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Hierarchical Bayesian Model to Estimate the Spawning Stock of Striped Bass (*Morone saxatilis*) in the Northwest Miramichi River, 1994 to 2010

Modèle bayésien hierarchique pour l'estimation d'abondance des géniteurs de bar rayé (*Morone saxatilis*) de la rivière Miramichi nord-ouest, 1994 à 2010

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ABSTRACT

A Bayesian hierarchical model is described and applied to the catch, mark and recapture data to estimate the spawning stock of Striped Bass in the Northwest Miramichi River for 1994 to 2010. The hierarchical structure of the model considers the variation in catchability among individual commercial gaspereau trapnets within years as well as the variation in catchabilities among years for individual traps. The estimated catchabilities of individual traps show large variation among years. The estimated sizes of the spawning stock of Striped Bass have varied from 3,700 to 92,000 spawners during 1994 to 2010. The estimates of population size derived from mark and recapture experiments are of good precision, annual coefficients of variations (CV) range from 7% to 25%. When only catches and effort are available, as was the case for 1994, 1996, 2006 and 2010, the estimated spawning stock sizes are highly uncertain, both in their location (median) and their precision (CV of 63% to 265%). Because of the highly variable catchabilities estimated among traps and among years, precise estimates of population size require the collection of annual mark and recapture data.

RÉSUMÉ

Les données de captures, de marquages et de recaptures sont analysées avec un modèle bayésien hierarchique afin d'estimer l'abondance des géniteurs de bar rayé (*Morone saxatilis*) de la rivière Miramichi nord-ouest pour les années 1994 à 2010. La structure du modèle hierarchique permet de considérer les variations entre trappes et entre années de la capturabilité pour le bar rayé dans les trappes commerciales à gaspareau. Les capturabilités estimées démontrent de grandes variations entre années. Les abondances estimées de géniteurs de bar rayé varient entre 3 700 et 92 000 individus durant la période 1994 à 2010. Les estimés d'abondance provenant des données d'expériences de marquage et de recapture sont de bonnes précisions avec des coéfficients de variation (CV) de l'ordre de 7% à 25%. Dans les années pour lesquelles on ne dispose que de données de capture et d'effort, dont 1994, 1996, 2006 et 2010, les estimés d'abondances des géniteurs sont très incertains, dans leurs niveaux (médiane) et leurs précisions (CV de 63% à 265%). En conséquence de ces importantes variations de capturabilité entre trappes et entre années, des données d'expériences de marquage et de recaptures sont nécessaires pour obtenir des estimés d'abondance de bonne précision.

INTRODUCTION

Striped Bass (*Morone saxatilis*) is a diadromous fish which was historically fished in commercial, recreational, and aboriginal food fisheries in the southern Gulf of St. Lawrence (Douglas et al. 2006). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the status of Striped Bass in eastern Canada and determined that the Designatable Unit (DU) of the southern Gulf of St. Lawrence met the criteria for a Threatened species due to its limited spawning area distribution (COSEWIC 2004). The only confirmed and annually consistent spawning site for southern Gulf of St. Lawrence Striped Bass is the tidal waters of the Northwest Miramichi River (COSEWIC 2004; Douglas et al. 2006).

The spawning population of Striped Bass in the Northwest Miramichi has been assessed annually since 1993. The assessment program relies upon partial capture methods, and since its inception has also integrated information on the bycatch of Striped Bass in the commercial fishery for gaspereau. There is an overlap in the Striped Bass spawning period in the Northwest Miramichi River and the spawning migration and fishery for gaspereau (*Alosa pseudoharengus* and *Alosa aestivalis*) and American Shad (*Alosa sapidissima*). The commercial gaspereau trapnets are effective gear for capturing Striped Bass just before and during the gaspereau spawning run in the river (Bradford et al. 1997).

Catches of Striped Bass in the gaspereau trapnets have been monitored by science personnel on board the fishing vessels as the trapnets are fished. However, the catches alone are insufficient to estimate the size of the spawning population because the catchabilities of the trapnets (i.e., the proportions of the population that are caught), for any of the species fished, are unknown. The catchability of trapnets or other fishing gear can be estimated using tagging experiments.

Since 1993, mark and recapture experiments have been conducted to estimate the size of the Striped Bass spawning stock (Bradford et al. 1993; Douglas et al. 2006). Provided the assumptions of mark and recapture experiments are respected and that there are sufficient informative observations collected during the program, these methods can provide estimates of the spawning stock size that are accurate and of good precision. However, experimental conditions vary among years and in some years, the mark and recapture experiments could not be conducted or were attempted but failed (for ex. insufficient numbers of animals were marked). In those cases, estimates of the catchabilities of the trapnets must be inferred from other years. Douglas et al. (2006) did so for a few years using a proportional relationship between mean catch rates (bass per day per trapnet of fishing effort) and estimates of population size accumulated over several years.

In the last decade or so, there has been a large amount of fisheries science literature describing models and approaches that are consistent with the way data are collected (observations) and can provide probabilistic descriptions of the parameters of interest (Rivot and Prevost 2002). These approaches include Bayesian modelling and inference. The Bayesian approaches are particularly appealing as they provide a structured framework for describing the associations between observations, processes and unknown parameters of interest in situations where the parameters of interest can not otherwise be observed. The Bayesian approaches also provide a convenient and flexible structure for including uncertainty and integrating it over multiple sources, observation error as well as process uncertainty. Bayesian approaches provide a robust structure for assessing the spawning population of Striped Bass from the Miramichi River in the southern Gulf of St. Lawrence.

This paper proposes an alternate model and approach to that described by Douglas et al. (2006), using the same data, to assess the size of the spawning stock of Striped Bass in the Northwest Miramichi River. The proposed Bayesian model takes advantage of knowledge gained over time in the estimation of the catchability coefficients of the individual commercial gaspereau trapnets and uses this knowledge to estimate the spawning stock when mark and recapture experimental data are poorly informative or not available. The uncertainty in all model components is incorporated in the posterior distributions of the parameter of interest (spawning stock size) which in turn represent true probability statements on the sizes of the spawning stock in different years.

MATERIALS AND METHODS

FISHERY, SAMPLING EFFORT AND MARK / RECAPTURE DATA

Mark and recapture experiments using commercial gaspereau trapnets are the basis of the assessment program to estimate the size of the spawning population of Striped Bass in the Northwest Miramichi River. A commercial gaspereau fisherman has been contracted to install one or two gaspereau trapnets prior to the opening of the gaspereau fishery for the purpose of capturing Striped Bass on the spawning ground and prior to spawning. Bass captured at the trapnet are tagged with external individually numbered t-bar tags, a subsample is measured, scale sampled and sex is determined when possible by pressure to the abdomen to extrude reproductive products. The period of sampling to estimate the spawning stock size is constrained to the period during which female Striped Bass are present on the spawning ground (Table 1). The presence of female bass is noted during sampling at the trapnets. Details of the assessment program are provided in Douglas et al. (2006).

In the Northwest Miramichi River, thirteen commercial gaspereau trapnets have been sampled over the past 17 years, 1994 to 2010. Most trapnets are sampled at least once during the Striped Bass spawning period (Table 2). At the sampled traps, all Striped Bass adults (generally > 30 cm in length) are counted, and any bass with a Floy tag is counted and the tag number recorded before the fish is released with its tag.

Catch, recapture, and effort data are tallied by trap and sampling date. For those years without mark and recapture data, catches and effort by trap and date are available. There is no useable mark and recapture information for the following years: 1994, 1996, 2006, and 2010.

The number of tags available for recapture changes over the season as additional animals are tagged or as tags are removed by fishermen. The marks available, the number of recaptured animals, the number of traps sampled and the total catch sampled are provided by sampling period and year in Appendix 1.

The number of individual traps sampled on any sampling day varies during and among years (Table 2). Trap NA0 was not fished after 2001. Traps AH1 and AH2 were fished by a different licence holder in 1994 and 1995 but the traps were in the same locations and fished in a similar manner over all years, and these traps are considered to be the same over the time series.

PREVIOUSLY USED POPULATION ASSESSMENT MODEL

In the previous assessments (Douglas et al. 2006), the mark and recapture data were grouped by sampling period, over all traps sampled, and a sequential Bayes estimate was derived with a binomial likelihood (Gazey and Staley 1986), as programmed in an Excel spreadsheet. A similar model structure was coded in OpenBUGS (Spiegelhalter et al. 2010) with two assumed likelihood distributions (binomial and Poisson) appropriate for count data and two prior distribution assumptions (Fig. 1; Table 3).

Under this model construct, the probability of recaptures and catches varies among sampling events. There is no transfer of information within a year (i.e. on catchability of trapnets among sampling periods) or among years and the model cannot estimate abundance from catches in years when there are no usable mark and recapture information.

ALTERNATE MODEL USING INDIVIDUAL TRAP CATCHES

An alternate model considers the information from individually sampled traps (data which were combined by sampling event in the previous model). A total of thirteen traps were visited at varying frequencies within and among years (Table 2). At each sampling visit, catch and recaptures were noted as well as the effort (in days) since the previous fishing event (Appendix 2). These data were used in the previous assessments (Douglas et al. 2006) to calculate a mean catch per unit of effort and relate these to the population size estimated in years when there were usable mark and recapture estimates of population size.

Two model structures were compared:

1. an annual model that estimates the catchability of individual trapnets and the population size for each year independently (Fig. 2; Table 4),
2. a hierarchical model (Fig. 3; Table 5) that assumes that the annual trapnet catchabilities are exchangeable among years because the trapnets are installed in fixed and identical locations, with identical structures (mesh size, size of trapnet, length of leader) and are maintained and fished by the same captain and commercial fishing crews over the years. Annual catchabilities may vary due to other factors, such as discharge conditions, and temperature, though these relationships were not modeled here. This model uses information over all years to infer individual annual estimates of catchability and estimates the overall catchability of a trap to be used in years without mark and recapture data. The model incorporates the uncertainty of the estimation of catchability of individual trapnets within year and the uncertainty of the catchability of a trap among years.

Model fitting, diagnostics

The models were coded in OpenBUGS (Spiegelhalter et al. 2010) and the posterior distributions of the parameters of interest (population size, trap catchabilities) were generated by Monte Carlo Markov Chain sampling using the GIBBS algorithm in OpenBUGS. Convergence was evaluated using the tools in OpenBUGS. Two chains of contrasting initial values were used. Posterior distributions were generated using an initial burn-in of 200 thousand simulations, which were discarded, and a further 200 thousand simulations from which every tenth value was retained, to reduce autocorrelation. Convergence, examined using the diagnostic tools in Openbugs, was achieved within the initial burn-in period.

The model fits were examined by comparing the observed versus predicted catches by year and by individual trap. The influence of individual traps on the population estimates was examined by comparing the estimates with each individual trap excluded from the model versus the model with all the traps. Finally, jackknifing of individual years was used to examine the performance of the model when mark and recapture data are available compared to when mark and recapture data are absent.

The posterior distributions are summarized as percentile plots (boxplots). Medians of the posterior distributions are also reported.

RESULTS

The period during which spawning Striped Bass were considered to be on the spawning ground began as early as May 21 in 1998 and 1999 to as late as June 4 in 1997 (Table 1; Douglas et al. 2006). The length of the spawning period has varied from 11 days in 2006 to as long as 28 days in 2000 (Table 1).

The maximum number of marks available in a given year varied from a low of 95 marks in 2005 to a high of 1,447 marks in 2002 (Appendix 1). Recaptures observed were as low as 7 in 2005 to a high of 279 in 2002. The number of fish sampled varied from a low of 547 fish in 1997 to a high of 10,991 fish in 2010. In terms of sampling events, there were as few as 7 days sampled in 2001 and 2002 to 23 days sampled in 2000. The number of individual trap samples varied from a low of 21 traps in 2002 to a high of 102 in 2000 (Table 1).

DATE AGGREGATED MODELS

The date aggregated model (Fig. 1) was fitted using two likelihood assumptions (binomial, Poisson) and two assumptions for the form of the prior distribution for the spawning stock parameter. The binomial likelihood is similar to the sequential Bayes model used in the previous assessments.

The two priors used in this model had contrasting strong assumptions about the spawning stock size (N) parameter. The uniform prior, between 1,000 and 500,0000, generally considered to be non-informative, has half the prior weight at abundances greater than 250,000 fish. This contrasts with the lognormal prior which has a very strong prior weight (75% probability) for abundances less than 10 fish (Fig. 4).

The choice of prior had minimal effect on the estimates of N for both the binomial likelihood and Poisson likelihood models. The medians of the catchabilities in the binomial model and the Poisson model tend to be slightly higher when the lognormal prior is used compared to the uniform prior (Fig. 5).

The Poisson likelihood model gives higher estimates of N compared to the binomial model, regardless of the prior on N (Fig. 6). The coefficient of variation of annual estimates are also higher with the Poisson likelihood (example shown is for lognormal prior) (Fig. 6). The catchabilities estimated from the Poisson likelihood model are correspondingly lower than the probability of capture rates from the binomial likelihood, which is why the estimates of N are higher for the Poisson likelihood model (Fig. 7). The systematic difference associated with the choice of likelihood is unrelated to the choice of prior on N (uniform vs lognormal) (Fig. 7).

Estimated spawning stock sizes (median values of the posterior distributions) from the two models are generally similar to those based on the sequential Bayes model programmed in the Excel spreadsheet (Table 6).

INDIVIDUAL TRAP CATCHABILITY MODEL

Annual model

The annual model estimates the individual trap catchabilities independently among years (Fig. 2; Table 4). Two likelihood assumptions (binomial, Poisson) using one prior assumption for N (lognormal prior, Fig. 4) were examined. As with the date aggregated model, the estimates of N from the Poisson likelihood are usually higher than those from the binomial likelihood and the CVs are also slightly higher for the Poisson model (Fig. 8).

The estimated catchabilities from individual traps are of similar magnitude and follow a similar pattern within years regardless of the likelihood assumption used (Fig. 9). There are some important differences in catchabilities for particular traps in particular years but most are similar regardless of the likelihood assumptions (Fig. 9).

Hierarchical model

There are thirteen trapnets which have been sampled for Striped Bass in the Northwest Miramichi over the 1994 to 2010 period. Mark and recapture data for estimating catchabilities are available for thirteen of those years (excluding 1994, 1996, 2006 and 2010). A hierarchical model (Fig. 3) that assumed that the trapnet specific catchabilities are exchangeable among years was fitted using the Poisson likelihood assumption and for two prior assumptions for N (lognormal, gamma; Fig. 4).

The prior assumption for N had no effect on the posterior estimates of N, the precision of N, or the estimated trap catchabilities (Fig. 10). The model with the lognormal prior was used in all subsequent analyses.

The hierarchical model with the lognormal prior for N provides predicted trap catches which are similar to the observed trap catches over all years and traps (Fig. 11). The only difference is that the hierarchical model does not adequately predict the maximum catches observed in most years (only 4 of 13 years where predicted maximum catch is greater than observed maximum catch) or for most traps (only 3 of 13 traps where predicted maximum catch is greater than observed maximum catch). Minimum catches and the major portion of the distribution of the observed catches are adequately predicted by the model. Based on this diagnostic, the hierarchical model with lognormal prior on N was considered to be adequate for estimating the catchabilities of the individual traps and the annual population sizes of Striped Bass.

