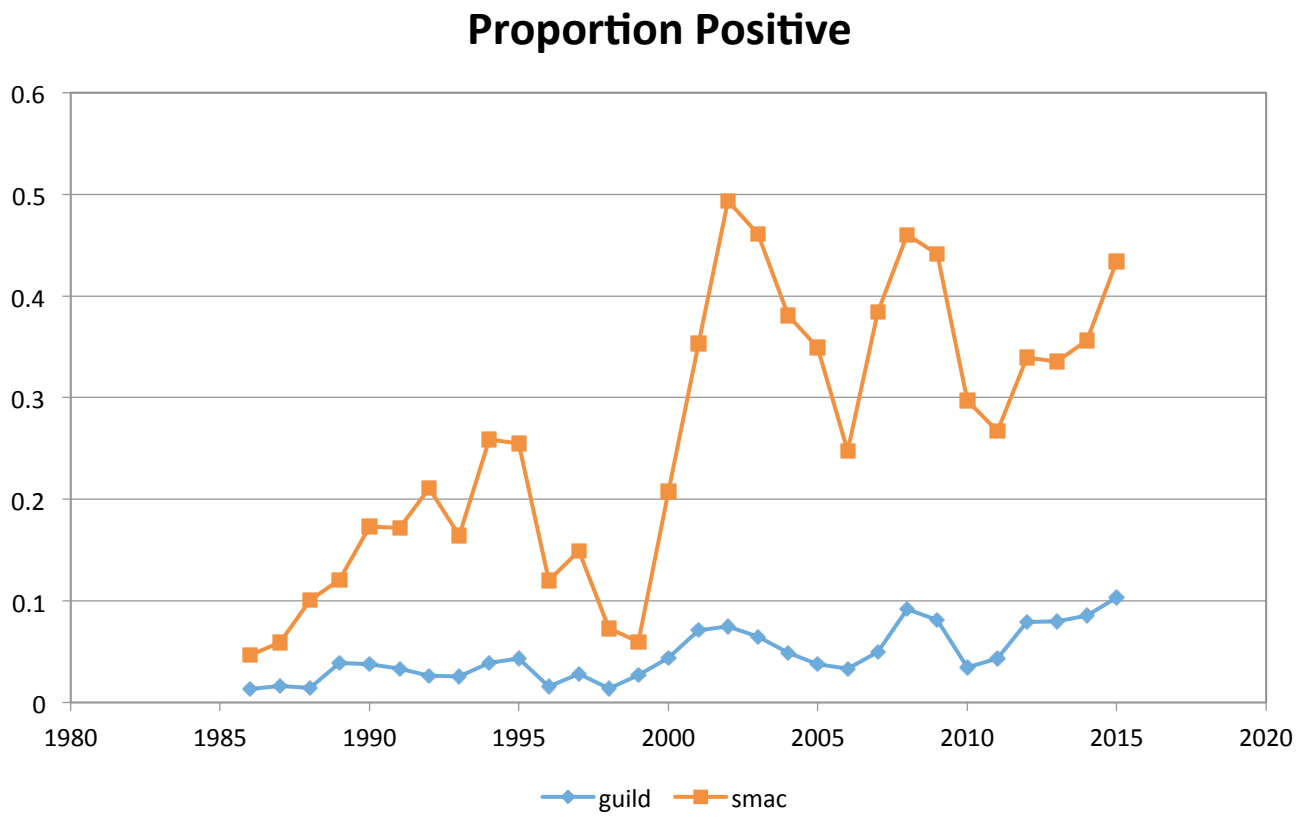


Figure 5. Annual proportion of trips capturing Almaco Jack when data were subset based on the guild approach (guild) and the method of Stephens and MacCall (SMAC).

