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Assessment of Bycatch in the 1997 and 1998 Shrimp Trawl Fisheries in British Columbia, with Emphasis on Eulachons

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ABSTRACT

A coast-wide observer program to determine the composition of catches in shrimp trawls in British Columbia started in 1997. The objective was to sample catches approximately according to the fishing effort, season, area and type of gear. This report presents the results for all bycatch species for both years, but concentrates on the bycatch of an anadromous smelt (Osmeridae), the eulachon (*Thaleichthys pacificus*). There is a potential conservation concern for eulachons in many areas of the BC coast. There are relatively few eulachon populations, perhaps 15 in BC and only 30-40 throughout the entire range, from California to Alaska. Nearly all populations in the south have declined sharply in recent years. Therefore one objective of this paper was to estimate eulachon bycatch from different areas of the coast and from the two major fishing gears (otter trawl and beam trawl). A second objective was to comment on the bycatch of other species. We present two basic methods for estimating eulachon bycatch. One is based on the relative proportion of eulachons to shrimp in the catches. This method is applicable mainly for eulachons and was used for in-season monitoring of eulachon catches. In this paper the authors show that *catch ratio* estimates based on the means of individual tows, called **MI-ratio** estimates ('mean in-season catch ratio' estimates) appear to overestimate bycatch. C*atch ratio* estimates based on the ratios of the cumulative totals eulachon and shrimp catches, **PI-ratio** or *'pooled in-season catch ratio estimates,* are summed over an aggregate of time or space (i.e. a Shrimp Management Area). It is concluded that **PI-ratio** estimates are more reliable and useful for in-season monitoring of bycatch. A 'post-season' method for estimating bycatch based on catch rates, called the **'MP-rate'** method *(mean post-season catch rate)* is used. This method follows closely the methods used to estimate bycatch in other fisheries and other species. This is called a 'post-season' estimate because catch rate data (kg of catch/h) are not available until the end of the fishing season. The authors conclude that the **MP-rate** is the most reliable estimate of bycatch.

The catch rate of eulachons varies greatly among different areas of the BC coast and also between 1997 and 1998. In general, bycatch rates were lower in 1998. In part, the reason for the lower 1998 estimates may have been a lower encounter rate, but there also is evidence that the fleet took evasive action to lower eulachon bycatch. The bycatch estimate methods developed for eulachons also are applicable for estimation of other species. In this regard, the authors observe that the catch composition of 'non-target species' varies widely with different areas. Several observations are made about areas of potential concern, especially with respect to high bycatch rates of pleuronectids (flatfishes). The paper concludes with some perspectives on bycatch in the BC shrimp fishery.

RÉSUMÉ

Un programme d'observateurs à l'échelle de toute la côte conçu dans le but de déterminer la composition des captures de crevettes faites au chalut en Colombie-Britannique a été entrepris en 1997. Il visait à échantillonner approximativement les captures d'après l'effort de pêche, la saison, la zone et le type d'engin. On trouve dans le rapport les résultats obtenus pour toutes les espèces capturées de façon accidentelle au cours des deux années, mais l'accent est mis sur les captures accidentelles d'un éperlan anadrome (osmeridé) : l'eulakane (*Thaleichthys pacificus*). La conservation des eulakanes est source potentielle d'inquiétude dans plusieurs régions de la côte de la C.-B. Il existe relativement peu de populations d'eulakanes, peut-être 15 en C.-B., et seulement de 30 à 40 dans toute son aire de répartition, de la Californie à l'Alaska. Pratiquement toutes les populations du sud ont décliné de façon abrupte au cours des dernières années. Un des objectifs de ce rapport était donc d'estimer les captures accidentelles d'eulakanes faites au moyen des deux principaux engins de pêche (chalut à panneaux et chalut à perche) dans les diverses zones de la côte. Un deuxième objectif était de commenter les captures accidentelles d'autres espèces. Deux méthodes de base sont présentées pour l'estimation des prises accidentelles d'eulakanes. L'une est fondée sur la proportion relative d'eulakanes par rapport aux crevettes au sein des prises. Cette méthode peut surtout être appliquée aux eulakanes et a été utilisée pour le contrôle en cours de saison des captures de ce poisson. Les auteurs montrent que les estimations du rapport des captures fondées sur la moyenne de traits chalut individuels, appelé dans le texte estimations **MI-ratio** (estimations du « rapport moyen des captures en cours de saison ») semblent surestimer les captures accidentelles. Les estimations du rapport des captures fondées sur les rapports des totaux cumulatifs des prises d'eulakanes et de crevettes, le **PI-ratio** *« estimations regroupées des rapports des captures en cours de saison »* sont additionnées pour une période ou une zone particulière (ex. : zone de gestion des crevettes). Il est conclu que les estimations du **PI-ratio** sont plus fiables et utiles pour le contrôle des prises accidentelles en cours de saison. Une méthode « d'après-saison » permettant d'estimer les prises accidentelles en fonction du taux de capture, appelée dans le texte le « **MP-rate** » *(taux de capture moyen d'après-saison)* est utilisée. Cette méthode est calquée de près sur les méthodes utilisées pour estimer les prises accidentelles pour d'autres pêcheries et espèces. Elle est nommée estimation « d'après-saison » car les données sur les taux de capture (kg de prises/h) ne sont obtenues qu'après la fin de la saison de pêche. Les auteurs concluent que le **MP-rate** constitue l'estimation la plus fiable des prises accidentelles.

Le taux de capture des eulakanes varie fortement en fonction des différentes zones de la côte de la C.-B. et aussi entre 1997 et 1998. De façon générale, les taux de capture accidentelle étaient inférieurs en 1998. Les plus faibles estimations de 1998 peuvent s'expliquer en partie par un taux de rencontre inférieur, mais l'on note aussi que les pêcheurs ont pris des mesures pour réduire la capture accidentelle d'eulakanes. Les méthodes d'estimation de ces captures accidentelles élaborées pour les eulakanes peuvent être appliquées à d'autres espèces. Ainsi, les auteurs font remarquer que la composition des captures des espèces « non visées » varie fortement d'une zone à l'autre. Plusieurs observations sont faites au sujet de zones pouvant être sources d'inquiétude, notamment en ce qui a trait au taux élevé de prises accidentelles de pleuronectidés (poissons plats). Ce rapport conclut en traitant, dans des perspectives diverses, des captures accidentelles de la pêche des crevettes en C.-B.

INTRODUCTION

Throughout the world, there are general concerns about bycatch in trawls, especially where the bycatch is killed and discarded, and when it may contain juveniles of other important commercial fish species (Alverson and Hughes 1996, Hall 1994). The same concerns exist in British Columbia (BC), although there is a particular concern about bycatch of a particular species, the anadromous smelt, the eulachon *Thaleichthys pacificus* (Osmeridae). This paper examines the bycatch in the 1997 and 1998 British Columbia shrimp trawl fishery. There are few eulachon-bearing rivers in the world, and most runs in the southern parts of their range have declined sharply in the last decade (Hay et al., 1997). This report presents a summary of bycatch of all species in the BC shrimp trawl fishery but the emphasis is on eulachons. Eulachons are one of the most common bycatch species in the shrimp trawl fishery and there is a developing conservation concern for eulachons in many areas of the coast.