Catchabilities

The estimated catchabilities by year for the thirteen traps and the overall catchabilities of the traps are shown in Figure 12. Annual catchabilities by trap are highly variable but similar for the annual Bayesian model and the hierarchical Bayesian model (Figs. 9, 12). Median catchabilities, expressed as the number of bass captured per day of fishing effort per bass available for capture, vary from a low of 0.0002 (2 bass per 10,000 fish available) to a high of 0.0156 (156 bass per 10,000 fish available) (Table 7). The coefficients of variation of the posterior distribution of the catchabilities also differ among the traps, the lowest annual CV for any trap was about 6% and the highest was 44% (Table 7). The medians of the posterior distribution for the overall catchabilities vary from a low of 0.0011 to a high of 0.0039 but the precision of the overall estimate is low, CVs ranging from 91% to as high as 362% (Table 7; Fig. 13). The trap (NA0) with a CV of 362% was only sampled for six years and ceased fishing in 2001. The recent estimates of population size are therefore based on sampling from twelve trapnets.

Catchabilities of traps operated by the same license holder are positively correlated, and in a few instances, strongly so (Table 8). Annual catchabilities are also occasionally positively correlated but can equally be negatively correlated such that there is little evidence of an annual factor which could account for the variation in catchability among traps and among years. There are a few years for which catchabilities are generally high or low at most traps; for example, catchabilities are the highest or one of the highest in 2002 at 8 of 10 sampled traps, and are among the lowest in 8 of 11 traps in 2009 (Fig. 12). Factors which could possibly account for this, such as discharge or run timing of bass, were not examined.

Comparison of posterior estimates of N among models

The posterior median estimates for N from the hierarchical model are generally lower than the median estimates from either the date-aggregated model or the annual model (Table 9). The CVs of the estimates are lowest for the hierarchical model.

Influence of individual traps on estimates of N

The model assumes that the catches in the trapnets are a proportional index of the spawning population of striped bass. Not all traps were sampled annually nor was the same sampling effort attributed to each trap (Table 2). The influence of individual traps on the estimates of N was described by a leaving-one-out (jackknife) approach; one trap at a time was excluded and the hierarchical model was fitted on the reduced set of data. The posterior distributions of the estimates of N were compared for the case when the trap is excluded relative to the full model when all the data from all the traps are included.

The bias (expressed as the median estimate of N with the trap excluded divided by the median estimate of N from the model with all the data) was variable by trap and year and generally not large (less than 10%) (Fig. 13). The bias was important (greater than 20%) in three instances: the estimate of N for 1995 when the data from trap 8 were excluded, the estimate of N for 2003 when trap 2 (AH2) was excluded, and the estimate of N for 2009 when trap 12 (OB1) was excluded.

Model performance – jackknife

Hierarchical model prediction performance for the years when there was no mark and recapture information was assessed by jackknifing; for each of the thirteen years with mark and recapture data, the population size for that year was estimated using only the catches and the predicted overall catchabilities of the sampled traps, as is the case for 1994, 1996, 2006 and 2010. The bias is described as the relative error in the median of the population estimate of the jackknifed year from the full hierarchical model (bias = (jackknife estimate – full model estimate) / full model estimate).

The absolute bias ranges from a low of 5% to a high of 225% (Table 10). In nine of the thirteen years, there is a negative bias, i.e. the population estimate based on the catches and the assumed catchabilities is less than the population estimate when the mark and recapture data are included (Table 10). The largest bias is for 2002; high catches in that year were the result of high catchabilities at most traps, rather than a high abundance of Striped Bass. In seven of the thirteen years, the negative bias was greater than 30%, and in these cases, the median of the jackknifed value was outside the 95% BCI range from the full model (Table 10). The jackknifed estimates of N have very high CVs, ranging from 61% to 83% (Table 10). As a result of this greater uncertainty, the median value from the full model estimate is contained within the 95% BCI range of the jackknifed value.

Hierarchical Bayesian Population Model Estimates of Striped Bass

The population sizes of Striped Bass in 1994, 1996, 2006 and 2010 were estimated based on the observed sampled catches, the reported effort, and the posterior estimates of the overall catchabilities from the individual traps, derived using the hierarchical model (Table 9). The uncertainty in the estimated population sizes for those years (CV: 63% to 265%) is much greater than the uncertainty for the years when mark and recapture data are available (CV: 6% to 25%). The estimate for 1994 based on the hierarchical model is highly uncertain, with a median estimate of 55,200 fish which is similar to the previously published value (Douglas et al. 2006) and a lower 95% BCI value of 7,400 fish (Table 9). The highest median abundance was estimated in 2008 at just over 92,000 fish and the lowest median abundances were estimated for 1996 to 2000 at about 4,000 to 5,000 fish (Table 9).

CONCLUSIONS AND RECOMMENDATIONS

In the previous assessments of the spawning population of striped bass, an estimate of the population size was obtained using mark and recapture data. A relationship (power function) between the estimated population size (mode or median) and the mean catch rate of striped bass in the commercial gaspereau fishery was derived. In the years without mark and recapture data, the population size was estimated from this function using the mean catch rate for the years of interest. Between 1995 and 2010, thirteen years have usable mark and recapture data.

The model presented in this paper used the same field information collected from commercial gaspereau trapnet catches but treats the observations in a Bayesian framework. The most important differences between the hierarchical Bayesian model and the previous method include the treatment of the catches from individual trapnets, the estimation of the population size for the years when only catch data are available, and the treatment of the uncertainty in both the population estimates and the catch rate estimates.

The assumptions of mark and recapture experiments were assumed to have been respected. It was assumed that tagged fish and unmarked fish had similar survival rates during the period of the experiment. It was assumed that the probability of capture of a previously tagged fish in a given year was similar to the probability of capture of an unmarked fish and that the probability of capture was independent among individuals (independent and identically distributed (iid) condition). The population was considered closed within the time period when females are present in the area sampled (Table 1). Although some marked fish moved out of the sampling area, we assumed the same happened for unmarked fish with similar probabilities of moving out of the area. Finally, all marked fish and all unmarked fish were sampled (no misreporting) because the data were collected by science personnel sampling individual trap catches and in all cases, the entire catch of the trapnet was sampled.

The mark and recapture population model differs from the previously published approach in that catches (and recaptured marks) from individual trapnets are treated directly, rather than the date aggregated values. The posterior distributions of the estimates from this data structure are very similar to those from the date-aggregated approach used in the previous assessments. This model was chosen in order to estimate the individual trapnet catchabilities which can then be applied to the individual trapnet catches in years when mark and recapture data are not available.

In previous assessments, the catches and efforts of individual traps were modelled using a covariance model with mean catch for the year estimated from observed catches adjusted for effort (covariate). In that formulation, there was no coefficient for individual trap catchabilities, and an overall annual mean catch rate for all traps was derived. The annual variation in mean catch per year, corrected for effort, was considered to be due to variation in abundance.

There are three issues with the previously published treatment of the catch data that are addressed with the hierarchical Bayesian model. First, the frequency of sampling of the thirteen traps varied within a year (Table 2) and the selection of trapnets to be sampled was not random. This would not be an issue if indeed the thirteen trapnets had identical catchability coefficients. The mark and recapture model results indicate that the catchability coefficients differed among traps within a year. For the thirteen trapnets during the thirteen years, estimated catchabilities (median) of individual traps varied from a low of 2 fish to a high of 156 fish per day of effort per 10,000 animals in the area. Secondly, the non-random sampling of the trapnets among years introduces a second level of potential bias, particularly if the variation in catchabilities among years are uncorrelated among traps. In the hierarchical model, each trap is considered individually. Catchabilities of individual traps varied widely despite the individual trapnets being placed in fixed locations every year, and being installed, maintained and fished by the same licence holders in all years. The estimated variation among years is due to factors not accounted for in the hierarchical model. Thirdly, the uncertainty of the mean annual catch rates from the general linear model were not considered in the model to predict abundance from mean catch.

In this paper, we used a hierarchical structure and modelled the individual trap catchabilities exchangeably over years to address the variation in catchabilities among traps within a year, the variation in catchabilities among years for individual traps, and to account for all levels of model uncertainty. The assumption of exchangeability among years for the catchabilities of individual trapnets provides the means to estimate the overall trap catchabilities using the informative mark and recapture experimental data. It is this overall catchability for each of the thirteen traps which is used to estimate the population size for the years without mark and recapture data, and to inform the estimation of the catchabilities for years where the mark and recapture data were weakly informative.

Some issues remain with this assessment. The estimated catchabilities of individual traps show large variation among years. This important annual variation within the hierarchical structure of the model results in very uncertain individual trap overall catchabilities (CVs mostly greater than 120%). Some of the uncertainty may be due to the prior assumptions for the hyperparameters of the catchabilities. However, the prior assumptions had little influence on the annual and individual trapnet catchabilities. On the other hand, thirteen observations (and frequently less than that number of years were sampled for all traps) is a small sample size with which to describe the overlying distribution of the trapnet catchabilities. The temporal variations in catchabilities among traps suggests that there is a factor(s) that contributes to the variation in catchability, for example perhaps discharge or timing of the spawning migration in the year. An examination of such associations would be a useful exploratory exercise to attempt to reduce the uncertainty in trapnet catchabilities.

Estimates of population size derived using only catches and effort, as was the case for 1994, 1996, 2006 and 2010, are highly uncertain, both in their location (median) and their precision (high CV). Because of the highly variable catchabilities estimated among traps and among years, precise and unbiased estimates of population size require the collection of annual mark and recapture data. With more years of collection of such information, an additional factor to model variation in annual catchabilities could be explored. Considering the data collected in the past and the expectation for data collection in the future, the Bayesian hierarchical model is the most appropriate approach for estimating the spawning stock of Striped Bass in the Northwest Miramichi.

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Table 1. Defined Striped Bass spawning period for the population estimation experiment, 1994 to 2010.

Year	Date Start	Date End	Traps sampled	Traps fishing	Sampling intensity
1993	28-May	16-Jun	37	na	na
1994	24-May	12-Jun	34	na	na
1995	24-May	9-Jun	31	na	na
1996	24-May	10-Jun	38	na	na
1997	4-Jun	20-Jun	61	na	na
1998	21-May	4-Jun	46	na	na
1999	21-May	8-Jun	84	143	58.7%
2000	25-May	21-Jun	102	220	46.4%
2001	25-May	11-Jun	26	63	41.3%
2002	23-May	4-Jun	21	60	35.0%
2003	24-May	11-Jun	37	78	47.4%
2004	24-May	11-Jun	28	69	40.6%
2005	24-May	8-Jun	35	68	51.5%
2006	23-May	2-Jun	30	61	49.2%
2007	22-May	11-Jun	47	114	41.2%
2008	26-May	16-Jun	65	190	34.2%
2009	23-May	11-Jun	54	153	35.3%
2010	30-May	12-Jun	49	123	39.8%

Table 2. Frequency of sampling of individual traps in 1994 to 2010. “na” means trap did not operate. Trap acronyms identify individual traps with common alphabetic label representing a common fisher and with the numeric label representing the number of traps of the fisher.

	Trap identification												
Year	AH1	AH2	AJ1	AJ2	AJ3	AM1	AM2	ER0	JR1	JR2	NA0	OB1	OB2
1994	6	12	0	0	0	1	0	0	0	0	13	0	2
1995	3	3	1	3	2	1	3	4	1	0	4	2	0
1996	7	8	0	0	0	8	6	2	1	2	1	1	1
1997	6	5	5	3	3	4	6	3	2	4	9	6	5
1998	4	6	2	5	4	3	3	0	3	5	4	5	2
1999	9	5	7	9	7	8	9	5	5	2	9	6	3
2000	6	5	7	8	11	8	14	9	6	3	7	11	7
2001	4	4	2	1	2	1	2	2	3	1	1	2	1
2002	3	4	2	2	3	0	2	1	0	1	na	1	2
2003	2	6	2	5	5	2	2	4	4	1	na	3	1
2004	1	3	2	2	5	4	3	2	2	1	na	2	1
2005	3	1	4	6	2	0	5	2	5	3	na	2	2
2006	2	2	1	5	2	0	4	4	2	1	na	5	2
2007	4	5	1	6	5	3	5	5	4	3	na	5	1
2008	3	6	2	9	5	7	7	2	7	5	na	8	4
2009	2	8	4	7	2	8	0	5	7	3	na	7	1
2010	3	7	3	7	2	3	3	7	7	1	na	5	1

Table 3. Likelihood distributions and priors for the date aggregated mark and recapture models shown in Figure 1.

Year = y
Sampling period in a year = d

Binomial likelihood model

Likelihoods

Recaps[y,d] ~ binomial(theta[y,d], **Marks**[y,d])
Catch[y,d] ~ binomial(theta[y,d], N[y])

With theta[y,d] = probability of a fish being captured over all sampled traps at sampling event d in year y
N[y] = population size of striped bass in year y

Priors

Theta[y,d] ~ beta(1,1)
N[y] ~ uniform(1000, 500000) or
~ lognormal(0, 10)

Poisson likelihood model

Likelihoods

Recaps[y,d] ~ Poisson(rho.m[y,d])
Catch[y,d] ~ Poisson(rho.n[y,d])

With rho.m[y,d] = theta[y,d] * **Marks**[y,d]
= average number of recaps per marked animal over all sampled traps at sampling event d in year y
rho.n[y,d] = theta[y,d] * N[y]
= average number of animals captured per population size over all sampled traps at sampling event d in year y

Priors

Theta[y,d] ~ gamma(0.1,1)
N[y] ~ uniform(1000, 500000) or
~ lognormal(0, 10)

Table 4. Likelihood distributions and priors for the individual trap mark and recapture annual models shown in Figure 2.

Year = y
Trap = t
Sampling period in a year = d

Binomial likelihood model

Likelihoods

Recaps[y,t,d] ~ binomial(mu.q[y,t,d], **Marks**[y,t,d])
Catch[y,t,d] ~ binomial(mu.q[y,t,d], N[y])

With mu.q[y,t,d] = 1 – exp(-(theta[y,t] * **Effort**[y,t,d])
theta[y,t] = catchability of trap t in year y
N[y] = population size of striped bass in year y

Priors

theta[y,t] ~ beta(1,1)
N[y] ~ uniform(1000, 500000) or
~ lognormal(0, 10)

Poisson likelihood model

Likelihoods

Recaps[y,t,d] ~ Poisson(rho.m[y,t,d])
Catch[y,t,d] ~ Poisson(rho.n[y,t,d])

With rho.m[y,t,d] = theta[y,t] * **Marks**[y,t,d] * **Effort**[y,t,d]
= average number of recaps at a sampling event at trap t in year y
rho.n[y,t,d] = theta[y,t] * N[y] * **Effort**[y,t,d]
= average number of bass captured at a sampling event at trap t in year y
theta[y,t] = average number of recaptures per marked animal or average catches per population size per day of fishing effort at trap t in year y

Priors

theta[y,t] ~ gamma(0.1,1)
N[y] ~ uniform(1000, 500000) or
~ lognormal(0, 10)

Table 5. Likelihood distributions and priors for the hierarchical population estimation model shown in Figure 3.

Year = y
Trap = t
Sampling period in a year = d

Poisson likelihood model

Likelihoods

Recaps[y,t,d] ~ Poisson(rho.m[y,t,d])
Catch[y,t,d] ~ Poisson(rho.n[y,t,d])

With rho.m[y,t,d] = theta[y,t] * **Marks**[y,t,d] * **Effort**[y,t,d]
= average number of recaps at a sampling event at trap t in year y

rho.n[y,t,d] = theta[y,t] * N[y] * **Effort**[y,t,d]
= average number of bass captured at a sampling event at trap t in year y

theta[y,t] = average number of recaptures per marked animal or average catches per population size per day of fishing effort at trap t in year y

Priors

theta[y,t] ~ gamma(alpha[t], beta[t])
alpha[t] = mu[t] * beta[t]
mu[t] ~ gamma(0.01, 0.01)
beta[t] ~ gamma(0.01, 0.01)
N[y] ~ lognormal(0, 10) or
~ gamma(1, 0.0001)

Table 6. Spawning stock size estimates from the date aggregated model assuming a binomial likelihood, Poisson likelihood, and from previous assessments (Bayes sequential model as per Gazey and Staley (1986) as reported by Douglas et al. (2006)). Median values from the posterior distributions with the lognormal prior for N are shown for the binomial and Poisson models, the mode is shown for assessment from Douglas et al. (2006).