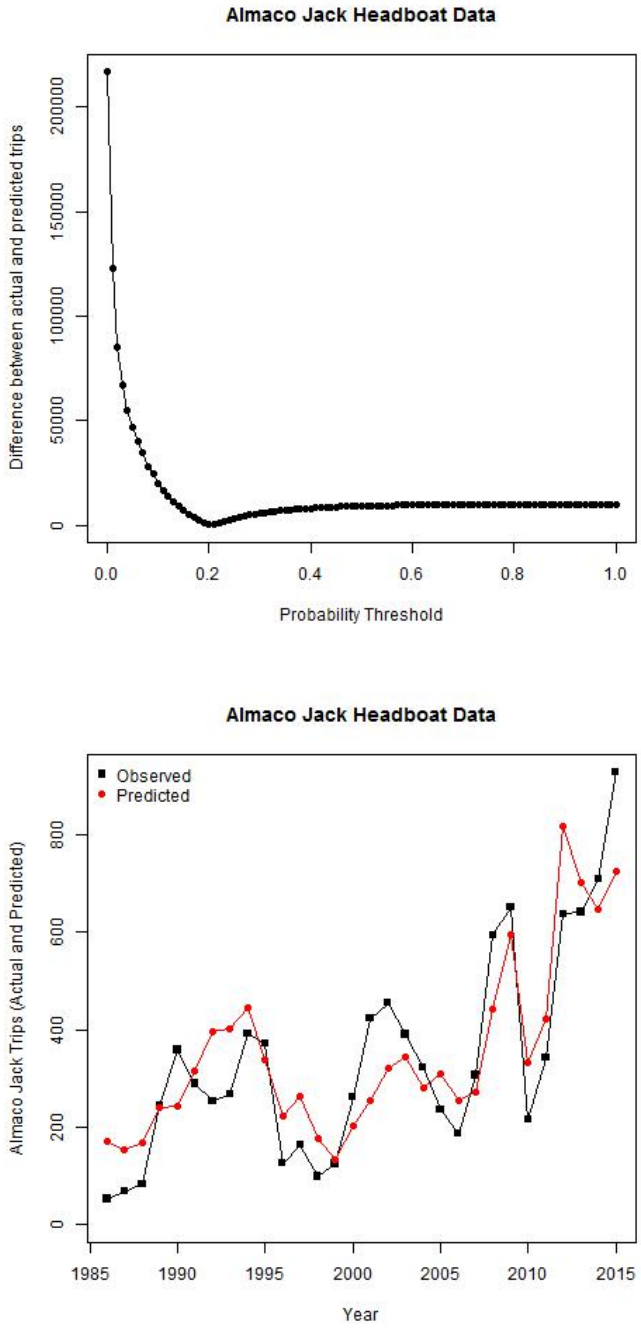


Figure 6. Difference between the number of records in which Almaco Jack are observed and those in which they are predicted to occur for each probabibilty threshold using the Stephens and MacCall (2004) approach (top panel). Difference between the observed number of trips capturing Almaco Jack and the predicted number of trips capturing Almaco Jack when trips are selected using the probability threshold of 0.20 (bottom panel).