The main objective of the work described in this paper was to estimate the approximate weight of bycatch or discards in shrimp trawl fisheries in different areas, years, and by different fishing gears. Details of this fishery, including area-specific quotas and effort are described in Convey et al. (1999), but a brief summary follows. The basic approach to estimating bycatch involves the analysis of catch composition estimates made by observers at sea and then expanding those estimates to reflect the total fishing catch or effort, according to (1) the gear types, (2) the fishing area, (3) the season. We examined two different bycatch estimation methods. Both methods use the bycatch incidence in observer-monitored catches that are expanded to fleet-wide estimates. This is the basic approach used in most bycatch estimates based on observer data (Hall 1994). In the BC shrimp fishery there are two relatively independent estimates of total catch. One is the 'hailed' catch, which is used for in-season monitoring of shrimp catch relative to area-specific quotas. The hailed estimate is the weight of the total shrimp catch, made at the time of catch sales by fishers to plants, and hailed to DFO within days of initial capture. For each Shrimp Management Area (SMA) the cumulative hailed catch is updated within each season and used to monitor total catches relative to the quotas for each SMA. A different catch estimate is available from 'logbook' records that provide details of every set, including time, place, depths, etc. Normally, logbook data are not available until several months after the completion of the fishery for each season. Therefore, although this provides better data for estimating total bycatch, it is not applicable to in-season management, either of shrimp or bycatch.

One method of estimating bycatch is called an '*in-season catch ratio*' method that uses the proportion or ratio of shrimp catches and eulachons catches from observer data and the in-season 'hailed' shrimp catch to make an estimate of eulachon bycatch. Therefore, the bycatch estimate for species of interest, like eulachons, can be monitored within season, and this was done for the first time in 1998 (Hay et al. 1998). The other method, called a '*post-season catch rate*' method, uses catch rate estimates (kg/h) of eulachons or other species from observer data. The estimate of total bycatch is adjusted according to the total fishing time for each SMA based on 'logbook data'. This method is only applicable for post-season estimation but it should be the best estimate of total effort, if the logbook data are complete. In 1998, for the first time, a bycatch limit for eulachons was imposed for certain areas, and as a consequence, the total fishing effort was limited by two ceilings: (1) a quota for shrimp and (2) a bycatch limit for eulachons. Therefore, a second, but important objective of this paper was to compare the estimate of bycatch made 'in-season with hailed data' with the post-season estimate made after-the-fact using logbook data.

An ideal objective of the bycatch program is the in-season estimation of total bycatch of eulachons, and perhaps other species. The problem, however, is that no in-season estimation of fishing effort is available. As an alternative to in-season fishing effort data, we proposed a method that estimated the area-specific ratio's of eulachons to shrimp, calculated from the observer database (the catch 'ratio' method). Once estimated, this ratio was adjusted according to the total shrimp catch (from the hailed database) to provide an in-season estimate of eulachon bycatch (Hay et al., 1988). An objective of the present paper was to calculate and compare the in-season catch ratio estimates with the post-season catch rate estimates.

For the convenience of readers, we include the following two sections to provide a brief review of the BC shrimp fishery and eulachon life history. While these sections are not directly related to the research methods or results presented here, they may provide some useful contextual information that will assist in understanding the background of the bycatch investigation.

The BC shrimp fishery

There are about 200 shrimp vessels which actively fish for shrimp in BC. The fleet consists of a mixture of otter trawlers and beam trawlers. In general, otter trawlers are larger, faster vessels, that often fish in more exposed, offshore waters. Beam trawlers usually are smaller, slower vessels, that fish lighter gear, mainly in inside protected waters. The 1997 and 1998 bycatch program attempted to sample shrimp catches approximately in proportion to the anticipated catch, according to gear-type, season and geographical area (Shrimp Management Areas or 'SMA'). We examined the fishing effort from 1995, in time and space, by both gear types (Hay et al., 1998) prior to planning the initial bycatch monitoring program. In 1995, beam trawl vessels took about 45% and otter trawls about 55% of the shrimp catch, respectively. In 1995 there were some distinct differences in areas fished between the two gear types. Much of the beam trawl catch was from Area 23 or Barkley Sound and waters immediately offshore of Barkley Sound. In contrast, most of the otter trawl catch was from areas offshore of the west coast of Vancouver island (Areas 123-125). In more recent years, the catch distribution has changed, partly in response to the establishment of area-specific quotas (see Convey et al., 1999 for the most recent description of the shrimp fishery).

A challenge for estimating bycatch in the British Columbia shrimp trawl fishery is resolving problems related to the complexity of the data and the abundance of variables. Bycatch estimates for a geographic area should be based on biological and management criteria. For example, Table 1 shows a list of the 35 different Shrimp Management Areas and the corresponding Statistical Areas and subareas (Fig. 1). Analysis of bycatch can be done at different temporal categories: by week, month, season, year, or any combination thereof. In this report, there are 2 years (1997 and 1998) or 24 months as potential time periods for analysis.

Complicating this is the fact that the fishing season and 'management seasons' do not match calendar years. There are two main types of fishing gear (otter and beam trawls), and several sub-categories of gears within each group. Species compositions vary as there are 5 major shrimp species and hundreds of bycatch species. Further, there are at least 3 different estimates of catch (hailed by fishers, fish plant weights and logbook weights), weights are measured in pounds or kilograms and there are several possible measures of fishing effort.

Considering the complexity of the fishery, some reduction in the number of potential variables was required prior to the analyses. For instance, our data included results from 2 principal types of fishing gear (otter and beam trawls), 2 years of surveys (1997 and 1998) and more than 30 potential SMA's, for a total of more than 120 potential combinations for which we could estimate bycatch. Clearly this is too many, so we did not attempt to present an analyses by month for each SMA. Analyses by month would expand the potential analytical combinations by a factor of 10, for a potential matrix of >500 'gear-year-area' combinations that can be used to estimate just one of the several potential bycatch estimates (i.e. the rate of capture of eulachons in time or kg/h). Even following deliberate limitation of variables, we still have almost 50 'gear-year-area' potential categories for bycatch estimation.

The complexity of the variables and the variability of the fishery, in terms of the times and places fished, types of gear, different quotas and the requirement for in-season estimation of bycatch within some SMA's, made the logistics and execution of an observer program complicated. Initially, a primary goal of the bycatch observer program was to distribute the observer sampling effort, in approximate proportion, in time and space, to the fishing effort, or catch. More refined objectives, which were in part implemented in 1998, involve more intensive sampling in locations of interest or concern. For instance, in 1998, there was a specific concern about the bycatch of eulachons in the Queen Charlotte Sound area, and the sampling effort in that area in 1999, reflects that concern.