Year	Binomial	Poisson	Previous assessment
1995	44,810	72,120	50,000
1997	3,522	6,200	8,000
1998	3,285	3,740	3,400
1999	3,736	3,802	3,940
2000	4,216	4,720	3,900
2001	32,260	28,690	23,000
2002	27,130	25,820	29,000
2003	18,550	20,270	21,000
2004	9,842	13,850	15,000
2005	7,779	15,480	20,000
2007	44,740	47,910	
2008	92,330	99,960	
2009	51,740	57,380	

Table 7. Catchabilities (fish per day of effort per unit fish in the population) (min. and max. range of median posterior value and CV of the posterior estimates) of individual traps over the thirteen years and the overall catchabilities by trap (median, CV).

	Annual estimates from the hierarchical model					
	Median (annual)		CV (annual)		Overall catchability	
Trap_index	Min	Max	Min	Max	Median	CV
AH1	0.0004	0.0120	6.4%	31.3%	0.0027	153.7%
AH2	0.0003	0.0156	6.1%	42.4%	0.0027	147.6%
AJ1	0.0002	0.0041	8.2%	37.8%	0.0017	131.7%
AJ2	0.0003	0.0111	6.7%	30.0%	0.0022	132.1%
AJ3	0.0004	0.0075	6.8%	26.7%	0.0027	120.9%
AM1	0.0009	0.0042	10.0%	25.2%	0.0022	125.7%
AM2	0.0005	0.0041	9.3%	25.2%	0.0016	128.5%
ER0	0.0015	0.0082	9.7%	24.7%	0.0039	91.2%
JR1	0.0007	0.0042	12.4%	27.3%	0.0018	132.9%
JR2	0.0004	0.0085	11.2%	41.4%	0.0032	116.7%
NA0	0.0002	0.0019	12.4%	34.3%	0.0011	361.5%
OB1	0.0006	0.0089	7.2%	27.0%	0.0024	117.4%
OB2	0.0003	0.0035	8.4%	43.9%	0.0013	158.0%

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Table 8. Between trap correlations (by year) of estimated catchabilities (median values from the posterior distributions) based on the annual model (upper table) and the hierarchical model (lower table). Comparisons within rectangles are traps belonging to a common licence holder.

Trap-index	AH1	AH2	AJ1	AJ2	AJ3	AM1	AM2	ER0	JR1	JR2	NA0	OB1
AH2	0.72											
AJ1	0.33	0.72										
AJ2	0.49	0.81	0.82									
AJ3	0.19	0.56	0.79	0.83								
AM1	-0.30	-0.03	-0.17	-0.23	0.01							
AM2	0.17	0.47	0.37	0.18	0.27	0.59						
ER0	-0.05	0.16	0.43	0.46	0.46	-0.13	-0.04					
JR1	0.41	0.71	0.49	0.66	0.53	0.36	0.55	-0.37				
JR2	-0.01	0.13	-0.15	-0.27	-0.14	0.82	0.75	-0.53	0.72			
NA0	-0.29	0.56	0.76	0.72	0.58	0.97	0.75	-0.05	0.62	0.96		
OB1	0.46	0.75	0.77	0.93	0.80	-0.21	0.13	0.24	0.71	-0.17	0.64	
OB2	0.27	0.55	0.60	0.55	0.61	0.16	0.65	0.50	0.15	0.02	0.47	0.42

Trap-index	AH1	AH2	AJ1	AJ2	AJ3	AM1	AM2	ER0	JR1	JR2	NA0	OB1
AH2	0.69											
AJ1	0.24	0.66										
AJ2	0.43	0.79	0.79									
AJ3	0.09	0.46	0.74	0.79								
AM1	-0.23	0.14	-0.10	0.03	0.14							
AM2	0.09	0.42	0.28	0.12	0.18	0.54						
ER0	-0.30	0.03	0.39	0.44	0.57	0.29	-0.02					
JR1	0.39	0.68	0.40	0.57	0.46	0.16	0.48	-0.18				
JR2	-0.02	0.09	-0.26	-0.34	-0.25	0.65	0.72	-0.36	0.64			
NA0	-0.41	0.41	0.56	0.52	0.29	0.96	0.65	0.67	0.39	0.95		
OB1	0.38	0.71	0.71	0.91	0.72	0.04	0.05	0.28	0.60	-0.24	0.62	
OB2	0.18	0.48	0.55	0.52	0.60	0.34	0.62	0.37	0.11	-0.04	0.42	0.39

Table 9. Posterior distribution descriptors of the population size estimates of Striped Bass for three estimation models. The lognormal prior for N was used for the Poisson model results shown.

	Median			CV		
Year	**Hierarchical**	**Annual**	**Date-aggregated**	**Hierarchical**	**Annual**	**Date-aggregated**
1994	55,200			265%		
1995	52,910	72,120	65,150	22%	30%	30%
1996	3,675			89%		
1997	4,588	6,200	6,323	21%	28%	28%
1998	3,845	3,740	3,748	12%	13%	13%
1999	3,844	3,802	3,880	7%	7%	7%
2000	4,290	4,720	3,665	14%	15%	15%
2001	26,990	28,690	22,480	14%	15%	15%
2002	26,600	25,820	28,920	6%	6%	6%
2003	19,890	20,270	20,770	12%	12%	12%
2004	12,550	13,850	13,750	18%	22%	22%
2005	14,400	15,480	16,480	25%	38%	41%
2006	16,200			63%		
2007	46,110	47,910	48,120	13%	14%	14%
2008	92,160	99,960	97,010	12%	13%	13%
2009	50,230	57,380	52,960	15%	17%	16%
2010	45,120			63%		

	2.5^{th} perc.			97.5^{th} perc.		
Year	**Hierarchical**	**Annual**	**Date-aggregated**	**Hierarchical**	**Annual**	**Date-aggregated**
1994	7,392			604,200		
1995	35,730	44,130	39,340	83,500	133,100	119,700
1996	851			15,480		
1997	3,144	3,847	3,946	7,053	10,900	11,080
1998	3,061	2,955	2,945	4,924	4,860	4,866
1999	3,344	3,295	3,364	4,434	4,398	4,491
2000	3,305	3,562	2,762	5,671	6,449	4,960
2001	20,960	22,020	17,130	35,520	38,730	30,190
2002	23,650	22,950	25,710	29,960	29,150	32,720
2003	16,010	16,220	16,600	25,180	25,780	26,310
2004	9,054	9,452	9,488	17,840	21,360	21,410
2005	9,328	8,422	8,950	24,180	32,910	36,170
2006	5,385			49,590		
2007	36,320	37,010	36,990	59,880	63,210	63,800
2008	73,600	77,860	76,410	117,900	131,200	126,800
2009	38,200	42,470	39,860	67,800	80,380	73,570
2010	14,670			134,300		

Table 10. Comparison of predicted population sizes for the jackknifed year (J) and the predicted value when the year is in the model (Ml). Bias is calculated as the difference of the jackknifed median value to the median value from the full model over the median value from the full model.

Year	Full model (M)			Jackknife predicted (J)			Bias
	median	95% BCI	CV	median	95% BCI	CV	[(J – M) / M]
1995	52,910	35,730 – 83,500	22%	20,820	4,688 – 75,250	78%	-61%
1997	4,588	3,144 – 7,053	21%	1,558	420 – 4,675	65%	-66%
1998	3,845	3,061 – 4,924	12%	4,128	1,162 – 13,560	70%	7%
1999	3,844	3,344 – 4,434	7%	4,400	1,193 – 14,070	69%	14%
2000	4,290	3,305 – 5,671	14%	2,108	662 – 6,019	60%	-51%
2001	26,990	20,960 – 35,520	14%	23,370	7,150 – 70,610	63%	-13%
2002	26,600	23,650 – 29,960	6%	86,330	21,010 – 331,400	83%	225%
2003	19,890	16,010 – 25,180	12%	20,920	5,938 – 69,220	68%	5%
2004	12,550	9,054 – 17,840	18%	8,569	2,783 – 26,000	63%	-32%
2005	14,400	9,328 – 24,180	25%	10,750	3,359 – 34,480	68%	-25%
2007	46,110	36,320 – 59,880	13%	30,790	9,835 – 93,950	65%	-33%
2008	92,160	73,600 – 117,900	12%	40,010	13,190 – 119,400	61%	-57%
2009	50,230	38,200 – 67,800	15%	19,140	6,088 – 61,120	68%	-62%

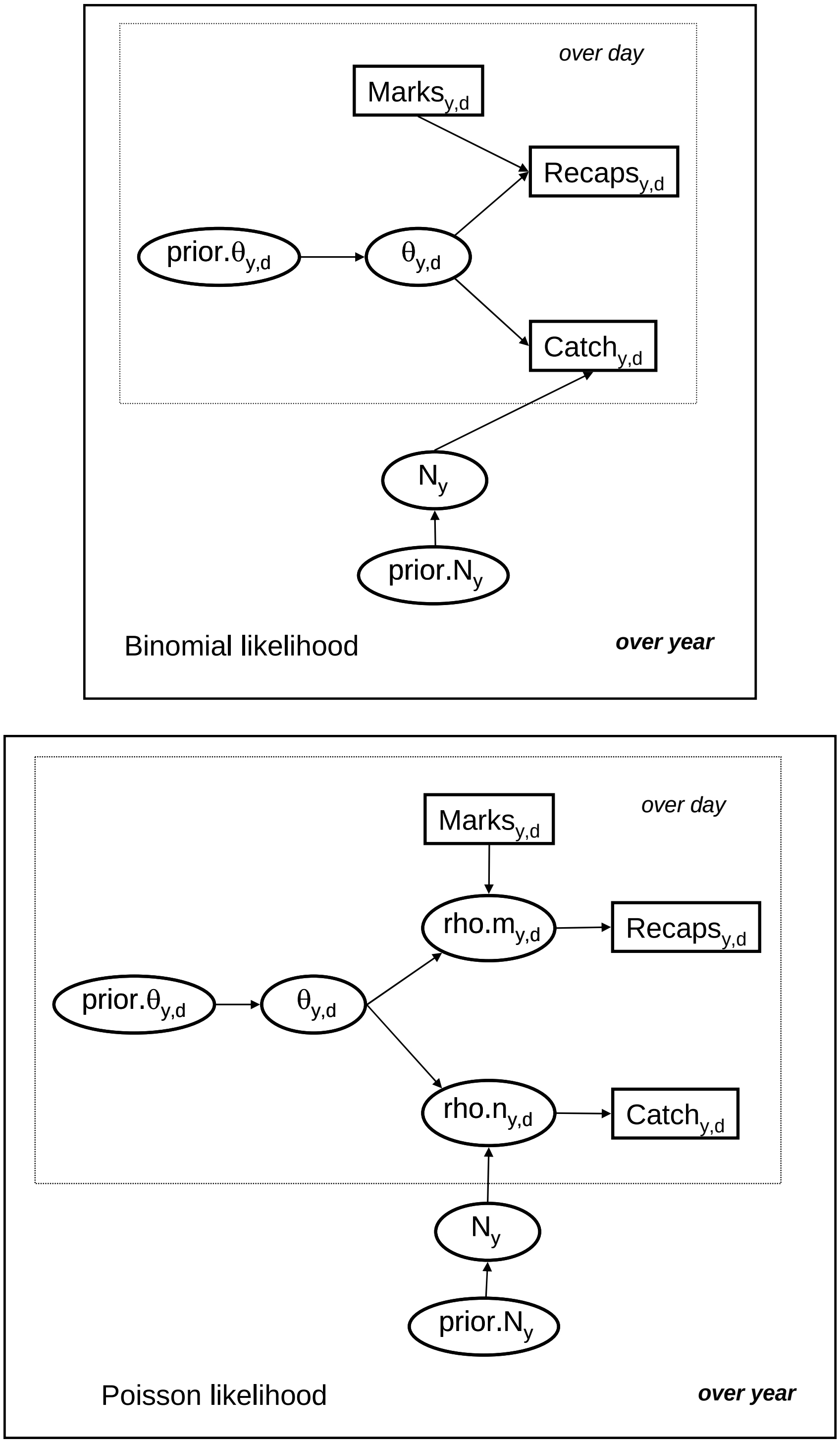
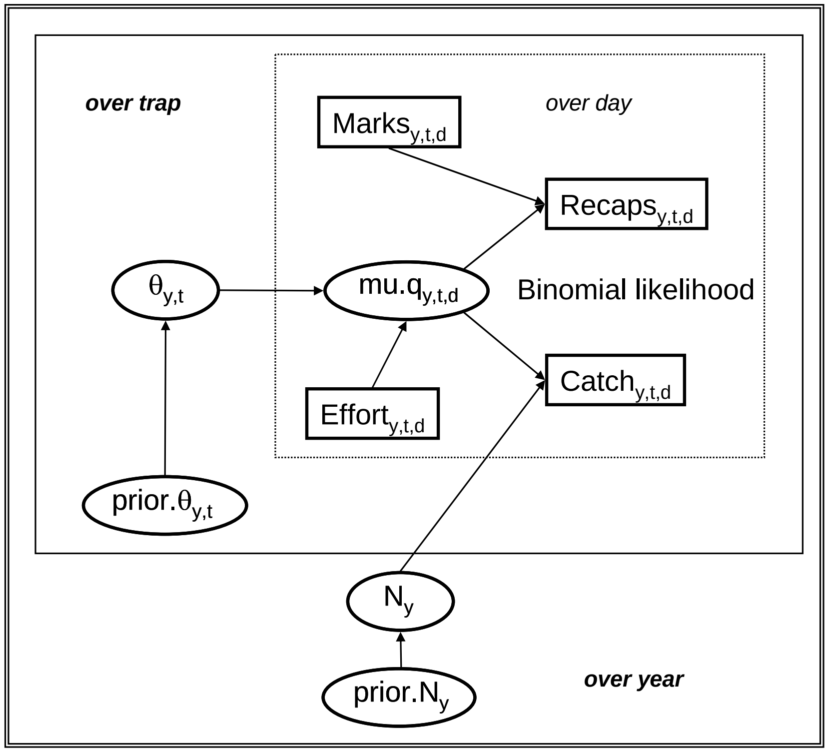


Figure 1. Directed Acyclical Graphs (DAG) of the date aggregated mark and recapture models with a binomial likelihood (upper) and a Poisson likelihood (lower). The rectangles represent observations and the ellipses are parameters and latent variables. Symbols are defined in table 3.