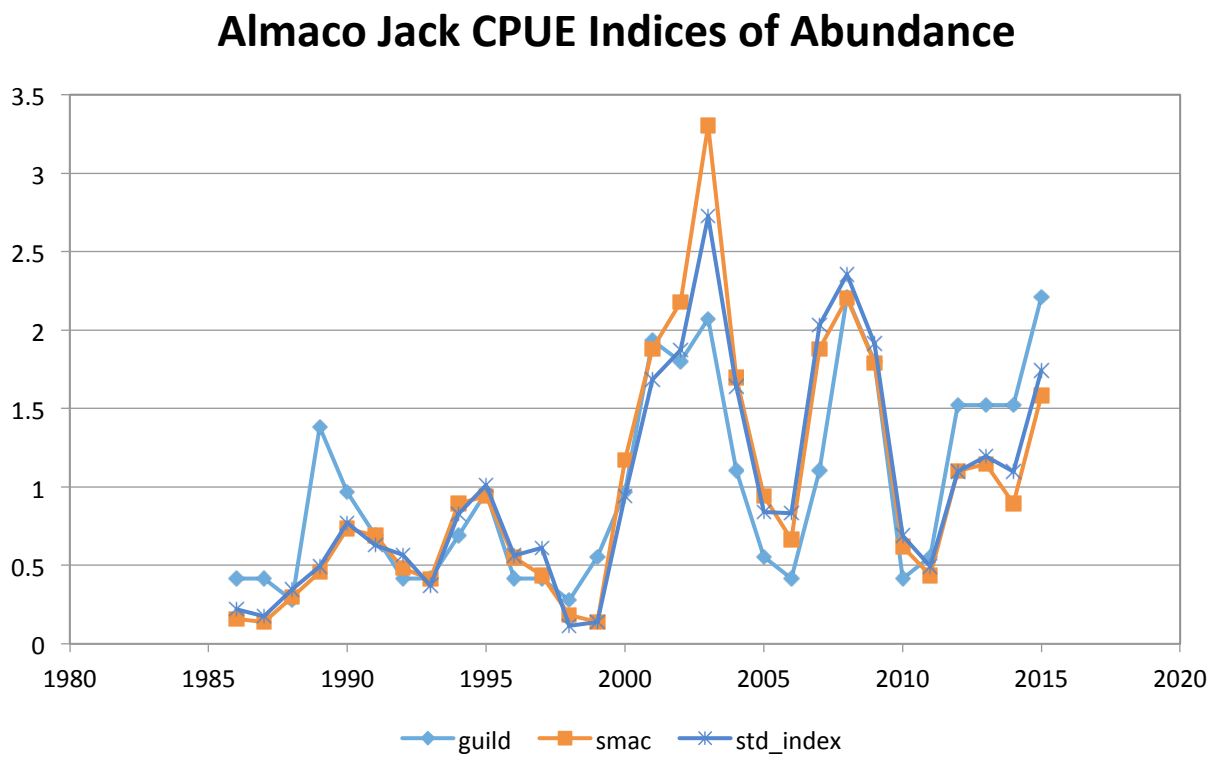


Figure 7. Nominal and standardized indices of abundance for Gulf of Mexico Almaco Jack when surveyed trips were subset based on the guild approach (guild) and the method of Stephens and MacCall (SMAC). Standardized index (std_index) is based on the SMAC data subset.