Overview of eulachon life history

Like salmon, eulachons are anadromous. They spawn in rivers and migrate to 'offshore' grounds where they feed and grow for 2-3 years before they return to spawn. Probably all eulachons die after spawning. Unlike salmon, however, the fidelity of spawning to natal rivers is less certain. Analyses of otolith chemistry (Carolsfeld and Hay, 1998 ms) and preliminary analysis of eulachon genetics (using both mitochondrial and microsatellite DNA) suggest that eulachons do not differ over broad geographic ranges, or between adjacent rivers. On the other hand, we observe that eulachons spawn in a relatively few number of rivers, which may indicate some selectivity on their part. Further, eulachon from many of the rivers have quite different spawning times, which is consistent with the assumption that eulachons return to their natal spawning rivers. With the uncertainty concerned with this issue, we feel that it is precautionary to assume that each river represents a separate spawning population. Therefore, at the present time, we cannot identify the origins of the eulachons taken in the bycatch samples using genetic or chemical approaches. Based on analyses of a research times series off the west coast of Vancouver Island (Hay et al., 1997) it seems that eulachon populations may change distribution between years. Also, some fishers have indicated that the abundance of eulachons in the Central coast in 1997 was unusual, and not seen in previous years. On the other hand, the fishing effort there, beginning in 1996, was unprecedented in the previous decade. Therefore, the summer distributions of eulachons may change from year to year. The key biological question, however, is whether a significant bycatch could be taken from a few small stocks. If so, the size of the bycatch may be very large relative to the size of some small runs. For instance, Pedersen et al. (1995) estimated the Kitimat River run at only 20 tonnes but acknowledged that this estimate may be conservative, perhaps by a factor of 5.

Presently, we believe that there may be only about 15 eulachon populations spawning in BC (Fig. 2). South of BC, there may only be two populations: one in the Columbia River and the other in the Klamath River. There may be only 3-4 populations spawning in rivers in Southeast Alaska. Therefore, there are only a few populations and many have experienced declines in abundance. The causes of the declines are uncertain and there may be a number of explanations including habitat deterioration and pollution (Rogers et al. 1990). Probably the fisheries for eulachon are not the cause of the decline because most are very small. Similarly, the bycatch of eulachons in shrimp nets may not be the cause of the decline but the bycatch may represent an obstacle for the recovery of some eulachon populations, especially if the bycatch were taken from some of the smaller populations.

Throughout much of their range, eulachon populations have declined in recent years (Moyle 1994, Hay et al., 1997). A gradual decline of eulachons, and other anadromous fishes has occurred in California during the last 15 years (Moyle 1994), although in one California river, the 1999 eulachon run may have been stronger than in previous years. The decline in the Columbia River has been recent, beginning in 1993. The Fraser River seems to have experienced a gradual decline followed by a sharp drop in availability of eulachons in 1994 (Hay et al., 1997). Apparently, eulachons have declined in some central BC coast rivers, although the timing and severity of the declines is uncertain at this time. The eulachon run in the Nass River, however, continues to support an active fishery and may not have experienced the same declines as other rivers to the south. The status of eulachons in Alaskan rivers is not well known or documented. In 1998, there was an exceptionally strong run of eulachons in the Copper River in Alaska (E. Brown, University of Alaska, pers. comm.). Also, there are reports of exceptionally strong runs in a few northern BC rivers. In contrast, the apparent 1999 eulachon runs have been exceptionally weak in most BC rivers, as well as in the Columbia River. There were some apparently unprecedented low runs in some northern rivers that had abundant runs in 1998.

MATERIALS AND METHODS

Data for bycatch estimation are from 3 different sources or databases: (1) the 'hailed' catch data, (2) logbook data and (3) observer data on composition of shrimp trawl catches made by observers on board fishing vessels. The *hailed catch database* provides estimates of landed shrimp weights at plants and are used for in-season monitoring of total catches. Vessel operators record the logbook catch data at sea, and then the data are transcribed into a DFO database for 'in-season' estimated of cumulative shrimp catches in different areas. In contrast, the *logbook database* provides details of the fishing location and fishing effort (duration in minutes of each tow) and total shrimp catch for each tow. This database is not complete until the end of each fishing season. Therefore, analyses based on effort data cannot be conducted until the completion of the fishing season. The *observer database* includes observations of catch composition from shipboard observers that are assigned to different fishing vessels and areas. For the analyses of this paper, we were obliged to comply with Section 20(1)(b) of the *Access to Information Act* that prevents Fisheries and Oceans Canada from disclosing to a third party, records containing financial, commercial, scientific or technical information that is confidential. Further, Section 20(1)(c) of the Act prevents Fisheries and Oceans Canada from giving out information, the disclosure of which could reasonably be expected to result in material financial loss or could reasonably be expected to prejudice the competitive position of the fisher. For most analyses in this paper catch data are presented as the cumulative catches for many sets with no precise geographical co-ordinates or other geographical data shown that would allow these data to be related to any specific vessel. Further, for all areas when there were 3 or fewer vessels reporting a catch, we do not reveal either the total catch or the total fishing time, in hours. Instead, we use the number symbol (#) to indicate areas where some catch or fishing effort occurred but which could be considered as confidential. The observer or catch-monitoring program started in June 1997. Therefore the period when 'hailed' data were available for 1997 was from June 1 to Dec 31, 1997. These data were available for all of 1998. All databases differentiate among different shrimp species, but for these analyses, we often pooled all shrimp species simply as 'shrimp'.

Observer data

A basic assumption of the program was that total bycatch was related to fishing effort, although at the onset we recognized that there may be differences between the two main types of trawling gear: otter and beam trawls. The program was designed to place sea-going observers on fishing vessels in all areas and seasons, in approximate proportion to the fishing effort, and type of gear. In practice, this is a difficult and complex task because of many uncertainties about future fishing plans and problems establishing contact with sea-going vessels. The deployment of observers started in March 1997. Initially it was conducted by Archipelago Marine Research of Victoria, BC. In 1998, the deployment of observers was conducted mainly from DFO in Nanaimo. In both years, the sampling protocol of observers was identical. They sampled as much of the catch as possible and identified the target shrimp species and the non-target species with as much detail as time allowed.

For the purposes of analyses, the smallest 'unit' of data was the trawl set or tow. For each set, data was collected on the catch composition, time and duration of the tow, location (co-ordinates) and depth of the start and finish of the tow, meteorological and sea conditions. Weights of shrimp catches were estimated by vessel captains. Discarded bycatch species weights were estimated by observers, often using containers (similar to graduated cylinders) that showed the approximate weight at different levels of fullness. We present data only on the catch composition and approximate locations of observer tows, organized to the geographical limits of Shrimp Management Areas (SMA's).

Analyses of observer data

The species catch composition was estimated for 5 different areas of the coast. The taxonomic precision of the catch analyses varies, but the most predominant fish and invertebrates are identified to species using a common and scientific name. Often there are ‘categories’ of species for which more detailed analyses is not possible, such as ‘rockfishes’, ‘eelpouts’ or ‘sculpins’. The analysis of these data in this report is brief, and more extensive analyses of non-eulachon species will be presented elsewhere. In this report, however, we do point out that there are a number of instances when bycatch of certain species may be a concern.