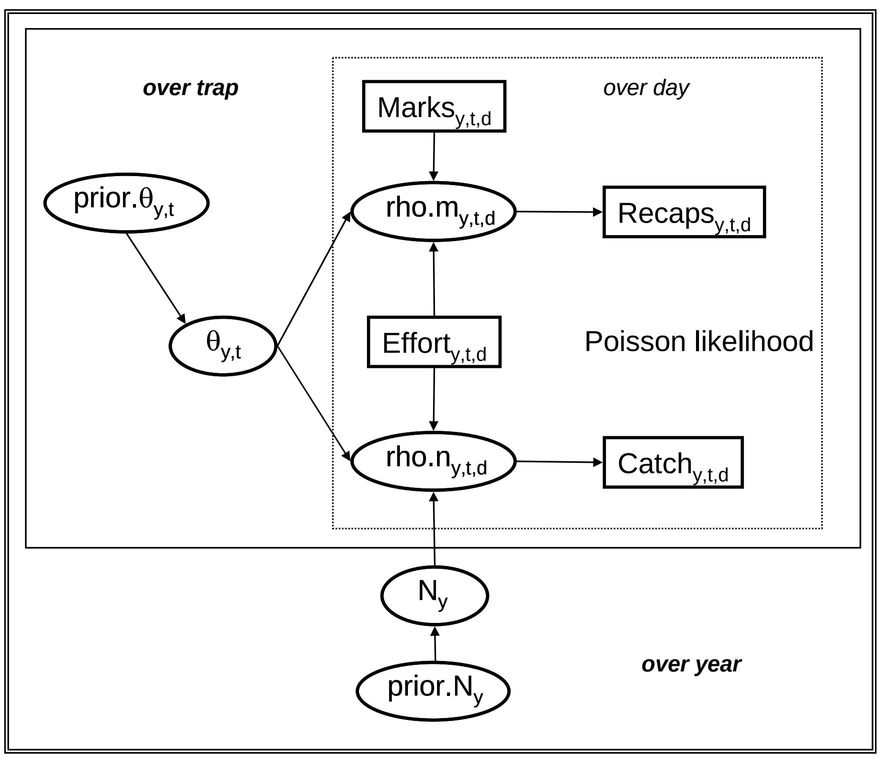


Figure 2. Directed Acyclical Graphs (DAG) of the individual trap annual mark and recapture models with a binomial likelihood (upper) and Poisson likelihood (lower). The rectangles represent observations and the ellipses are parameters and latent variables. Symbols are defined in table 4.

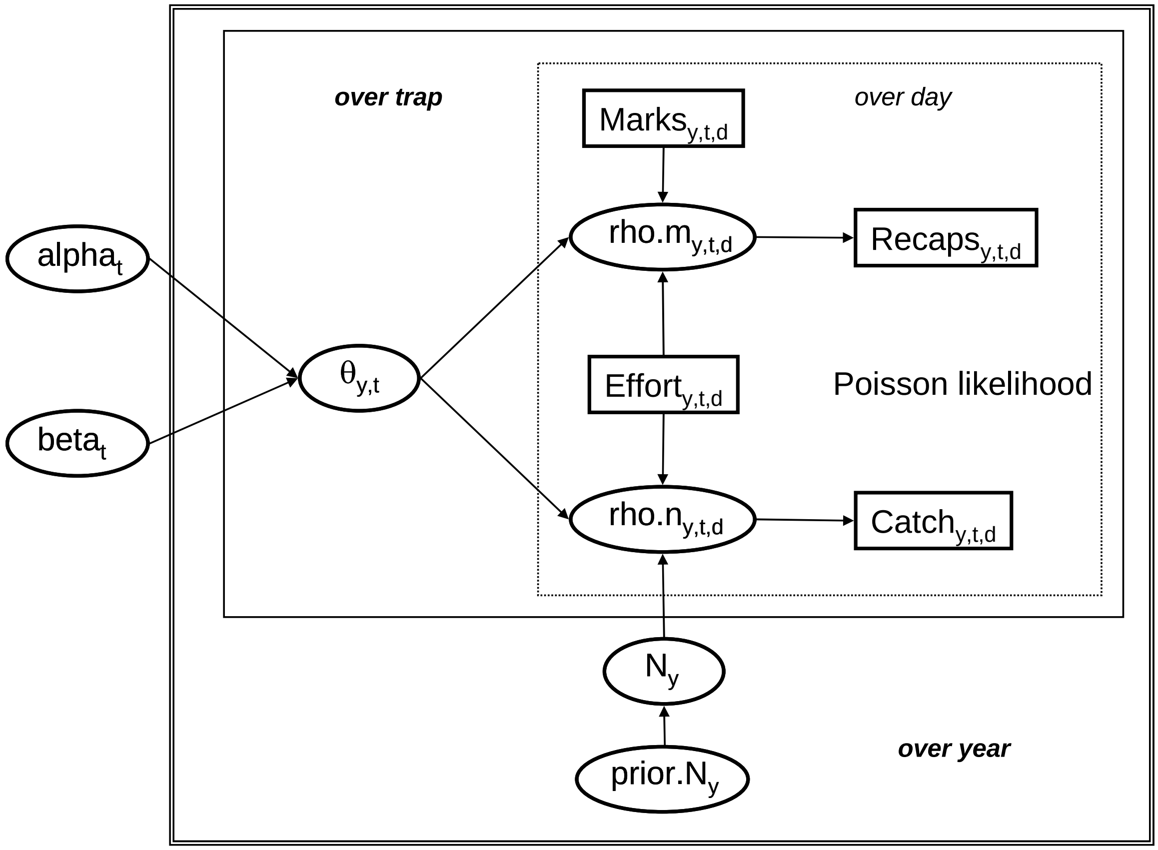


Figure 3. Directed Acyclical Graphs (DAG) of the hierarchical model with a Poisson likelihood. The rectangles represent observations and the ellipses are parameters and latent variables. Symbols are defined in table 5.

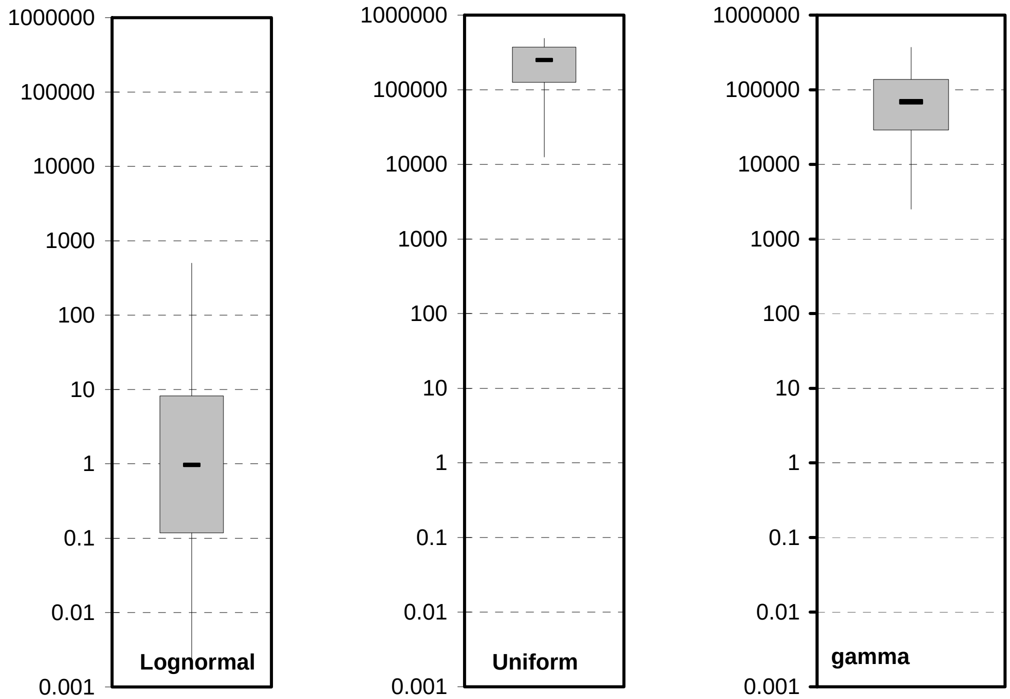


Figure 4. Prior distributions for the spawning stock size parameter (number of fish). Boxplots are: vertical line is the 95% Bayesian Credibility Interval (BCI), the rectangle is the interquartile range and the horizontal dash is the median.

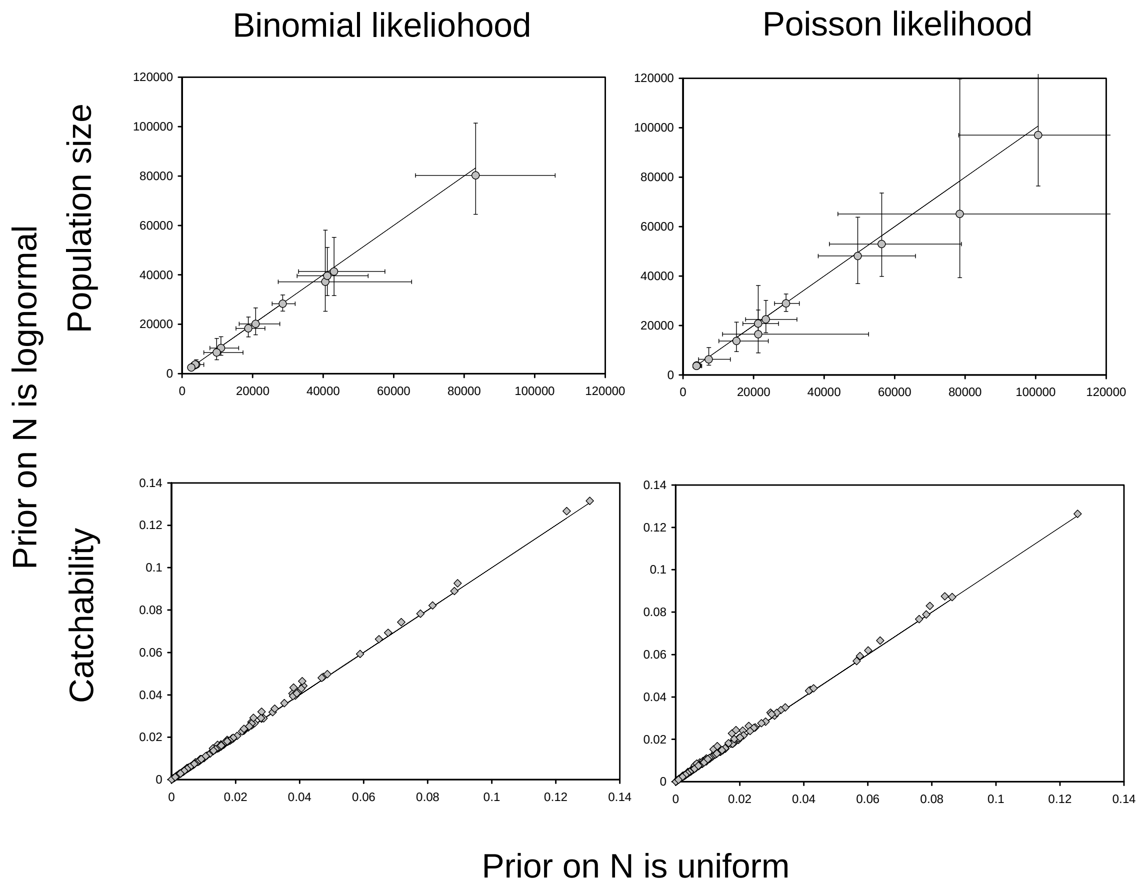


Figure 5. Estimates of spawning stock size (median, 95% BCI range) (upper panels) and trapnet catchabilities (median; lower panels) for the binomial likelihood (left panels) and the Poisson likelihood (right panels) models relative to the prior assumptions for spawning stock size (uniform on x-axis, lognormal on y-axis).

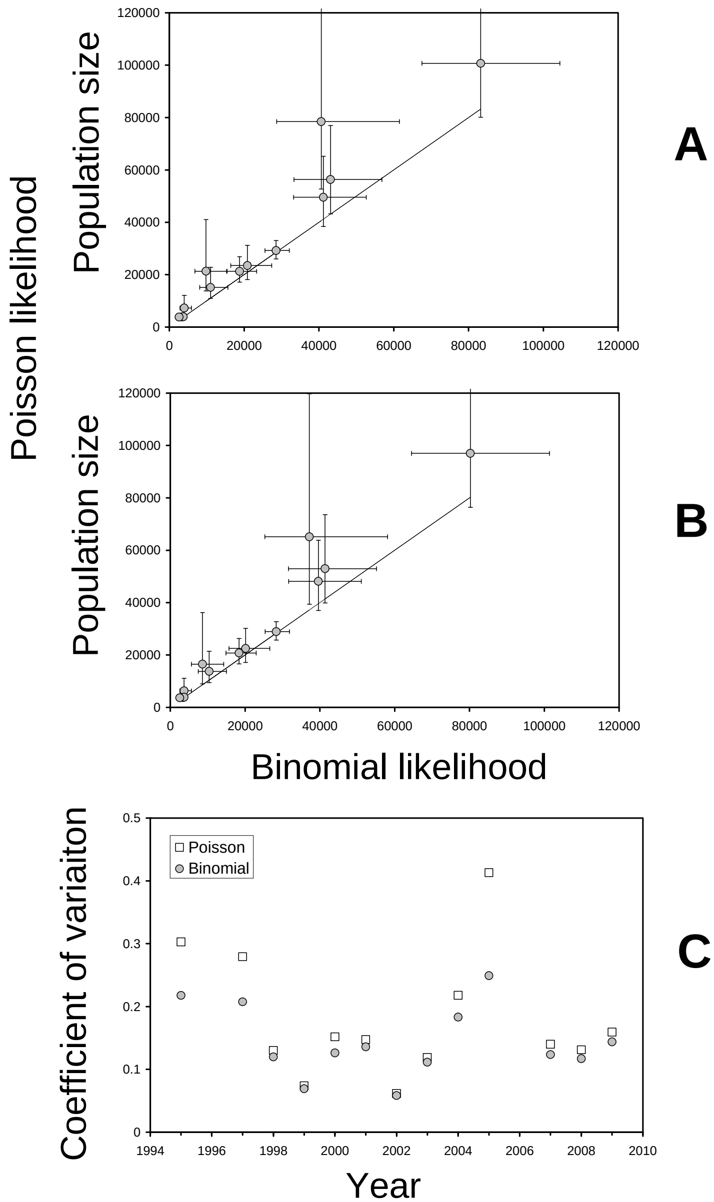


Figure 6. Comparison of posterior distributions for the spawning stock size (N) based on prior assumptions for N being uniform (panel A) or lognormal (panel B) with the binomial likelihood (x-axis) versus the Poisson likelihood (y-axis) models. Panel C compares the coefficient of variation (std. dev. / mean) for N for the binomial likelihood and the Poisson likelihood models by year, based on the lognormal prior for N.