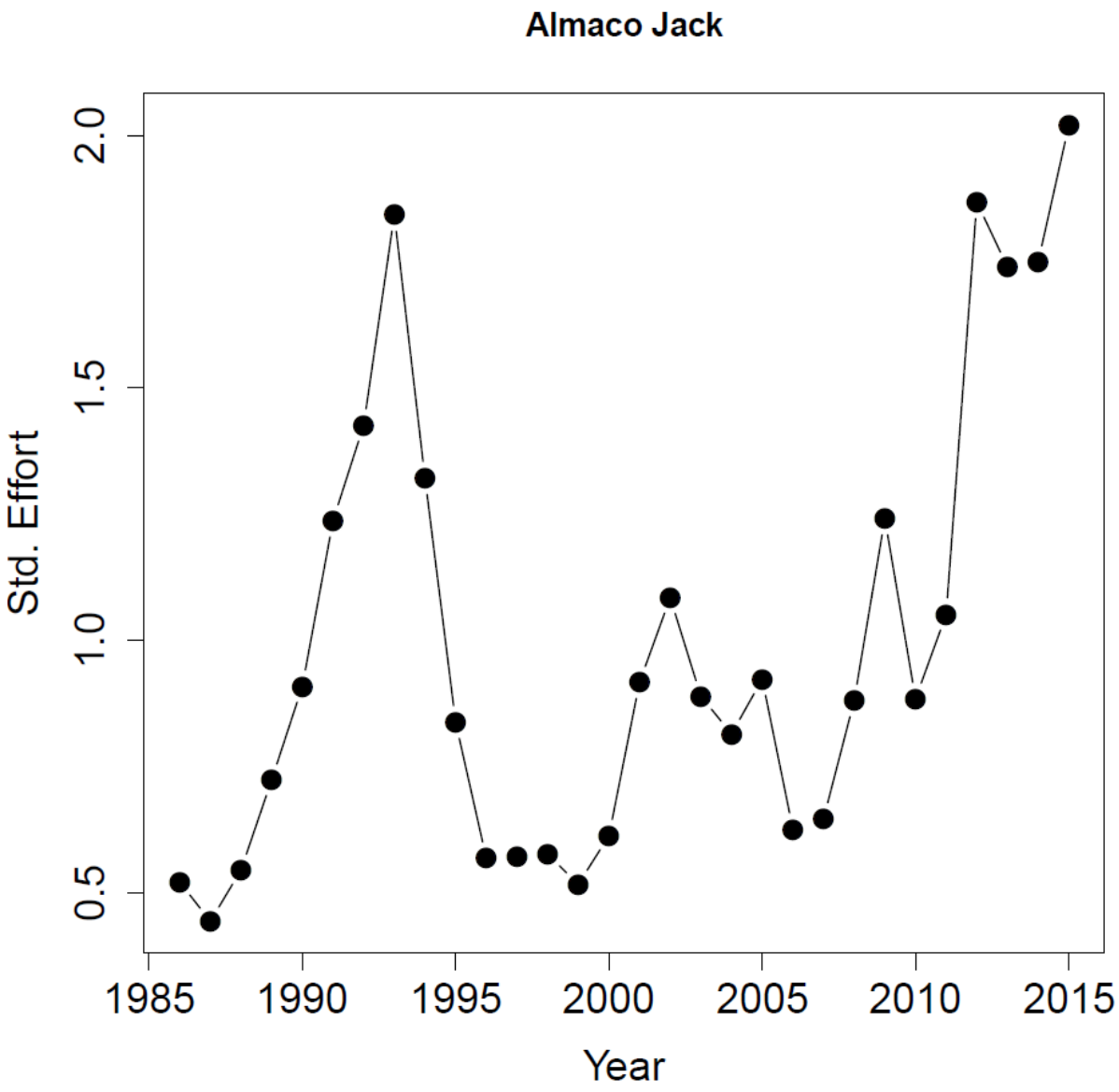


Figure 8. Timeseries of fishing effort for Almaco Jack from the Gulf of Mexico headboat fishery standardized by mean timeseries effort. Annual effort was calculated from the SMAC data subset implying that only effort from trips that caught Almaco Jack or species commonly associated with Almaco Jack were included.

# Appendix 1.

Annual number of trips that caught the target species for all species included in SEDAR 49. Values displayed were obtained from the raw survey data and do not reflect any trip deletions due to data filtering or trip selection from guild or SMAC (Stephens and MacCall 2004) protocols. Summary data obtained from three or fewer vessels have been redacted to protect data confidentiality.

| Year | Almaco Jack | Lane Snapper | Lesser Amberjack | Red Drum | Snowy Grouper | Speckled Hind | Wenchman | Yellowmouth Grouper |
|---|---|---|---|---|---|---|---|---|
| 1986 | 56 | 966 | X | 33 | 17 | 34 | X | 24 |
| 1987 | 71 | 920 | X | 67 | 33 | 42 | X | 13 |
| 1988 | 87 | 1097 | X | 42 | 58 | 83 | X | 21 |
| 1989 | 318 | 1560 | 15 | 9 | 45 | 63 | X | 10 |
| 1990 | 379 | 2492 | X | 42 | 57 | 36 | X | 22 |
| 1991 | 303 | 2819 | 17 | 34 | 18 | 35 | X | 30 |
| 1992 | 261 | 3269 | 80 | 77 | 12 | 25 | X | 15 |
| 1993 | 271 | 3552 | 18 | 120 | 63 | 38 | X | 13 |
| 1994 | 398 | 3361 | 19 | X | 42 | 23 | X | 18 |
| 1995 | 374 | 2760 | X | 107 | 49 | 17 | X | 7 |
| 1996 | 129 | 2300 | 4 | 133 | 23 | 29 | X | X |
| 1997 | 163 | 1862 | X | 91 | 33 | 9 | X | 9 |
| 1998 | 99 | 1562 | X | 92 | 48 | 30 | X | 8 |
| 1999 | 125 | 1320 | X | X | 8 | 25 | X | 12 |
| 2000 | 264 | 1820 | 11 | 81 | 19 | 36 | X | X |
| 2001 | 426 | 1680 | 8 | 20 | 54 | 67 | X | 7 |
| 2002 | 461 | 1829 | 10 | X | 30 | 69 | X | X |
| 2003 | 397 | 1980 | 14 | 11 | 9 | 21 | X | X |
| 2004 | 324 | 2062 | 10 | X | 11 | 30 | X | 12 |
| 2005 | 236 | 2051 | 11 | 11 | 21 | 27 | X | 11 |
| 2006 | 186 | 1607 | 11 | 21 | 15 | 15 | X | 15 |
| 2007 | 311 | 1823 | 7 | 24 | 24 | 22 | X | 13 |
| 2008 | 599 | 2325 | 15 | 40 | 25 | 33 | X | 6 |
| 2009 | 665 | 3108 | 27 | 65 | 32 | 60 | X | 9 |
| 2010 | 216 | 1750 | 14 | 37 | 39 | 24 | X | 17 |
| 2011 | 344 | 2210 | 22 | 155 | 46 | 40 | X | 7 |
| 2012 | 643 | 2645 | 39 | 100 | 25 | 45 | X | 15 |
| 2013 | 645 | 2686 | 21 | 151 | 16 | 56 | X | 10 |
| 2014 | 715 | 2619 | 14 | 143 | 33 | 74 | X | 9 |
| 2015 | 949 | 2991 | 23 | 149 | 32 | 48 | X | 12 |