There were 21 SMA’s that were examined by observers, so it is impractical to provide a detailed species composition (100+ species) for each area. Therefore, some SMA’s were aggregated into larger geographical areas, as follows:

General location	SMA
Prince Rupert District (PRD)	PRD
Central Coast (CC)	7IN, 8IN, 9IN, QCSND
Northern Johnstone Strait (NJS)	12, 12IN, 12OUT
West Coast Vancouver Island (WCVI)	23IN, 23OFF, 124OFF, 125OFF, 23IN, 27IN, 27OFF
Strait of Georgia (SOG)	14, 17, 18, 19, GSTE, FR

In-season estimation of bycatch – based on hailed data, for eulachons only

We estimated the ratio of any non-target species catch (kg) to the total shrimp catch (kg) for each tow from the bycatch data collected in the 1997 and 1998 observer program. In practice, we did this only for eulachons, as a method of in-season monitoring of bycatch. For instance, if the total eulachon shrimp catch was 2 kg and the total shrimp catch was 100 kg, the ratio is 2/100 or 0.02. In the many instances where no eulachons were captured, the ratio was 0 and these 0-estimates were included in the analyses.

The method assumes that the ratio of eulachons (E) to shrimp (S) in observer tows was representative of the ratio for the commercial catch in a Shrimp Management Area. So, if **Eo** is defined as the weight (kg) of eulachons in a single tow from the *observer* database, and **So** is the estimate of the total shrimp weight (all species) from the same observer database, then the ratio of eulachon to shrimp is **Eo/So**. For each SMA and gear type we assume that the ratio of eulachons to shrimp from the observer samples is similar to the ratio of the total catch of eulachons and shrimp from the fishery, so

$$\sum([Eo/So])/n \; = \; Ec/Sc \qquad \text{(Equation 1)}$$

where **n** is the number of observer tows analysed, **Ec** is the total weight of eulachons in the total catch (or catch in a specific area or time period) and **Sc** is the weight of the shrimp catch (all landed species). Therefore,

$$Ec \; = \; (\,Sc)(\sum([Eo/So]/n) \qquad \text{(Equation 2: \textit{the MI-ratio estimate})}$$

The estimated **Ec** is subsequently called the '*mean in-season catch ratio'* estimate or **'MI-ratio'** estimate to distinguish it from other estimates. The ratio of eulachons to shrimp (**Eo/So**) is estimated from the observer data, and the shrimp catch **Sc** is estimated from the hailed catch data. We estimate **Ec** separately for each SMA and gear. In 1998, we used bootstrapping procedures (Efron, 1993) to estimate error for selected area and gear type (Hay et al., 1998). The mean ratio (and 95% confidence limits) was estimated from 500 bootstrap replications (sampled with replacement) from the data from each area. A variation of this estimate is simply the ratio of the sums of the eulachon catch and the shrimp catch, summed over all the tows for each area (or time period within an area).

$$Ec = (Sc)(\sum Eo)/(\sum So)$$ (Equation 3: *the PI-ratio estimate*)

This procedure provides a single estimate of the ratio of eulachons to shrimp based on the ratio of the cumulative catches of eulachons and shrimp for each SMA or any combination of SMA's or time periods. This simple estimate is useful for in-season management and is subsequently called the '*pooled in-season catch ratio'* estimate or the '**PI-ratio'** estimate.

Post-season bycatch estimation – based on logbooks

From the bycatch data collected in the 1997 and 1998 observer program, we estimated the mean catch rates (kg/h) for 2 main species categories: eulachons and all 'non-target species, including eulachons. These are defined as follows: **E** is the catch weight of eulachons and **Eh** is the catch per hour (kg/h) in the observer tows. Similarly **N** is the weight of all non-target species, **S** is the weight of shrimp and **Nh** and **Sh** are the catch rates per hour of each category. For instance, if the catch during a 1 hour tow consisted of 100 kg shrimp, 2 kg eulachon and 10 kg of 'other species', then **Sh** = 100, **Eh** = 2 and **Nh** = 12 (i.e. 10 kg non-target species plus 2 kg eulachons).

For each year and each SMA (or groups of several SMA's) the **Eh**, **Nh** and **Sh** are estimated from observer tows as follows:

$$Eh = \sum((E)/(Ho)/n)$$ (Equation 4: *the MPE-rate estimate*)

$$Nh = \sum((N)/(Ho)/n)$$ (Equation 5: *the MPN-rate estimate*)

$$Sh = \sum((S)/(Ho)/n)$$ (Equation 6: *the MPS-rate estimate*)

where **n** is the total number of sets examined and **Ho** is the number of tow hours. We call these estimates of total bycatch or catch the 'mean post-season catch rate estimate' or **MP-rate**. This is distinguished as **MPE-rate** for eulachons, **MPN-rate** for or all non-target species and **MPS-rate** for all shrimp species. We include 'shrimp' in these analyses so that we can later compare the catch rates of eulachons and non-target species with the catch rates of shrimp.

It follows that the estimates based on pooled data, summed over an aggregation of space or time can be defined as follows:

$$Eh = \sum(E)/\sum(Ho)$$ (Equation 7: *the PPE-rate estimate*)

$$Nh = \sum(N)/\sum(Ho)$$ (Equation 8: *the PPN-rate estimate*)

$$Sh = \sum(S)/\sum(Ho)$$ (Equation 9: *the PPS-rate estimate*)

We call these estimates of total bycatch or catch as the 'pooled post-season catch rate estimate' or **PP-rates**. These are distinguished as **PPE-rate** for eulachons, **PPN-rate** for or all non-target species and **PPS-rate** for all shrimp species. These estimates are considered as supplementary to the more general estimates shown in equations 4-6. We included them here (equations 7-9) only to determine if these estimate vary from those calculated from means (equations 4-6).

In the results, we compare all estimates of eulachon bycatch by year, gear and geographical areas (different SMA's). We also show estimates for the whole coast by year and gear. We use the general bycatch equations (equation 4-6) to make post-season estimates of the mean bycatch weight of eulachons, all 'non-target' species (i.e., all species excluding shrimp) and catch weight shrimp by gear type and SMA's. In the results, we compare and contrast the 2 different approaches to bycatch estimation, one based on the in-season *bycatch ratios* (the **'MI-ratio'** and **'PI-ratio'** estimates) and the post-season catch rate estimates (**MP-rate and PP-rates)**. The potential differences in estimation between the in-season catch ratios the post-season catch proportions **(PI-ratio)**, for some gear-year-area categories, are particularly important. These differences are described and discussed.

RESULTS

Catch and Effort data

Hailed Data – Shrimp Catches by Gear type, Year and Area. Table 2 shows the distribution of catch in kg, for each Shrimp Management Area (SMA). Queen Charlotte Sound area (QCSND) was the site of the largest shrimp quota in 1998, but this area had only small catches and relatively light fishing effort before 1996.

Logbook Data – Shrimp Catches by Gear type, Year and Area. Table 3 shows the logbook catch data, for both gear types in each SMA, for 1997 and 1998. Table 4 shows the fishing effort data, or numbers of hours fished for the same gear-year-area categories.

Observer data

A total of 1378 tows were examined both from beam and otter trawlers, 680 in 1998 and 698 in 1997 (Table 5). For each year and gear the total numbers are as follows:

1997 Beam	332
1997 Otter	366
1998 Beam	248
1998 Otter	432

Most (348) of the 432 otter trawl sets made in 1998 were examined from one SMA (QCSND) and there was relatively little observer data from other areas of the coast in 1998. This exceptional effort in this area reflected an attempt by managers to monitor and limit bycatch in that area. The consequence was that some areas, such as the West Coast of Vancouver Island had fewer observer trips than would have been necessary to provide better estimates of bycatch. On the other hand, the concentrated observer effort in Queen Charlotte Sound, with a relatively large number of sets examined for 2 consecutive years, provide an opportunity for some detailed comparison, in time and between vessels, that would not have otherwise been possible.