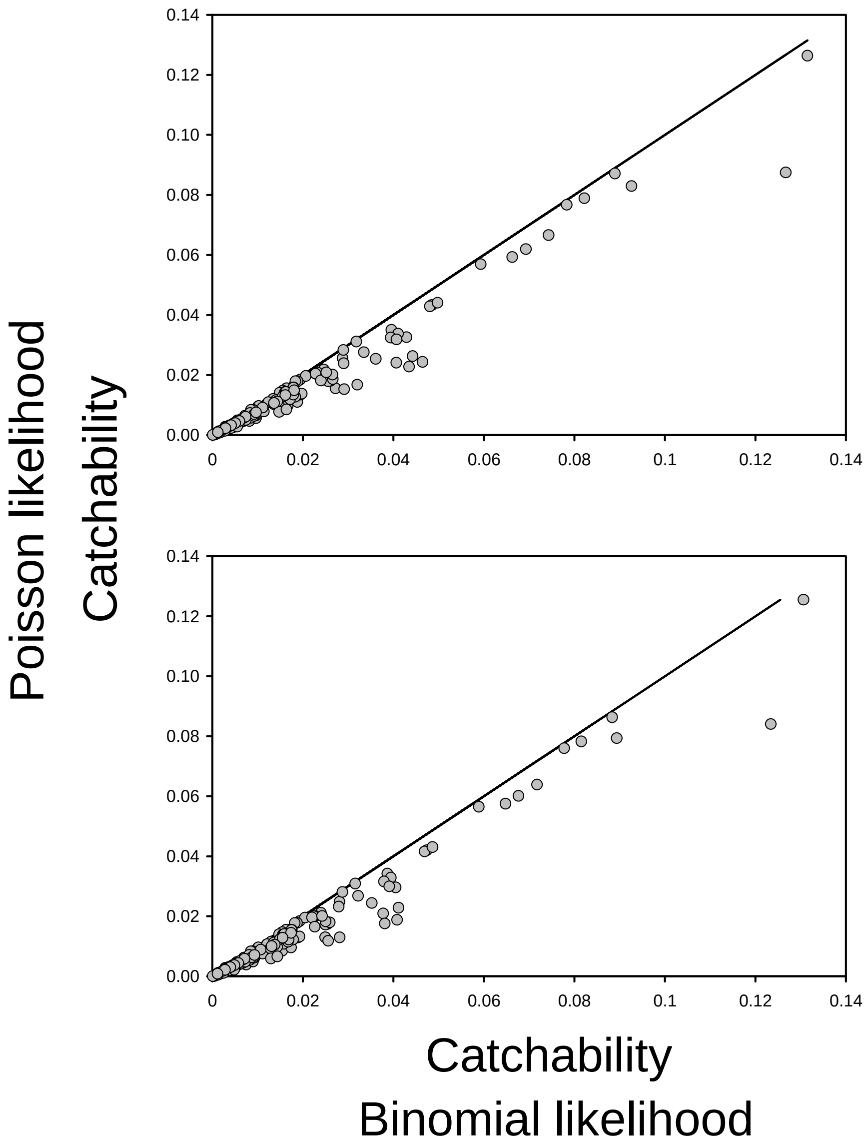


Figure 7. Comparison of median values of the posterior distributions for the catchabilities based on the binomial likelihood (x-axis) versus the Poisson likelihood (y-axis) for uniform prior on N (upper panel) and lognormal prior on N (lower panel). The diagonal line is the equivalency line.

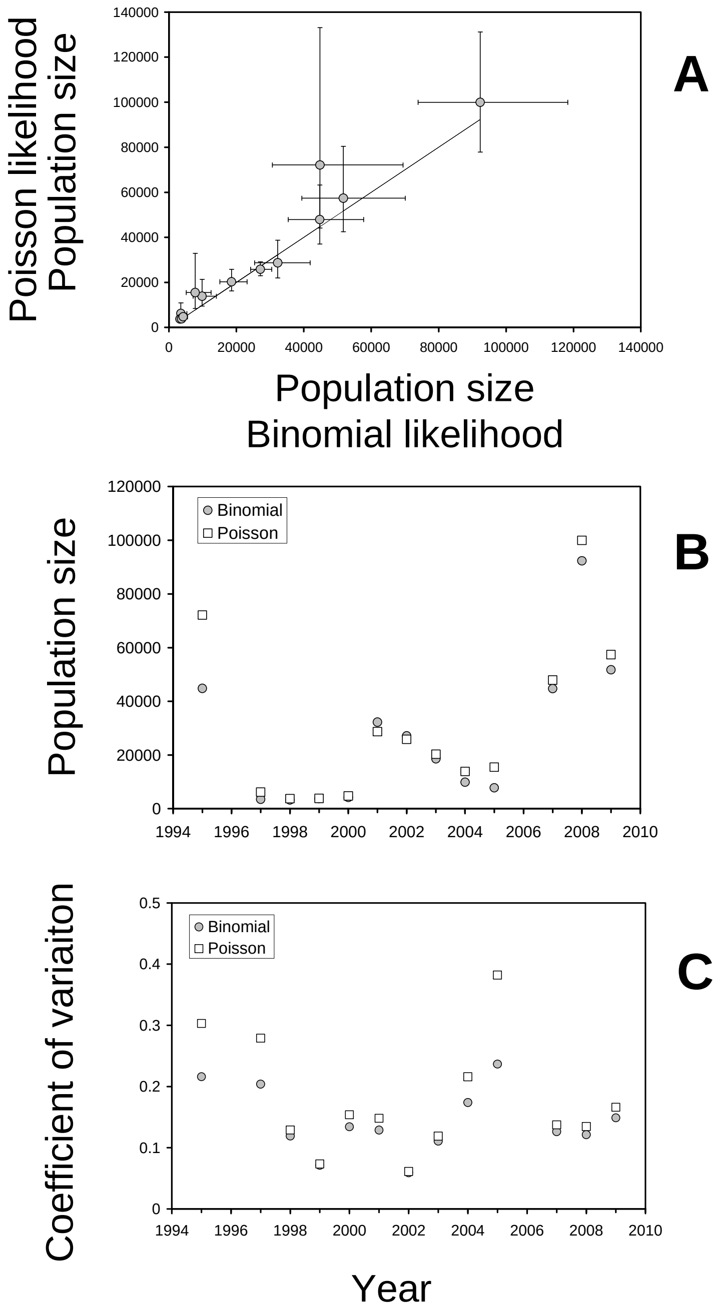


Figure 8. Comparison of the spawning stock size (N) using individual trapnet catchabilities in annual models with Poisson likelihood (y-axis) versus binomial likelihood (x-axis) (panel A), median estimates of N by year for the Poisson versus binomial likelihood models (panel B) and the coefficient of variation for N for the Poisson versus binomial likelihood models (panel C). Prior on N was assumed lognormal.

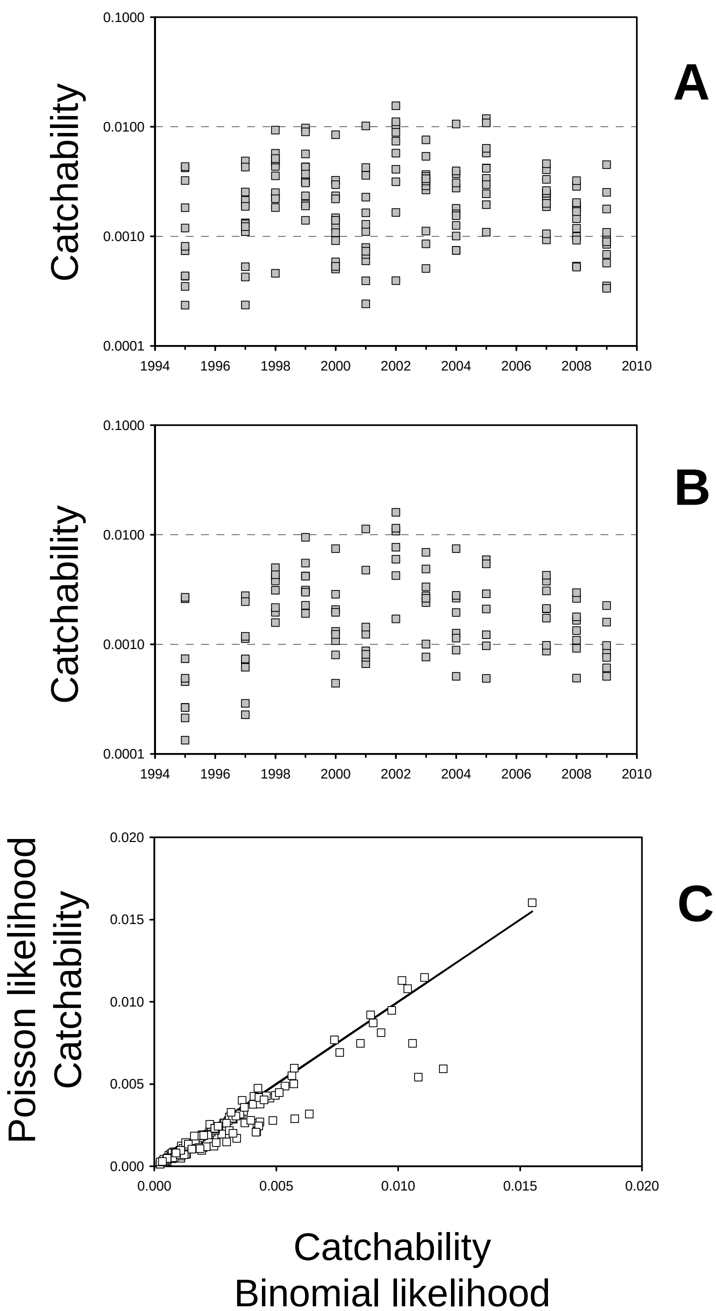


Figure 9. Median values of the posterior distributions for the individual trapnet catchabilities by year based on the binomial likelihood (panel A), the Poisson likelihood (panel B) and contrast of trap specific catchabilities (by trap and year) based on the likelihood assumptions of the models (panel C; binomial x-axis, Poisson y-axis). The diagonal line in panel C is the equivalency line.

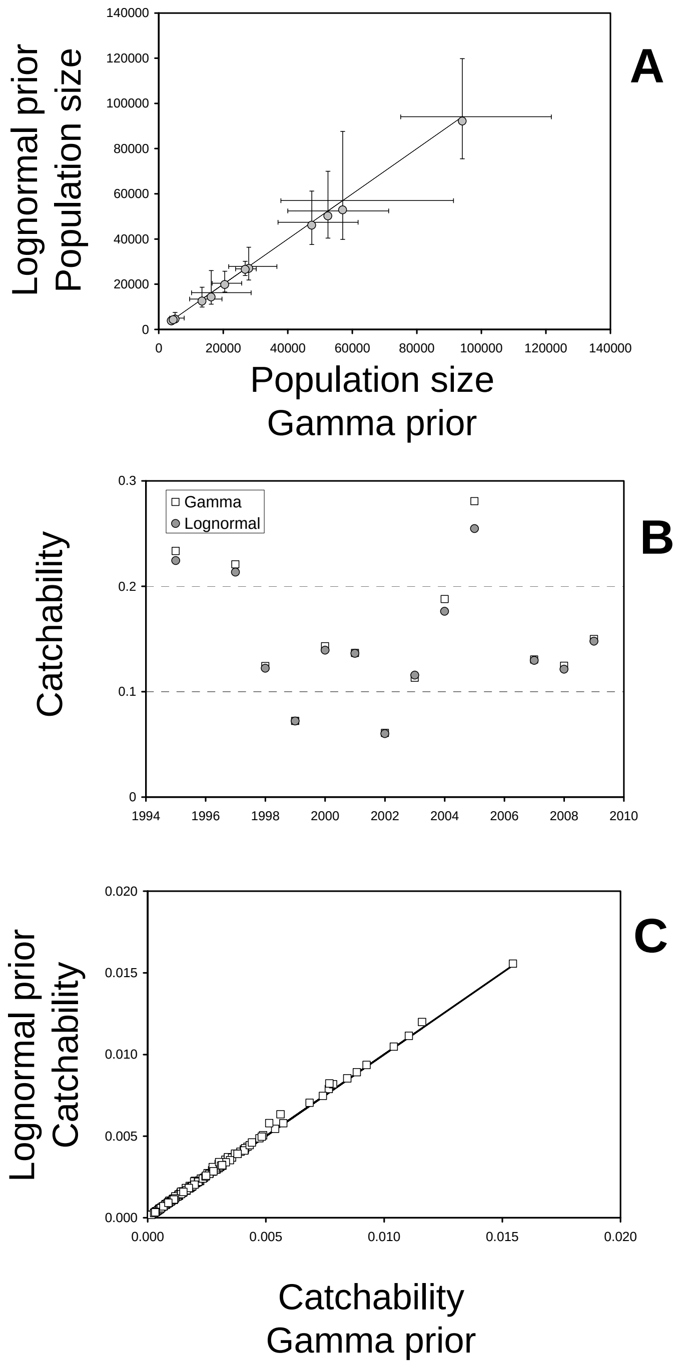


Figure 10. Comparison of the spawning stock size (N) using the individual trap catchabilities and the hierarchical model. Panel A shows the posterior distributions (median; 95% BCI range) for N based on a gamma prior (x-axis) versus a lognormal prior (y-axis) for N. Panel B are the year specific CV estimates of N based on the prior assumption. Panel C compares individual trap / year catchabilities (median) for the two prior assumptions on N. The diagonal line in panel C is the equivalency line.

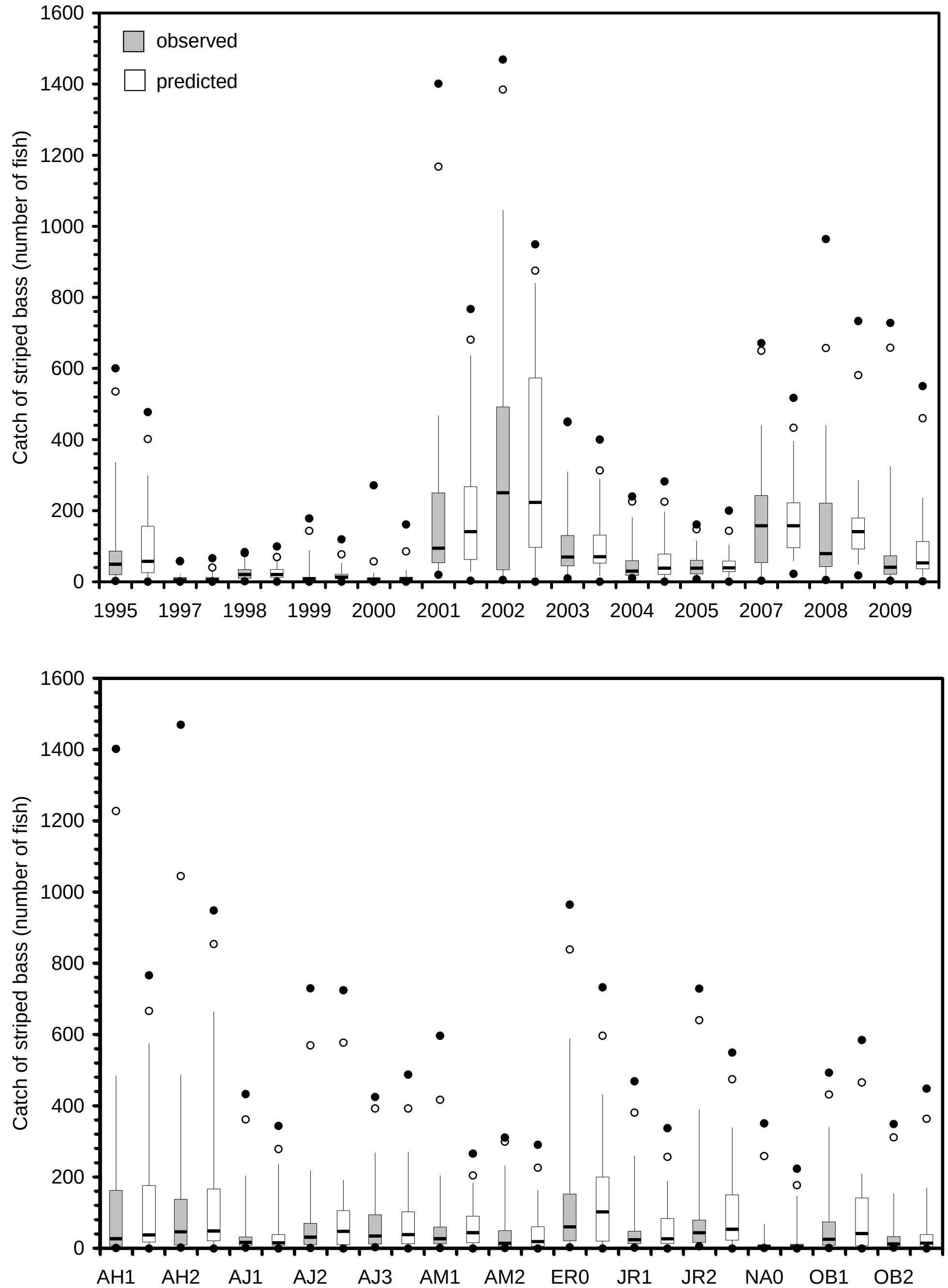
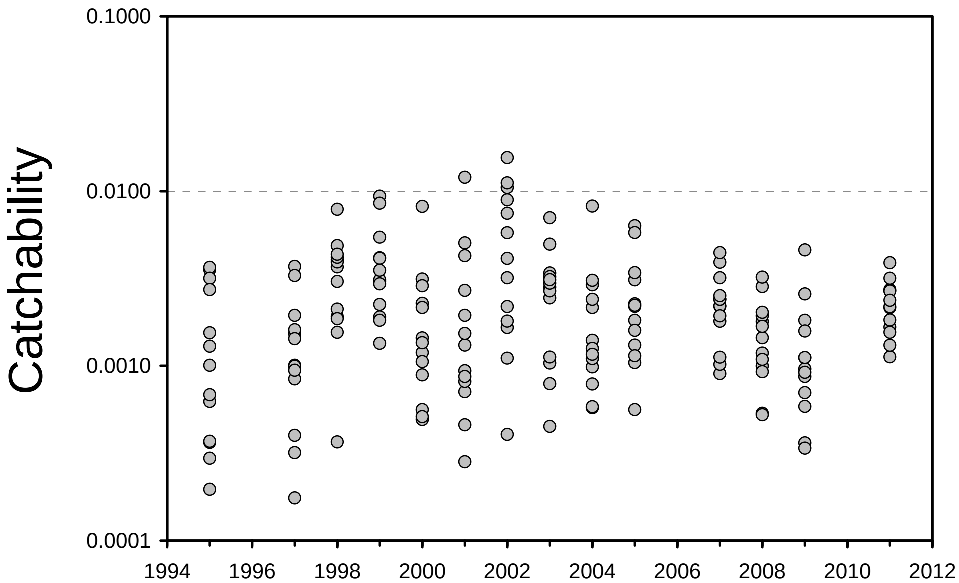


Figure 11. Boxplots of predicted catches from the hierarchical model compared with the observed catches of striped bass over all traps by year (upper panel) and over all years by trap (lower panel). Box plots are as described in Figure 4 with the addition of the minimum and maximum catches as filled circles, the 99th percentile of predicted catches as the open circles.