Analyses of catch composition by area

The SMA's were aggregated into 5 geographical areas: (1) Prince Rupert District (PRD); (2) Central Coast (CC) including SMA's 7IN, 8IN, 9IN, QCSND; (3) Northern Johnstone Strait (NJS) including SMA's 12, 12IN, 12OUT; (4) West Coast Vancouver Island (WCVI), including SMA's 23IN, 23OFF, 124OFF, 125OFF, 23IN, 27IN, 27OFF; and (5) Strait of Georgia (SOG), including SMA's 14, 17, 18, 19, GSTE, FR.

The catch composition of each general location is shown in Table 6. The purpose of the table is to determine if there are any outstanding differences in bycatch species composition among areas – so we did not distinguish by year or gear. The list is ranked, from the highest to the lowest percentage composition, based on the total bycatch composition for both years. Consequently, within each of the 5 general locations, the order in the list is not necessarily from most to least frequent.

The top 3 species in the list (all shrimp) are 'target ' species, and the percent composition (from observer tows) is nearly 88% in the CC and 87% on the WCVI. The data also shows that the main target species changes between areas, from sidestripe shrimp in PRD, smooth pink shrimp on the WCVI and CC, spiny pink shrimp in NJS, and a mixture in SOG. Note that in SOG the total percent catch of target species appears low because the shrimp catch consists of a number of species and some target species (marked with an asterisk) appear in the list below the top 3.

Non-target species or non-target species 'categories' with relatively high frequencies are indicated in bold. Particularly high frequencies are underlined. For example, slender soles and herring each account for more than 3% of the SOG bycatch. In this list eulachons are the most frequent bycatch species in the WCVI and CC. The high estimate of 'unknown fish' in NJS is misleading, because data from these areas include some 'shrimp survey data' where total species composition was not examined in the same detail as other areas. There are a number of species in the PRD and SOG that warrant more attention in future bycatch surveys. In particular, there is a number of commercially important pleuronectids (flatfishes) and gadoids (codfishes) in the bycatch. It would be valuable to have more information on the size (or age composition) of these species.

Different methods of estimating bycatch

The observer data are summarized in Table 7 for each year (1997 and 1998) and gear (otter and beam trawls). This table summarizes much of the observer data and, for each 'gear-year-area' category, shows the numbers of sets observed, the total catch (kg) of 3 'species <u>categories</u>' (eulachons, shrimps and 'non-target', or all species except shrimp). Table 7 lists the MI-ratio and PI-ratio bycatch estimates of eulachon for all areas. Also presented are the MP-rate and PP-rate estimates for eulachons (MPE-rate and PPE-rate), non-target species (MPN-rate, and PPN-rate) and catch rates of shrimp (MPS-rate and PPS-rate).

Initially we believed that the MI-ratio estimate, based on means from individual tows, would be preferable because having a number of independent estimates could provide a measure of variability. Unfortunately, the estimates of bycatch from this approach appear to differ from those of the other methods, and in general the MI-ratio seems to inflate bycatch estimates of eulachons, although the explanation for this is not clear. Table 7 shows some important differences between the **MI-ratio** and **PI-ratio**, or pooled catch proportion. The **MI-ratio** estimates are always higher, and sometimes much higher, than the simple ratio based on the pooled sums of eulachons and shrimp (**PI-ratio**'s). The largest discrepancies are underlined in Table 7 and also are seen in Figure 2 that compares the **MI-ratio** and **PI-ratio** for all areas.

Figure 3 shows a comparison of the rates and proportions: **MI-ratio** versus **MPE-rate** (Fig. 3a) and **PI-ratio** and **PPE-rate** (Fig. 3b). The axes of Fig. 3a and Fig. 3b are not in the same units, but most of the points in Fig. 3a are scattered, indicating a poor agreement between the **MI-ratio** and **MPE-rate.** In contrast, in Fig. 3b, the **PI-ratio** and **PPE-rate** estimates show relatively closer agreement.

Comparisons of the catch rate estimates (**MP-rate** and **PP-rate**) for each SMA for each of the survey years (1997 and 1998) are also seen in Table 7. In general, there is little difference between them, either for shrimp, eulachons or the 'non-target species category. These comparisons are shown in Figures 4a-c, and all appear to show relatively close agreement (for most of the points). Correlation coefficients between the paired comparisons (from Table 7) **MPE-rate** versus **PPE-rate** , **MPN-rate** versus **PPN-rate**, **MPS-rate** versus **PPS-rate**, are 0.990, 0.996 and 0.967 respectfully. Therefore it seems to make little difference in bycatch estimation if the catch <u>*rate*</u> data are examined at the level of individual tow, or by an aggregated sum of the catches and the effort. These relationships are summarized in the following correlation matrix comparing the 4 estimates of eulachon bycatch from observer data. The comparisons using the **MI-ratio** are the lowest (*in italics*). The two catch rate estimates **(MP-rate** and **PP-rate)** are closely correlated (0.99) and the pooled catch proportions **(PI-ratio)** is also closely related to the two rate estimates (***bold italics)***. The relatively poor correspondence between the MI-ratio and the other estimates indicates that it is not a reliable estimate of bycatch.

Correlation Coefficients

	MPE-rate	MI-ratio	PI-ratio
MI-ratio	*0.743*		
PI-ratio	***0.910***	0.858	
PPE-rate	0.990	*0.747*	***0.913***

Estimates of bycatch – by SMA, gear and year.

For each year, gear and SMA, two estimates of the total bycatch of eulachons are made. The first, following Equations 5-7, is a product of the catch rates in kg/h (**MPE-rate)** estimated from the observer data, and the number of hours fished in each area (from Table 4), taken from the logbook data . These estimates are shown in Table 8, with the estimated sum of eulachons for each SMA shown in bold. The coastal totals, for each gear are shown at the bottom. The total estimate in 1997 was about 10,000 kg (10 t) for beam trawlers and 76 t for otter trawlers. The estimates for 1998 were lower: 5 t for beam trawlers and 30 t for otter trawlers. Note that many areas did not have any observer data so these areas are not included in the summary. Therefore these estimates will underestimate the total bycatch. Most areas with high numbers of hours fished, however, had some observer estimates, so the underestimate probably is not large.

The second bycatch estimate, following from Hay et al. (1998) is based on the ratio of eulachons to shrimp, as shown in Equations 1-3. The bycatch estimate is a product of the *mean catch proportion* (**MI-ratio)** of eulachons to shrimp, and the total 'hailed' weight of the shrimp catch in kg, as shown in Table 2. We also make an estimate using the *pooled catch proportion* (**PI-ratio)** as a comparison with the MI-ratio estimate. Both estimates, for each SMA, gear and year are shown in Table 9.

In general the estimates (in metric tonnes) using **MI-ratio** are much higher, but the PI-ratio estimates are lower, and roughly comparable to those estimated using catch rate data (**MPE-rate**).

Summary of total eulachon bycatch estimates (tonnes) using 3 different methods:

Year and Gear	**MPE-rate**	**PI-ratio**	**MI-ratio**
1997 Beam trawlers	10	18	21
1997 Otter trawlers	76	101	140
Total	86	119	161
1998 Beam trawlers	5	9	41
1998 Otter trawlers	30	50	127
Total	35	59	168

This summary indicates that the higher estimates of eulachon bycatch presented by Hay et al. (1998) for the 1997 fishery probably were too high. The 1997 total bycatch estimate based on catch rates, (86 tonnes - see above) is probably conservative, for two reasons. First, bycatch was not estimated for many parts of the coast where observer data was not available, although there often were shrimp catches in such areas. Second, the MP-rate and PP-rate estimates are based on logbook catches (corresponding to logbook effort or hours of fishing).

Both fishing effort and shrimp catches are taken from the same database, summarized in Tables 3 and 4. The hailed catch data (Table 2) has slightly different estimates of catch, and were considerably higher for otter trawlers in 1997. The data for both gear types, however, is similar in 1998.

Summary of total shrimp catch estimates (tonnes) from hailed and logbook records:

Year and Gear	Hailed	Logbook
1997 Beam	977	1420
1997 Otter	2373	1630
1977 Total	3350	3050
1998 Beam	1396	1470
1998 Otter	1612	1650
1988 Total	3009	3120

The estimate of 86 tonnes of eulachon bycatch in 1997 may be conservative, perhaps by 30% or more, but the lower estimate of eulachon bycatch in 1998 (35 tonnes) is probably better, (i.e. less affected by discrepancies in catch data) but still underestimated because of limited observer coverage. On the other hand the PI-ratio estimate is intermediate and should be used if nothing better is available. This estimate should be used with the recognition that it may err slightly on the high side.

DISCUSSION

The initial purpose of this report was to describe bycatch of eulachons and other species in the BC shrimp fishery. The intention was to use logbook data to provide more detail to the first analyses. In the process, however, it became clear the estimates of bycatch based on catch proportions, particularly the **MI-ratio** method, was suspect, and probably resulted in an over-estimate of bycatch in some locations. This is an important issue, and throughout the last year we have been puzzled about the variation in estimates made by different people, that were apparently based on the same numbers from the same databases. In effect, one of us (Hay) estimated more eulachon bycatch than managers. The reason for this appears to be that managers were comparing 'aggregations' of data (i.e., the summed eulachon catch and the summed shrimp catch), corresponding approximately to the **PI-ratio** estimate in this paper, to determine the eulachon:shrimp ratios.

Higher estimates of bycatch were obtained using the eulachon:shrimp ratio based on the means of individual tows (the **MI-ratio** estimate). These differences became apparent during the preparation of this report, and to our knowledge, this particular aspect of bycatch analyses, although not profound, has not been described before. Simply put, the analysis shows that bycatch estimates based on the means of individual tows over-estimate the catch of non-target species. The reasons for this may be self evident, but are difficult to confirm. Fishers encountering high bycatch probably move, or diminish effort in poor areas. Most fishing effort would be spent in the areas yielding the highest catch rates of target species. Therefore, unless observed fishing effort is exactly proportional to total fishing effort, analyses based on estimates of means from observed tows, will probably be biased. This is a concern when the 'ratios' of two species are estimates, as in the **MI-ratio** estimates. For **MI-ratio** estimates, tow duration is not considered so even very short tows, that may have exceptionally high estimates of bycatch are given equal weight with longer tows with little or no bycatch. There are other concerns with the use of 'ratios', such as the potential for bias with small sample size (Cochran 1977). Therefore, in this report we suggest that methods based on catch *rates* are preferable, specifically the **MP-rate** method. The problem for managers, however, is that fishing effort data (hours towed) are not available for in-season monitoring. If these data could be made available as rapidly as the hailed catch data, the monitoring of bycatch would be simpler and more accurate.

Our initial intention in this report was to provide error estimates of bycatch, similar to the 1998 report (Hay et al., 1988). The inclusion of such 'error' estimates, however, can be misleading if there is a flaw in the approach, as there appears to be in the **MI-ratio** estimates. There are other concerns, including a large difference in the estimation of total catches. The logbook catch data (Table 4) and the hailed catch data (Table 2) vary. If the hailed catches are correct then the 1998 MP-rate bycatch estimates presented in this report (and based on logbook data) are lower than if they had been estimated using hailed catch data. Given these discrepancies, which need to be resolved for future analyses, presentation of error estimates in total bycatch could be misleading. We acknowledge their worth, however, and recommend that they be included in future analysis. In particular, estimates of error of catch rates (kg/h) can be estimated but error estimates of catch rates should recognize some biotic and key variables that affect catch rates. For instance, some small juvenile fish become vulnerable to shrimp gear during their first summer. Therefore, catch compositions and subsequent bycatch analyses made early in the season may differ from those made later in the season.

The distribution of eulachon bycatch - and confusion with capelin?

The bycatch of eulachons were assessed mainly from specific SMA's and not others. There were virtually no eulachons captured in the Strait of Georgia, by any gear. The few eulachon records that exist (see the "*åEul*" column in Table 7, corresponding to SMA's in the Strait of Georgia) could have been capelin (*Mallotus villosus*). Capelin have reappeared in the Strait of Georgia after an absence of many years. They were encountered for the first time during juvenile herring surveys in 1998, but not in the previous 6 years of the survey. Further, these fish are small and difficult to distinguish from juvenile eulachons. Therefore, even these few observations of eulachons in Georgia Strait may have been an error.

Biological impact of the eulachon bycatch

A key issue concerning bycatch, is the origin of eulachons taken by the gear. Hay et al. (1997) speculated that some of the bycatch from the west coast of Vancouver Island may be from the Columbia River. This is based on the following observations: (1) There are no known eulachon spawning areas on any of the rivers on the west coast of Vancouver Island. (2) The Fraser and Columbia Rivers are the largest and closest eulachon populations to the west coast shrimp fishing grounds. (3) Columbia River eulachons spawn mainly in January and February (Smith and Saalfeld 1955) whereas Fraser River eulachons spawn mainly in April and May (Ricker et al 1954). (4) The west coast shrimp fishery, and an annual shrimp trawl research survey has captured eulachons at the same time (April and May) as the main Fraser River spawning run is in progress - when most Fraser River eulachons would be spawning and not be present on the west coast. It is possible that eulachons caught on the west coast at this time are immature Fraser River eulachons, or that they could be caught in the west coast shrimp fishery at other times in the year.

Until recently, the Columbia River eulachon population supported an annual fishery of several thousand tonnes (Anon 1993). The Fraser River run was probably much smaller, but in the 1950's, the commercial fishery took several hundred tonnes per year (Ricker et al 1954). Since spawning run sizes in the Fraser and Columbia Rivers are many hundreds or thousands of tonnes, a total bycatch of 35 tonnes in 1998 or 90 tonnes in 1997 (the estimates made in this report from Tables 8 and 9), while not desirable, would be a larger concern if the spawning runs of eulachons were smaller - and both the Fraser and Columbia runs appear to be low at the present time. The Central coast bycatch is a particular concern because it is possible that some of these eulachons originate from relatively small eulachon populations spawning in Central coast rivers. Although we do not know the size of these runs, it is reasonable to expect that they are much smaller than the Columbia and Fraser River runs.