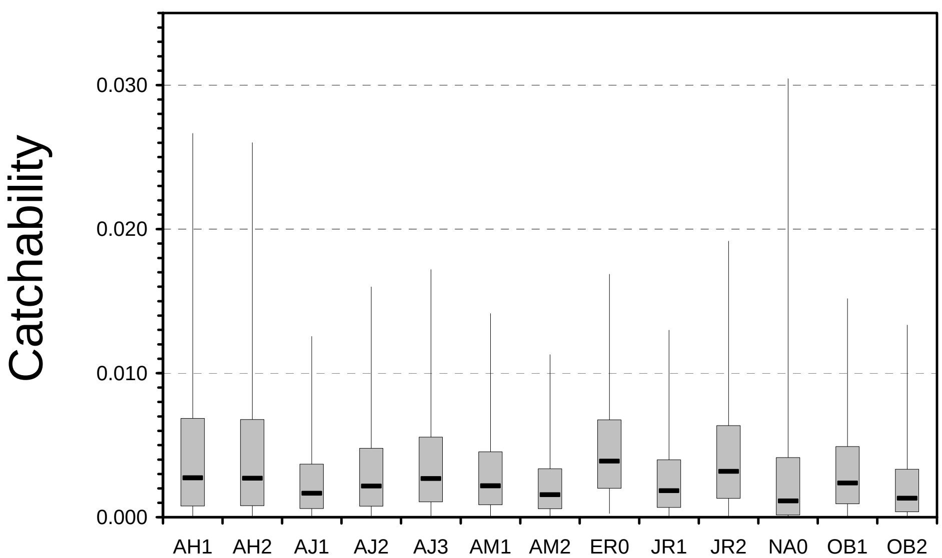


Figure 12. Annual catchabilities and the overall catchabilities (posterior median) as estimated from the hierarchical model for the thirteen traps (upper panel) and summaries of the posterior distributions of the overall catchabilities of the thirteen trapnets (lower panel). Box plots are interpreted as in Figure 4.

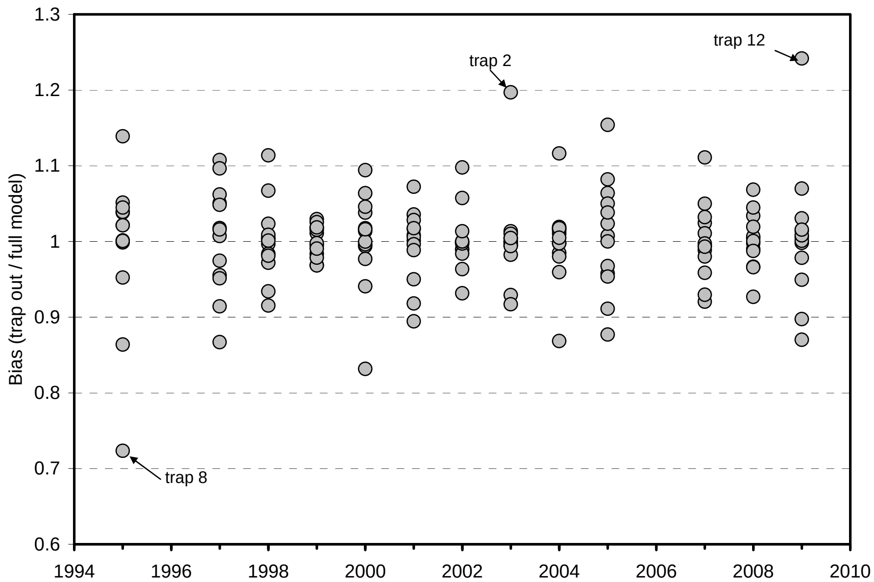


Figure 13. Diagnostics for the influence of individual traps on model fits of N.

Appendix 1. Sampling, mark and recapture data from the sampling date model (aggregated over traps).

Marks available by sampling period by year													
Sampling period	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2007	2008	2009
1	0	172	214	527	0	0	0	0	0	0	0	0	0
2	0	170	202	591	109	334	500	198	39	13	3	290	158
3	20	170	237	568	131	334	1078	333	88	57	62	487	419
4	47	166	219	559	168	336	1447	401	238	80	323	612	518
5	318	166	216	534	214	336	1444	408	239	83	323	616	524
6	426	166	210	532	214	336	1447	420	240	86	323	618	524
7	418	166	207	525	217	337	1447	423	241	92	324	619	524
8	446	165	204	522	220			432	244	94	323	622	524
9	471	164	200	507	221			437	246	95	323	624	527
10	526	163		496	223			445			323	625	529
11	539	163		493	224			447			323	625	529
12		162		473	225						323	627	529
13					225							628	529
14					225							630	
15					226								
16					226								
17					227								
18					227								
19					227								
20					229								
21					230								
22					235								
23					235								

Appendix 1 (continued).

Sampled catch by sampling period by year

Sampling period	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2007	2008	2009
1	71	170	83	311	321	1865	519	225	55	13	3	310	180
2	87	153	77	40	22	267	815	151	59	47	61	291	596
3	47	61	227	493	68	467	2514	92	185	24	274	245	119
4	304	37	12	226	50	1509	2232	722	140	253	1624	2022	1686
5	1020	13	94	34	16	461	896	927	59	375	1326	1276	249
6	70	15	230	75	65	324	246	225	448	278	1565	1137	566
7	21	70	162	60	93	143	83	297	277	403	1156	591	403
8	593	18	165	72	17			332	253	127	718	1252	161
9	168	1	77	65	50			330	97	139	628	1300	207
10	37	6		57	41			304			442	309	172
11	170	1		53	70			298			253	302	99
12		2		34	39						184	420	120
13					2							233	49
14					50							106	
15					16								
16					25								
17					19								
18					25								
19					47								
20					23								
21					47								
22					2								
23					27								

Appendix 1 (continued).

Recaptures by sampling period by year

Sampling period	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2007	2008	2009
1	0	1	4	37	0	0	0	0	0	0	0	0	0
2	0	4	4	3	0	8	19	3	0	0	0	2	0
3	0	3	10	70	1	9	101	11	2	0	2	1	2
4	0	0	1	27	2	12	98	20	4	0	14	13	18
5	1	0	8	9	3	6	51	7	0	2	11	8	1
6	1	0	16	7	5	6	8	7	8	0	10	2	5
7	1	2	10	9	6	5	2	3	5	1	3	4	2
8	3	2	5	15	1			5	2	1	4	4	1
9	4	0	5	14	3			6	1	3	6	3	5
10	0	1		8	3			2			1	3	1
11	1	0		9	3			7			1	7	0
12		0		3	1						0	4	1
13					0							5	1
14					4							1	
15					0								
16					1								
17					1								
18					1								
19					3								
20					2								
21					0								
22					0								
23					4								

Appendix 1 (continued).

Traps sampled by sampling period by year													
Sampling period	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	2007	2008	2009
1	1	7	1	2	2	2	2	1	1	1	1	1	1
2	2	11	1	1	1	2	2	1	1	1	1	1	1
3	3	8	7	8	2	2	2	1	1	1	1	1	1
4	3	6	2	5	4	5	4	2	6	7	5	6	5
5	3	5	7	11	3	6	3	3	1	6	4	4	3
6	2	3	8	10	5	5	3	3	4	3	5	7	7
7	1	8	6	9	5	4	5	5	6	5	5	5	5
8	3	5	6	9	3			4	3	5	5	6	5
9	5	1	8	8	5			5	5	6	4	6	6
10	1	4		6	6			6			6	5	6
11	3	1		7	7			6			4	6	4
12		2		8	5						6	6	5
13					2							5	5
14					7							6	
15					5								
16					6								
17					5								
18					5								
19					6								
20					6								
21					6								
22					1								
23					5								

Appendix 2. Individual trap sampling data from the Northwest Miramichi, 1994 to 2010. Effort is days of fishing.

Year	Date	Trap	Marks	Recaps	Catch	Effort
1994	24-May	1	0	NA	673	1.5
1994	26-May	1	0	NA	1998	2
1994	1-Jun	1	0	NA	61	2
1994	3-Jun	1	0	NA	559	2
1994	5-Jun	1	0	NA	213	2
1994	6-Jun	1	0	NA	119	1
1994	24-May	2	0	NA	103	1.5
1994	26-May	2	0	NA	557	2
1994	1-Jun	2	0	NA	49	2
1994	3-Jun	2	0	NA	354	2
1994	5-Jun	2	0	NA	213	2
1994	6-Jun	2	0	NA	72	1
1994	7-Jun	2	0	NA	51	1
1994	8-Jun	2	0	NA	39	1
1994	9-Jun	2	0	NA	123	1
1994	10-Jun	2	0	NA	124	1
1994	11-Jun	2	0	NA	58	1
1994	12-Jun	2	0	NA	20	1
1994	9-Jun	6	0	NA	71	1
1994	24-May	11	0	NA	144	1.5
1994	25-May	11	0	NA	15	1
1994	27-May	11	0	NA	64	2
1994	1-Jun	11	0	NA	55	2
1994	3-Jun	11	0	NA	115	1.5
1994	5-Jun	11	0	NA	130	2
1994	6-Jun	11	0	NA	33	1
1994	7-Jun	11	0	NA	24	1
1994	8-Jun	11	0	NA	14	1
1994	9-Jun	11	0	NA	36	1
1994	10-Jun	11	0	NA	14	1
1994	11-Jun	11	0	NA	30	1
1994	12-Jun	11	0	NA	48	1
1994	11-Jun	13	0	NA	14	1
1994	12-Jun	13	0	NA	6	1
1995	26-May	1	0	0	26	2
1995	1-Jun	1	426	1	61	2
1995	6-Jun	1	471	0	9	1
1995	26-May	2	0	0	61	2
1995	30-May	2	318	0	70	1
1995	6-Jun	2	471	0	2	1
1995	27-May	3	20	0	10	1
1995	27-May	4	20	0	15	1
1995	6-Jun	4	471	2	23	1
1995	9-Jun	4	539	0	7	1
1995	27-May	5	20	0	22	1
1995	9-Jun	5	539	0	17	1
1995	5-Jun	6	446	1	189	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
1995	28-May	7	47	0	49	1
1995	5-Jun	7	446	1	101	1
1995	8-Jun	7	526	0	37	1.5
1995	30-May	8	318	1	600	2
1995	2-Jun	8	418	1	21	1
1995	5-Jun	8	446	1	303	1
1995	9-Jun	8	539	1	146	1.5
1995	28-May	9	47	0	36	1
1995	24-May	11	0	0	71	1
1995	30-May	11	318	0	350	2
1995	1-Jun	11	426	0	9	2
1995	6-Jun	11	471	0	64	1
1995	28-May	12	47	0	219	1
1995	6-Jun	12	471	2	70	1
1996	24-May	1	0	NA	3	4
1996	29-May	1	0	NA	5	1
1996	31-May	1	0	NA	44	2
1996	3-Jun	1	0	NA	20	1
1996	5-Jun	1	0	NA	9	1
1996	6-Jun	1	0	NA	9	1
1996	10-Jun	1	0	NA	5	1
1996	24-May	2	0	NA	5	4
1996	29-May	2	0	NA	8	1
1996	31-May	2	0	NA	23	2
1996	1-Jun	2	0	NA	7	1
1996	3-Jun	2	0	NA	4	1
1996	5-Jun	2	0	NA	29	1
1996	6-Jun	2	0	NA	12	1
1996	10-Jun	2	0	NA	4	1
1996	29-May	6	0	NA	2	1
1996	31-May	6	0	NA	28	2
1996	1-Jun	6	0	NA	6	1
1996	3-Jun	6	0	NA	17	1
1996	5-Jun	6	0	NA	18	1
1996	6-Jun	6	0	NA	16	1
1996	9-Jun	6	0	NA	4	1
1996	10-Jun	6	0	NA	12	1
1996	29-May	7	0	NA	2	1
1996	31-May	7	0	NA	13	2
1996	5-Jun	7	0	NA	11	1
1996	6-Jun	7	0	NA	13	1
1996	9-Jun	7	0	NA	8	1
1996	10-Jun	7	0	NA	14	1
1996	31-May	8	0	NA	114	2
1996	9-Jun	8	0	NA	16	1
1996	1-Jun	9	0	NA	5	1
1996	1-Jun	10	0	NA	2	1
1996	6-Jun	10	0	NA	27	1
1996	10-Jun	11	0	NA	21	2
1996	9-Jun	12	0	NA	34	1
1996	6-Jun	13	0	NA	8	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
1997	4-Jun	1	172	0	2	1
1997	6-Jun	1	170	1	5	2
1997	8-Jun	1	170	0	4	2
1997	10-Jun	1	166	0	0	1
1997	12-Jun	1	166	0	4	2
1997	16-Jun	1	165	0	1	1
1997	4-Jun	2	172	0	3	1
1997	6-Jun	2	170	0	5	2
1997	8-Jun	2	170	1	1	2
1997	12-Jun	2	166	0	1	2
1997	18-Jun	2	163	0	1	1
1997	4-Jun	3	172	0	10	2
1997	6-Jun	3	170	0	14	2
1997	8-Jun	3	170	0	5	2
1997	9-Jun	3	166	0	1	1
1997	14-Jun	3	166	0	4	1.5
1997	6-Jun	4	170	0	12	2
1997	9-Jun	4	166	0	5	1
1997	10-Jun	4	166	0	2	1
1997	4-Jun	5	172	0	58	2
1997	6-Jun	5	170	0	27	2
1997	9-Jun	5	166	0	4	1
1997	4-Jun	6	172	0	17	1
1997	6-Jun	6	170	0	19	2
1997	14-Jun	6	166	0	2	1.5
1997	18-Jun	6	163	0	2	1
1997	6-Jun	7	170	1	11	2
1997	8-Jun	7	170	2	8	2
1997	10-Jun	7	166	0	0	1
1997	12-Jun	7	166	0	10	2
1997	14-Jun	7	166	0	9	1.5
1997	16-Jun	7	165	0	4	1
1997	4-Jun	8	172	0	57	2
1997	6-Jun	8	170	1	15	2
1997	9-Jun	8	166	0	21	2
1997	4-Jun	9	172	1	23	2
1997	14-Jun	9	166	0	3	1.5
1997	8-Jun	10	170	0	13	2
1997	9-Jun	10	166	0	6	1
1997	14-Jun	10	166	1	22	1.5
1997	16-Jun	10	165	2	7	1
1997	6-Jun	11	170	0	4	3
1997	8-Jun	11	170	0	0	2
1997	10-Jun	11	166	0	0	2
1997	14-Jun	11	166	0	1	3.5
1997	16-Jun	11	165	0	1	1
1997	17-Jun	11	164	0	1	1
1997	18-Jun	11	163	1	2	1
1997	19-Jun	11	163	0	1	1
1997	20-Jun	11	162	0	2	1
1997	6-Jun	12	170	1	16	2