Perspective of bycatch and bycatch analyses

We regard this preliminary analysis as part of a larger, longer-term initiative to develop methods to estimate bycatch. This will take time but much has been learned in the last two years. A pre-requisite to analyses of bycatch is an acceptable method of estimation, and this is a major aspect of this paper. We recognize that more analyses can be presented, particularly on biotic factors and analyses of fishing gear relative to bycatch. We point out, however, that this is the second paper presented within two years. The present paper includes data that were collected less than 6 months prior to the June 1999 PSARC meeting. Ideally, we would prefer to take more time and present more detailed analyses. The purpose of this presentation of this report at this time, however, is to provide managers with current information in order to respond to an apparent conservation issue regarding eulachons, and other bycatch issues. To do this, we could not pursue all of the potential analyses that we wished, particularly about other bycatch species. This will have to await a future report.

We point out that it is one thing to estimate bycatch (of eulachons or any other species) and another to comment on the validity of concerns or the biological impacts of such bycatch. In the instance of eulachons, the recommendation is clear, even if our understanding of the biology is not. Throughout the BC coast, and elsewhere in parts of the range of eulachons, spawning runs have declined, and the decline is sharp since 1994 (Hay et al. 1997). We do not understand the cause of the decline, but the decline is consistent with the observations that ocean climate has changed. We also acknowledge that there are habitat concerns in most (but not all) of the spawning rivers used by eulachons. Recent genetic analysis indicates that there may not be differences among adjacent spawning populations. Therefore, it is not clear if eulachons regularly leave and re-colonize different systems. On the other hand, to be pre-cautionary, we must assume that each river represents a separate population (not a great leap of logic) until shown otherwise. For this reason we urge both managers and fishers to take the utmost effort to limit bycatch until we better understand the consequences. As shown in Tables 8 and 9, eulachon bycatch is only a concern in some areas (Fig. 5) where the catch rates are high.

We can offer only limited conclusions, perspectives and recommendations on bycatch of other species. First, the bycatch in the BC shrimp fishery should be compared between areas with BC and between seasons within the same areas. In part, we attempted to do this in Table 6, but the data are limited in the numbers of comparisons that can be made. We note, however, that total bycatch (kg/h) of non-target species varies among SMA's as shown in Fig. 6. Also, the areas with high overall bycatch are not necessarily the same as those with high eulachon bycatch (compare Figs. 5 and 6). In a number of locations, total catch of non-target species can exceed 50% (Fig. 7).

How much bycatch is too much? Aside from the consideration of eulachons, where a conservation concern has direct management implications (to reduce eulachon bycatch), we ask this rhetorical question without attempting to answer it. Rather we point out that the answer could be more judgmental than scientific, and beyond the scope of analyses based mainly on biological considerations. There are, however, two key considerations about this question. The first is that the BC shrimp fishery is not the only fishery with significant discards. To gain a perspective of the scale of discards in the BC shrimp fishery, data and analyses from other fisheries need to be considered and compared – specifically the groundfish fishery. The second perspective is that the total level of discards from some areas (but not all) of the BC shrimp fishery is very low. In many respects, some areas, particularly in offshore waters, may have some of the 'cleanest' shrimp fisheries in the world, but there are few comparable studies. Those that are available, however, indicate that some fisheries, such as the prawn trawling fishery in New South Wales, have ratios of bycatch to target species of about 10:1 (Kennelly et al. 1988) although some of the 'bycatch' or non-target species are retained and sold. Still, other reports (Liggins et al. 1996) indicate bycatch rates 2:1 (or 50% non-target species) in other Australian prawn trawl fisheries. Other estimates from various shrimp fisheries are available but few are published in peer-reviewed documents. For instance, many different estimates of bycatch, corresponding to different fisheries and bycatch experiments, are presented in Christian et al. (*MS* 1993), or Burrage et al. (1999). Many of these sources indicate that the ratio of bycatch to target species has a ratio of 3:1 or 4:1, and sometimes as high as 10:1. Sometimes these estimates are controversial but the most conservative estimates from most of these other shrimp fisheries are usually greater than those estimated for the BC shrimp fisheries in this report. It is unfortunate that in BC, many of the areas with the lowest overall bycatch are the ones with the highest eulachon bycatch.

RECOMMENDATIONS

We recommend that further analyses be continued pending agreement on the most suitable approach to bycatch estimation. More analyses can be done, particularly on aspects of catch patterns in time and space, as well as biotic factors than may affect both catch and bycatch. In part, such analyses are complicated and even confounded by the considerable variation in the data, particularly the different gear types (there are several sub-categories of beam and trawl gears), fishing dates and times, etc. There also are potentially important biological differences in bycatch species, with juveniles of some species (i.e., pleuronectids or flatfishes) becoming 'recruited' to the bycatch fishery during the first summer. Therefore, an active shrimp fishery may encounter a different composition of bycatch of the same species in early summer compared to later in the summer. There is some indication this may happen in eulachons, but this will require further data and analyses. The analyses can be extended to examine the biological or ecosystem impacts of catches of non-target species that have no commercial value.

Analyses of catch composition of trawls should continue, and observers should be placed on vessels fishing in some of the Shrimp Management Areas, identified in this report, where observer coverage is lacking.

Bycatch in the shrimp fishery should be compared and contrasted with the bycatch in other fisheries, particularly bottom trawl fisheries.

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Table 1. Shrimp Management Areas (SMA's) showing the statistical areas and subareas and shrimp catch ceilings (in pounds) as were applied in 1997/98.

SHRIMP MANAGEMENT AREA	STATISTICAL AREAS AND SUBAREAS	CATCH CEILING (LBS)
DXE	1, 101	22,050
QCI	2, 102, 142	22,050
3IN	3-5 to 3-16	22,050
PRD	3-1 to 3-4, 103, 4-1 to 4-16, 104, 5-1, 5-2, 5-23	220,460 sidestripes 220,460 other shrimp
5IN	5-3 to 5-10, 5-12 to 5-19, 5-21, 5-24	22,050
5OFF	5-11, 5-20, 5-22, 105	22,050
6IN	6-1 to 6-8, 6-10 to 6-12, 6-14 to 6-16, 6-18 to 6-28	22,050
6OFF	6-9, 6-13, 6-17, 106	22,050
7IN	7-2 to 7-25, 7-27 to 7-30	22,050
8IN	8-2 to 8-16	22,050
9IN	9-1 to 9-12	22,050
10IN	10-3 to 10-12	22,050
QCSND	107, 7-1, 7-26, 7-31, 108, 8-1, 109, 110, 10-1, 10-2, 111, 11-1, 11-2, 130	1,322,750 (fished by permit, survey required)
11IN	11-3 to 11-10	22,050
12IN	12-22, 12-23, 12-26 to 12-48	TBA
12OUT	12-1 to 12-21, 12-24, and 12-25	TBA
GSTE	13, 15, 16	220,460
14	14	220,460
17	17	22,050
18	18	220,460
19	19	44,090
20	20	22,050
FR	28, 29	198,410
21OFF	121/21	*
23IN	23-1 to 23-6	385,800
23OFF	123, 23-7 to 23-11	*
24IN	24	22,050
124OFF	124	*
125OFF	125	*
25IN	25	22,050
26IN	26	22,050
126OFF	126	*
27IN	27-3, 27-7 to 27-11	22,050
27OFF	127, 27-1, 27-2, 27-4 to 27-6	110,230

Table 2. Hailed shrimp catches (kg) by Shrimp Management Area (SMA), year and gear. To comply with confidentiality requirements catches in some areas cannot be shown and are indicated by the number symbol (#).