Year	Date	Trap	Marks	Recaps	Catch	Effort
1997	8-Jun	12	170	0	18	2
1997	9-Jun	12	166	0	0	1
1997	14-Jun	12	166	0	11	3.5
1997	18-Jun	12	163	0	1	1
1997	20-Jun	12	162	0	0	1
1997	6-Jun	13	170	0	25	2
1997	8-Jun	13	170	0	12	2
1997	10-Jun	13	166	0	11	2
1997	14-Jun	13	166	1	18	3.5
1997	16-Jun	13	165	0	5	1
1998	23-May	1	237	1	22	2
1998	25-May	1	219	1	9	1
1998	27-May	1	216	0	3	2
1998	4-Jun	1	200	0	2	1
1998	21-May	2	214	4	83	1
1998	23-May	2	237	0	8	2
1998	25-May	2	219	0	3	1
1998	27-May	2	216	0	4	2
1998	3-Jun	2	204	1	16	1
1998	4-Jun	2	200	2	11	1
1998	27-May	3	216	3	14	3
1998	29-May	3	210	3	19	2
1998	23-May	4	237	0	34	3
1998	27-May	4	216	0	20	3
1998	29-May	4	210	1	28	2
1998	3-Jun	4	204	0	32	1
1998	4-Jun	4	200	0	9	1
1998	27-May	5	216	0	9	3
1998	29-May	5	210	0	41	2
1998	2-Jun	5	207	2	41	1.5
1998	3-Jun	5	204	2	54	1
1998	23-May	6	237	2	24	3
1998	29-May	6	210	5	25	2
1998	2-Jun	6	207	5	37	1.5
1998	23-May	7	237	1	20	3
1998	29-May	7	210	2	18	2
1998	4-Jun	7	200	1	10	1
1998	23-May	9	237	5	64	3
1998	3-Jun	9	204	0	10	1
1998	4-Jun	9	200	1	6	1
1998	22-May	10	202	4	77	2
1998	29-May	10	210	5	74	2
1998	2-Jun	10	207	2	42	1.5
1998	3-Jun	10	204	0	11	1
1998	4-Jun	10	200	1	25	1
1998	27-May	11	216	1	21	3
1998	29-May	11	210	0	24	2
1998	2-Jun	11	207	0	4	1.5
1998	4-Jun	11	200	0	7	1
1998	23-May	12	237	1	55	3
1998	27-May	12	216	4	23	3

Year	Date	Trap	Marks	Recaps	Catch	Effort
1998	2-Jun	12	207	1	34	1.5
1998	3-Jun	12	204	2	42	1
1998	4-Jun	12	200	0	7	1
1998	29-May	13	210	0	1	2
1998	2-Jun	13	207	0	4	1.5
1999	21-May	1	527	21	178	3
1999	25-May	1	591	3	40	2
1999	27-May	1	568	4	26	2
1999	31-May	1	534	0	1	1
1999	1-Jun	1	532	1	12	1
1999	3-Jun	1	522	0	4	1
1999	4-Jun	1	507	2	6	1
1999	5-Jun	1	496	1	5	1
1999	6-Jun	1	493	1	6	1
1999	21-May	2	527	16	133	2
1999	27-May	2	568	9	89	2
1999	31-May	2	534	0	4	1
1999	3-Jun	2	522	5	20	1
1999	5-Jun	2	496	0	12	1
1999	31-May	3	534	0	2	1
1999	1-Jun	3	532	1	9	1
1999	2-Jun	3	525	2	7	1
1999	3-Jun	3	522	3	18	1
1999	4-Jun	3	507	1	7	1
1999	5-Jun	3	496	1	10	1
1999	6-Jun	3	493	2	6	1
1999	27-May	4	568	8	61	3
1999	29-May	4	559	0	5	2
1999	31-May	4	534	1	3	1
1999	1-Jun	4	532	1	5	1
1999	2-Jun	4	525	0	2	1
1999	3-Jun	4	522	0	0	1
1999	4-Jun	4	507	0	1	1
1999	6-Jun	4	493	1	8	1
1999	8-Jun	4	473	0	4	1
1999	27-May	5	568	5	27	1
1999	31-May	5	534	3	9	1
1999	1-Jun	5	532	1	11	1
1999	2-Jun	5	525	1	6	1
1999	4-Jun	5	507	4	12	1
1999	6-Jun	5	493	1	6	1
1999	8-Jun	5	473	1	6	1
1999	27-May	6	568	18	92	2
1999	31-May	6	534	0	0	1
1999	1-Jun	6	532	1	14	1
1999	2-Jun	6	525	0	1	1
1999	3-Jun	6	522	0	7	1
1999	5-Jun	6	496	3	12	1
1999	6-Jun	6	493	1	12	1
1999	8-Jun	6	473	0	3	1
1999	27-May	7	568	15	136	3

Year	Date	Trap	Marks	Recaps	Catch	Effort
1999	29-May	7	559	4	19	2
1999	31-May	7	534	0	1	1
1999	1-Jun	7	532	1	3	1
1999	2-Jun	7	525	1	6	1
1999	3-Jun	7	522	0	5	1
1999	4-Jun	7	507	0	9	1
1999	5-Jun	7	496	3	14	1
1999	8-Jun	7	473	0	1	1
1999	29-May	8	559	9	61	3
1999	31-May	8	534	1	2	1
1999	1-Jun	8	532	0	3	1
1999	3-Jun	8	522	3	11	1
1999	8-Jun	8	473	1	4	1
1999	27-May	9	568	4	32	2
1999	31-May	9	534	1	6	1
1999	1-Jun	9	532	0	7	1
1999	4-Jun	9	507	2	14	1
1999	6-Jun	9	493	2	10	1
1999	29-May	10	559	9	82	2
1999	2-Jun	10	525	2	21	1
1999	27-May	11	568	7	30	3
1999	31-May	11	534	2	5	1
1999	1-Jun	11	532	1	4	1
1999	2-Jun	11	525	0	7	1
1999	3-Jun	11	522	1	2	1
1999	4-Jun	11	507	3	9	1
1999	5-Jun	11	496	0	4	1
1999	6-Jun	11	493	1	5	1
1999	8-Jun	11	473	0	7	1
1999	31-May	12	534	1	1	1
1999	1-Jun	12	532	0	7	1
1999	2-Jun	12	525	0	3	1
1999	3-Jun	12	522	3	5	1
1999	4-Jun	12	507	2	7	1
1999	8-Jun	12	473	1	5	1
1999	29-May	13	559	5	59	3
1999	2-Jun	13	525	3	7	1
1999	8-Jun	13	473	0	4	1
2000	25-May	1	0	0	271	3
2000	30-May	1	168	1	25	2
2000	6-Jun	1	223	1	5	1
2000	9-Jun	1	225	0	10	1
2000	12-Jun	1	226	0	9	1
2000	15-Jun	1	227	0	5	1
2000	25-May	2	0	0	50	2
2000	31-May	2	214	1	8	1
2000	1-Jun	2	214	0	5	1
2000	6-Jun	2	223	1	13	1
2000	15-Jun	2	227	0	6	1
2000	1-Jun	3	214	0	10	2
2000	5-Jun	3	221	2	17	3

Year	Date	Trap	Marks	Recaps	Catch	Effort
2000	8-Jun	3	224	1	4	2
2000	9-Jun	3	225	0	1	1
2000	11-Jun	3	225	1	7	2
2000	19-Jun	3	230	0	10	2
2000	21-Jun	3	235	0	3	2
2000	30-May	4	168	0	3	1
2000	2-Jun	4	217	0	12	1
2000	3-Jun	4	220	0	8	1
2000	5-Jun	4	221	0	10	2
2000	6-Jun	4	223	1	6	1
2000	8-Jun	4	224	0	16	2
2000	12-Jun	4	226	0	0	1
2000	21-Jun	4	235	0	3	2
2000	1-Jun	5	214	4	19	2
2000	8-Jun	5	224	2	21	2
2000	9-Jun	5	225	1	11	1
2000	11-Jun	5	225	0	2	2
2000	12-Jun	5	226	0	4	1
2000	14-Jun	5	227	1	10	2
2000	15-Jun	5	227	0	4	1
2000	16-Jun	5	227	0	7	1
2000	17-Jun	5	229	0	4	1
2000	19-Jun	5	230	0	12	2
2000	21-Jun	5	235	1	8	2
2000	27-May	6	131	1	57	2
2000	30-May	6	168	0	15	2
2000	31-May	6	214	1	7	1
2000	8-Jun	6	224	0	19	2
2000	10-Jun	6	225	0	2	1
2000	13-Jun	6	226	0	4	1
2000	17-Jun	6	229	0	7	1
2000	19-Jun	6	230	0	10	2
2000	27-May	7	131	0	11	2
2000	30-May	7	168	1	7	2
2000	31-May	7	214	1	1	1
2000	2-Jun	7	217	0	4	1
2000	3-Jun	7	220	0	4	1
2000	8-Jun	7	224	0	2	2
2000	10-Jun	7	225	0	0	1
2000	12-Jun	7	226	0	2	2
2000	13-Jun	7	226	0	0	1
2000	14-Jun	7	227	0	0	1
2000	16-Jun	7	227	0	1	2
2000	17-Jun	7	229	0	1	1
2000	19-Jun	7	230	0	7	2
2000	20-Jun	7	235	0	2	1
2000	1-Jun	8	214	0	22	2
2000	2-Jun	8	217	2	27	1
2000	6-Jun	8	223	0	12	1
2000	9-Jun	8	225	0	9	1
2000	11-Jun	8	225	0	15	2

Year	Date	Trap	Marks	Recaps	Catch	Effort
2000	16-Jun	8	227	2	25	2
2000	17-Jun	8	229	2	7	1
2000	19-Jun	8	230	0	4	2
2000	21-Jun	8	235	1	8	2
2000	26-May	9	109	0	22	1
2000	1-Jun	9	214	1	9	2
2000	5-Jun	9	221	1	12	2
2000	11-Jun	9	225	0	7	2
2000	13-Jun	9	226	0	1	1
2000	15-Jun	9	227	0	2	1
2000	2-Jun	10	217	1	24	1
2000	11-Jun	10	225	1	13	2
2000	13-Jun	10	226	0	13	1
2000	3-Jun	11	220	1	5	2
2000	5-Jun	11	221	0	7	2
2000	6-Jun	11	223	0	2	1
2000	8-Jun	11	224	0	1	2
2000	12-Jun	11	226	0	1	1
2000	14-Jun	11	227	0	2	1
2000	16-Jun	11	227	1	8	2
2000	2-Jun	12	217	3	26	3
2000	5-Jun	12	221	0	4	3
2000	6-Jun	12	223	0	3	1
2000	8-Jun	12	224	0	7	2
2000	9-Jun	12	225	0	8	1
2000	11-Jun	12	225	2	5	2
2000	13-Jun	12	226	0	4	1
2000	14-Jun	12	227	0	5	1
2000	15-Jun	12	227	1	8	1
2000	16-Jun	12	227	0	2	1
2000	17-Jun	12	229	0	3	1
2000	11-Jun	13	225	0	1	2
2000	13-Jun	13	226	1	3	1
2000	14-Jun	13	227	0	2	1
2000	16-Jun	13	227	0	4	1
2000	17-Jun	13	229	0	1	1
2000	19-Jun	13	230	0	4	2
2000	21-Jun	13	235	2	5	2
2001	25-May	1	0	0	1401	2
2001	28-May	1	334	7	156	1
2001	30-May	1	334	6	266	1.5
2001	1-Jun	1	336	2	286	2
2001	25-May	2	0	0	464	2
2001	28-May	2	334	1	111	1
2001	30-May	2	334	3	201	1.5
2001	1-Jun	2	336	1	113	2
2001	4-Jun	3	336	0	77	3
2001	11-Jun	3	337	1	19	2
2001	6-Jun	4	336	1	50	2
2001	4-Jun	5	336	1	39	3
2001	6-Jun	5	336	3	68	2

Year	Date	Trap	Marks	Recaps	Catch	Effort
2001	4-Jun	6	336	1	70	3
2001	6-Jun	7	336	1	103	2
2001	11-Jun	7	337	2	38	2
2001	4-Jun	8	336	2	144	3
2001	11-Jun	8	337	1	62	2
2001	1-Jun	9	336	2	468	3.5
2001	4-Jun	9	336	1	85	3
2001	6-Jun	9	336	1	72	2
2001	1-Jun	10	336	5	345	3
2001	6-Jun	11	336	0	31	4
2001	1-Jun	12	336	2	297	3.5
2001	4-Jun	12	336	1	46	3
2001	11-Jun	13	337	1	24	2
2002	23-May	1	0	0	164	1.5
2002	25-May	1	500	7	312	2
2002	27-May	1	1078	40	1045	2
2002	23-May	2	0	0	355	1.5
2002	25-May	2	500	12	503	2
2002	27-May	2	1078	61	1469	2
2002	29-May	2	1447	39	761	2
2002	31-May	3	1444	12	254	2
2002	4-Jun	3	1447	1	23	0.5
2002	29-May	4	1447	34	729	2
2002	4-Jun	4	1447	0	20	0.5
2002	29-May	5	1447	15	250	1
2002	31-May	5	1444	21	424	2
2002	4-Jun	5	1447	1	23	0.5
2002	3-Jun	7	1447	3	55	1
2002	4-Jun	7	1447	0	12	0.5
2002	3-Jun	8	1447	5	158	1
2002	4-Jun	10	1447	0	5	0.5
2002	29-May	12	1447	10	492	2
2002	31-May	13	1444	18	218	2
2002	3-Jun	13	1447	0	33	1
2003	30-May	1	401	8	275	3
2003	3-Jun	1	408	1	220	2
2003	24-May	2	0	0	225	1.5
2003	26-May	2	198	3	151	2
2003	28-May	2	333	11	92	2
2003	30-May	2	401	12	447	2
2003	3-Jun	2	408	5	450	2
2003	10-Jun	2	445	1	97	1
2003	4-Jun	3	420	1	31	1
2003	5-Jun	3	423	1	67	1
2003	4-Jun	4	420	4	130	1
2003	7-Jun	4	432	0	52	2
2003	9-Jun	4	437	4	77	1.5
2003	10-Jun	4	445	1	56	1
2003	11-Jun	4	447	0	49	1
2003	5-Jun	5	423	0	59	1
2003	7-Jun	5	432	0	87	2

Year	Date	Trap	Marks	Recaps	Catch	Effort
2003	9-Jun	5	437	1	98	1.5
2003	10-Jun	5	445	0	34	1
2003	11-Jun	5	447	1	75	1
2003	7-Jun	6	432	1	44	2
2003	10-Jun	6	445	0	18	1
2003	9-Jun	7	437	0	26	1.5
2003	11-Jun	7	447	0	14	1
2003	5-Jun	8	423	2	131	2
2003	7-Jun	8	432	4	149	2
2003	10-Jun	8	445	0	52	1
2003	11-Jun	8	447	3	74	1
2003	3-Jun	9	408	1	257	2
2003	5-Jun	9	423	0	31	1
2003	9-Jun	9	437	0	27	1.5
2003	11-Jun	9	447	0	17	1
2003	4-Jun	10	420	2	64	1
2003	9-Jun	12	437	1	102	1.5
2003	10-Jun	12	445	0	47	1
2003	11-Jun	12	447	3	69	1
2003	5-Jun	13	423	0	9	1
2004	5-Jun	1	240	0	22	3
2004	2-Jun	2	238	0	18	2
2004	7-Jun	2	241	0	15	2
2004	11-Jun	2	246	0	30	1
2004	2-Jun	3	238	1	29	2
2004	7-Jun	3	241	0	24	1
2004	4-Jun	4	239	0	59	2
2004	11-Jun	4	246	0	24	1
2004	2-Jun	5	238	2	38	2
2004	5-Jun	5	240	2	130	3
2004	7-Jun	5	241	1	33	1
2004	10-Jun	5	244	0	129	2.5
2004	11-Jun	5	246	1	18	1
2004	24-May	6	0	0	55	2
2004	26-May	6	39	0	59	2
2004	29-May	6	88	2	185	2.5
2004	2-Jun	6	238	1	30	2
2004	5-Jun	7	240	3	56	3
2004	7-Jun	7	241	1	12	2
2004	10-Jun	7	244	1	48	2.5
2004	5-Jun	8	240	3	240	2
2004	7-Jun	8	241	3	176	2
2004	2-Jun	9	238	0	13	2
2004	7-Jun	9	241	0	17	1
2004	10-Jun	10	244	1	76	2.5
2004	2-Jun	12	238	0	12	2
2004	11-Jun	12	246	0	10	1
2004	11-Jun	13	246	0	15	1
2005	1-Jun	1	80	0	33	2
2005	3-Jun	1	83	0	20	1.5
2005	7-Jun	1	94	1	32	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
2005	1-Jun	2	80	0	8	1
2005	1-Jun	3	80	0	55	1.5
2005	4-Jun	3	86	0	42	1
2005	7-Jun	3	94	0	35	1
2005	8-Jun	3	95	0	16	1
2005	1-Jun	4	80	0	22	1.5
2005	3-Jun	4	83	1	112	2
2005	4-Jun	4	86	0	75	1
2005	6-Jun	4	92	1	104	2
2005	7-Jun	4	94	0	30	1
2005	8-Jun	4	95	2	36	1
2005	1-Jun	5	80	0	70	1.5
2005	4-Jun	5	86	0	161	1
2005	24-May	7	0	0	13	3
2005	27-May	7	13	0	47	3
2005	29-May	7	57	0	24	2
2005	6-Jun	7	92	0	54	1
2005	7-Jun	7	94	0	13	1
2005	6-Jun	8	92	0	122	1
2005	8-Jun	8	95	0	47	1
2005	1-Jun	9	80	0	44	1.5
2005	3-Jun	9	83	0	50	2
2005	6-Jun	9	92	0	38	1
2005	7-Jun	9	94	0	17	1
2005	8-Jun	9	95	0	23	1
2005	1-Jun	10	80	0	21	1.5
2005	3-Jun	10	83	0	72	2
2005	8-Jun	10	95	1	10	1
2005	3-Jun	12	83	0	64	2
2005	6-Jun	12	92	0	85	1
2005	3-Jun	13	83	1	57	1
2005	8-Jun	13	95	0	7	1
2006	30-May	1	18	0	222	2
2006	1-Jun	1	25	0	143	1
2006	30-May	2	18	0	13	1
2006	31-May	2	19	0	17	1
2006	2-Jun	3	29	0	14	1
2006	29-May	4	18	0	11	1
2006	30-May	4	18	0	117	1
2006	31-May	4	19	0	104	1
2006	1-Jun	4	25	1	48	1
2006	2-Jun	4	29	0	33	1
2006	29-May	5	18	0	59	1
2006	31-May	5	19	0	108	1
2006	23-May	7	0	0	10	2.5
2006	25-May	7	10	0	8	2
2006	28-May	7	17	0	1	3
2006	31-May	7	19	0	3	1
2006	29-May	8	18	1	34	1
2006	30-May	8	18	0	273	1
2006	1-Jun	8	25	0	68	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
2006	2-Jun	8	29	0	23	1
2006	29-May	9	18	0	7	1
2006	1-Jun	9	25	0	21	1
2006	31-May	10	19	0	63	1
2006	29-May	12	18	0	11	1
2006	30-May	12	18	0	64	1
2006	31-May	12	19	0	110	1
2006	1-Jun	12	25	0	59	1
2006	2-Jun	12	29	0	26	1
2006	30-May	13	18	0	77	1
2006	31-May	13	19	0	98	1
2007	29-May	1	323	8	624	1.5
2007	2-Jun	1	323	4	227	2
2007	7-Jun	1	323	1	172	1
2007	11-Jun	1	323	0	56	1.5
2007	22-May	2	0	0	3	3
2007	24-May	2	3	0	61	2
2007	26-May	2	62	2	274	1.5
2007	4-Jun	2	324	0	51	2
2007	11-Jun	2	323	0	26	1.5
2007	4-Jun	3	324	1	203	2
2007	31-May	4	323	5	469	2
2007	2-Jun	4	323	1	183	2
2007	6-Jun	4	323	0	76	2
2007	7-Jun	4	323	2	101	1
2007	8-Jun	4	323	1	67	1
2007	9-Jun	4	323	0	16	1
2007	29-May	5	323	3	365	1.5
2007	2-Jun	5	323	1	247	2
2007	6-Jun	5	323	2	196	2
2007	8-Jun	5	323	0	208	1
2007	11-Jun	5	323	0	17	0.5
2007	29-May	6	323	2	143	1.5
2007	6-Jun	6	323	0	44	2
2007	8-Jun	6	323	0	24	1
2007	29-May	7	323	1	231	1.5
2007	31-May	7	323	0	205	2
2007	8-Jun	7	323	0	39	1
2007	9-Jun	7	323	0	61	1
2007	11-Jun	7	323	0	49	1.5
2007	2-Jun	8	323	1	671	2
2007	4-Jun	8	324	0	371	2
2007	6-Jun	8	323	2	297	2
2007	7-Jun	8	323	3	198	1
2007	9-Jun	8	323	1	107	1
2007	29-May	9	323	0	261	1.5
2007	4-Jun	9	324	0	171	2
2007	6-Jun	9	323	0	105	2
2007	8-Jun	9	323	0	47	1
2007	31-May	10	323	2	304	2
2007	9-Jun	10	323	0	69	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
2007	11-Jun	10	323	0	16	0.5
2007	2-Jun	12	323	3	237	2
2007	4-Jun	12	324	2	360	2
2007	7-Jun	12	323	0	157	1
2007	8-Jun	12	323	0	57	1
2007	11-Jun	12	323	0	20	1.5
2007	31-May	13	323	4	348	3
2008	3-Jun	1	616	0	63	1
2008	7-Jun	1	624	0	44	1
2008	9-Jun	1	625	0	42	1
2008	2-Jun	2	612	5	485	2.5
2008	4-Jun	2	618	0	229	1
2008	5-Jun	2	619	1	200	1
2008	6-Jun	2	622	2	276	1
2008	14-Jun	2	628	0	45	1
2008	16-Jun	2	630	0	5	1
2008	2-Jun	3	612	4	432	1
2008	9-Jun	3	625	0	93	1
2008	3-Jun	4	616	3	483	1
2008	4-Jun	4	618	0	209	1
2008	5-Jun	4	619	0	94	1
2008	6-Jun	4	622	0	152	1
2008	7-Jun	4	624	0	128	1
2008	9-Jun	4	625	0	22	1
2008	10-Jun	4	625	1	32	1
2008	14-Jun	4	628	1	67	1
2008	16-Jun	4	630	0	20	1
2008	2-Jun	5	612	0	261	1
2008	3-Jun	5	616	2	288	1
2008	4-Jun	5	618	0	155	1
2008	7-Jun	5	624	1	92	1
2008	13-Jun	5	627	1	97	1
2008	2-Jun	6	612	1	221	1
2008	5-Jun	6	619	0	51	1
2008	6-Jun	6	622	0	213	1
2008	10-Jun	6	625	1	26	1
2008	13-Jun	6	627	0	70	1
2008	14-Jun	6	628	3	49	1
2008	16-Jun	6	630	1	12	1
2008	26-May	7	0	0	310	2
2008	28-May	7	290	2	291	1.5
2008	30-May	7	487	1	245	2
2008	4-Jun	7	618	1	61	1
2008	7-Jun	7	624	0	25	1
2008	10-Jun	7	625	0	39	1
2008	13-Jun	7	627	1	65	1
2008	7-Jun	8	624	2	964	2
2008	13-Jun	8	627	0	79	1.5
2008	2-Jun	9	612	0	285	1
2008	6-Jun	9	622	0	149	1
2008	7-Jun	9	624	0	47	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
2008	10-Jun	9	625	2	24	1
2008	13-Jun	9	627	1	41	1
2008	14-Jun	9	628	0	37	1
2008	16-Jun	9	630	0	15	1
2008	3-Jun	10	616	3	442	1
2008	4-Jun	10	618	0	115	1
2008	9-Jun	10	625	2	46	1
2008	10-Jun	10	625	3	135	1
2008	16-Jun	10	630	0	35	1
2008	2-Jun	12	612	3	338	1
2008	4-Jun	12	618	1	321	1
2008	5-Jun	12	619	3	217	1
2008	6-Jun	12	622	2	389	1
2008	9-Jun	12	625	1	106	1
2008	13-Jun	12	627	1	68	1
2008	14-Jun	12	628	1	35	1
2008	16-Jun	12	630	0	19	1
2008	4-Jun	13	618	0	47	1
2008	5-Jun	13	619	0	29	1
2008	6-Jun	13	622	0	73	1
2008	10-Jun	13	625	0	46	1
2009	2-Jun	1	524	0	137	2.5
2009	5-Jun	1	527	1	33	1
2009	29-May	2	518	0	48	1
2009	1-Jun	2	524	0	137	1.5
2009	3-Jun	2	524	0	81	1
2009	4-Jun	2	524	0	30	1
2009	5-Jun	2	527	1	45	1
2009	8-Jun	2	529	0	20	1
2009	10-Jun	2	529	0	10	1
2009	11-Jun	2	529	0	3	1
2009	2-Jun	3	524	0	55	1
2009	4-Jun	3	524	0	31	1
2009	9-Jun	3	529	0	20	1
2009	11-Jun	3	529	1	12	1
2009	29-May	4	518	1	220	2
2009	1-Jun	4	524	1	70	1.5
2009	2-Jun	4	524	0	59	1
2009	3-Jun	4	524	0	36	1
2009	4-Jun	4	524	1	31	1
2009	5-Jun	4	527	0	40	1
2009	8-Jun	4	529	0	22	1
2009	8-Jun	5	529	0	33	1
2009	10-Jun	5	529	0	38	1
2009	23-May	6	0	0	180	2
2009	25-May	6	158	0	596	2
2009	27-May	6	419	2	119	2
2009	2-Jun	6	524	0	52	1
2009	3-Jun	6	524	0	74	1
2009	4-Jun	6	524	0	41	1
2009	8-Jun	6	529	1	34	2

Year	Date	Trap	Marks	Recaps	Catch	Effort
2009	11-Jun	6	529	0	8	1
2009	29-May	8	518	6	518	2
2009	2-Jun	8	524	3	118	1
2009	5-Jun	8	527	1	49	1
2009	8-Jun	8	529	0	49	1
2009	9-Jun	8	529	0	42	1
2009	1-Jun	9	524	0	42	1.5
2009	2-Jun	9	524	1	30	1
2009	5-Jun	9	527	1	14	1
2009	8-Jun	9	529	0	14	1
2009	9-Jun	9	529	0	18	1
2009	10-Jun	9	529	0	11	1
2009	11-Jun	9	529	0	7	1
2009	29-May	10	518	2	728	2
2009	3-Jun	10	524	1	160	1
2009	10-Jun	10	529	1	44	1
2009	29-May	12	518	9	172	2
2009	2-Jun	12	524	1	115	2.5
2009	3-Jun	12	524	1	52	1
2009	4-Jun	12	524	0	28	1
2009	5-Jun	12	527	1	26	1
2009	9-Jun	12	529	0	19	1
2009	11-Jun	12	529	0	19	1
2009	10-Jun	13	529	0	17	1
2010	2-Jun	1	0	NA	43	1
2010	7-Jun	1	0	NA	49	1.5
2010	9-Jun	1	0	NA	42	2
2010	1-Jun	2	0	NA	79	1
2010	2-Jun	2	0	NA	74	1
2010	4-Jun	2	0	NA	62	2
2010	7-Jun	2	0	NA	38	1.5
2010	9-Jun	2	0	NA	14	2
2010	10-Jun	2	0	NA	13	1
2010	12-Jun	2	0	NA	16	1
2010	31-May	3	0	NA	588	1
2010	4-Jun	3	0	NA	436	3
2010	10-Jun	3	0	NA	32	1
2010	30-May	4	0	NA	804	2
2010	1-Jun	4	0	NA	221	1
2010	4-Jun	4	0	NA	121	2
2010	7-Jun	4	0	NA	105	1.5
2010	9-Jun	4	0	NA	22	1
2010	10-Jun	4	0	NA	29	1
2010	12-Jun	4	0	NA	25	1
2010	31-May	5	0	NA	774	1
2010	10-Jun	5	0	NA	30	1
2010	30-May	6	0	NA	310	2
2010	31-May	6	0	NA	141	1
2010	12-Jun	6	0	NA	16	1
2010	30-May	7	0	NA	187	2
2010	31-May	7	0	NA	72	1

Year	Date	Trap	Marks	Recaps	Catch	Effort
2010	9-Jun	7	0	NA	22	2
2010	30-May	8	0	NA	2148	2
2010	1-Jun	8	0	NA	1840	1
2010	4-Jun	8	0	NA	641	3
2010	7-Jun	8	0	NA	324	2.5
2010	9-Jun	8	0	NA	92	2
2010	10-Jun	8	0	NA	46	1
2010	12-Jun	8	0	NA	67	2
2010	31-May	9	0	NA	382	1
2010	1-Jun	9	0	NA	137	1
2010	4-Jun	9	0	NA	94	2
2010	7-Jun	9	0	NA	57	1.5
2010	9-Jun	9	0	NA	16	1
2010	10-Jun	9	0	NA	36	1
2010	12-Jun	9	0	NA	15	1
2010	2-Jun	10	0	NA	141	1
2010	1-Jun	12	0	NA	130	1
2010	2-Jun	12	0	NA	178	1
2010	4-Jun	12	0	NA	136	2
2010	10-Jun	12	0	NA	52	1
2010	12-Jun	12	0	NA	50	1
2010	7-Jun	13	0	NA	44	2.5