SMA	1997 Beam	1998 Beam	1997 0tter	1998 0tter
10IN	9,050	346	0	0
11IN	#	#	0	0
124OFF	#	0	355,811	32,186
125OFF	#	0	#	187,788
126OFF	0	0	#	#
12IN	94,393	165,539	0	9,169
12OUT	17,551	10,380	0	0
14	31,485	74,860	10,137	15,525
17	7,760	11,844	#	0
18	46,024	73,895	#	2,678
19	24,192	19,242	#	#
20	0	0	0	0
21OFF	0	0	0	0
23IN	123,508	63,388	29,396	#
23OFF	421,678	592,696	311,885	277,644
24IN	217	#	#	0
25IN	#	#	#	#
26IN	0	0	0	#
27IN	0	#	0	#
27OFF	0	1,580	#	47,693
3IN	10,541	3,246	#	2,940
5IN	#	854	#	4,679
6IN	#	#	7,709	8,079
6OFF	0	0	0	25,594
7IN	1,155	7,063	#	4,222
8IN	#	2,365	#	#
9IN	0	24,590	#	17,501
DXE	#	0	0	0
FR	67,598	142,712	#	0
GSTE	66,012	97,425	#	#
PRD	39,019	70,119	34,606	87,139
QCI	0	9,151	0	15,843
QCSND	0	6,686	478,290	848,478
TOTALS	**976,648**	**1,396,033**	**2,372,681**	**1,612,116**

Table 3. Shrimp fishery logbook catch data. Estimated catches (kg) from logbooks are shown by SMA, year and gear. Some larger numbers are rounded. The column headers 97 U and 98 U represent unknown gear types**.** To comply with confidentiality requirements catches in some areas cannot be shown and are indicated by the number symbol (#).

SMA	97 Beam	97 Otter	97 U	97 Total	98 Beam	98 Otter	98 U	98 Total
10IN	11,192	-	-	11,192	460	#	-	460
11IN	#	-	-	#	#	-	-	#
124OFF	38,032	418,000	-	456,032	2,082	17,283	-	19,365
125OFF	#	94,401	-	94,483	#	181,000	-	181,204
126OFF	#	#	-	#	-	#	-	#
12IN	145,000	-	-	145,000	177,000	11,596	-	188,596
12OUT	23,902	-	-	23,902	17,342	#	-	19,144
14	68,691	23,415	4,503	96,610	93,044	18,780	247	112,072
17	10,731	#	-	10,858	11,638	-	-	11,638
18	159,000	#	1,882	161,422	106,000	5,513	-	111,513
19	52,310	-	-	52,310	21,457	#	-	21,461
20	-	-	-	-	#	-	-	#
21OFF	-	6,762	-	6,762	247	597	-	844
23IN	202,000	38,942	-	240,942	75,465	672	-	76,137
23OFF	387,000	336,000	-	723,000	552,000	263,000	-	815,000
24IN	148	#	-	6,624	#	-	-	#
25IN	#	#	-	449	-	#	-	#
26IN	-	-	-	-	#	#	-	#
27IN	#	-	-	#	5,139	-	-	5,139
27OFF	#	20,494	-	20,543	#	56,112	-	57,360
3IN	16,759	3,246	-	20,005	8,405	7,251	-	15,656
5IN	#	#	-	985	78	#	-	133
5OFF	-	#	-	#	-	#	-	#
6IN	2,167	9,952	-	12,119	1,057	11,821	-	12,878
6OFF	-	-	-	-	#	#	-	9,600
7IN	2,395	1,330	-	3,724	9,089	16,261	-	25,350
8IN	-	#	-	#	#	3,995	-	5,683
9IN	#	4,748	-	4,992	30,666	24,130	-	54,796
DXE	-	#	-	#	-	-	-	-
FR	88,780	#	1,191	90,653	131,000	#	-	131,095
GSTE	116,000	4,007	-	120,007	113,000	2,781	-	115,781
-none-	824	-	-	824	26	-	-	26
PRD	91,068	60,736	-	151,803	84,665	123,000	-	207,665
QCI	#	#	-	332	8,147	15,095	-	23,242
QCSND	#	600,000	9,433	609,499	11,849	881,000	-	892,849
All	**1,420,000**	**1,630,000**	**17,009**	**3,067,009**	**1,470,000**	**1,650,000**	**247**	**3,120,247**

Table 4. Shrimp fishery logbook effort data. The total number of hours fished is shown by SMA, year and gear. The column headers 97 U and 98 U represent unknown gear types.

SMA	97 Beam	97 Otter	97 U	98 Beam	98 Otter	98 U	All
10IN	175	-	-	7	1	-	183
11IN	0	-	-	75	-	-	75
124OFF	477	1,570	-	78	232	-	2,350
125OFF	14	493	-	8	906	-	1,420
126OFF	1	1	-	-	17	-	19
12IN	1,290	-	-	1,140	82	-	2,510
12OUT	962	-	-	933	13	-	1,910
14	2,290	296	78	4,940	244	9	7,860
17	886	13	-	999	-	-	1,900
18	3,010	21	113	4,070	162	-	7,370
19	1,220	1	-	533	2	-	1,760
20	-	-	-	4	-	-	4
21OFF	-	29	-	11	12	-	52
23IN	2,810	236	-	1,660	24	-	4,730
23OFF	4,240	1,390	-	7,990	1,800	-	15,400
24IN	21	31	-	10	-	-	62
25IN	33	1	-	-	3	-	36
26IN	-	-	-	0	18	-	18
27IN	144	-	-	166	-	-	310
27OFF	2	105	-	14	236	-	357
3IN	456	101	-	134	137	-	829
5IN	5	33	-	10	3	-	50
5OFF	-	7	-	-	2	-	9
6IN	134	493	-	115	282	-	1,020
6OFF	-	-	-	25	40	-	65
7IN	81	48	-	181	159	-	468
8IN	-	11	-	27	69	-	107
9IN	22	97	-	974	345	-	1,440
DXE	-	8	-	-	-	-	8
FR	6,330	115	31	7,690	10	-	14,200
GSTE	3,890	147	-	4,010	21	-	8,070
PRD	3,940	2,270	-	2,920	2,910	-	12,000
QCI	20	8	-	236	50	-	313
QCSND	6	2360	39	184	5,080	-	7,680
-none-	21	-	-	1	-	-	22
All	**32,500**	**9,890**	**261**	**39,100**	**12,900**	**9**	**94,600**

Table 5. Summary of the number of sets examined by observers on commercial vessels in 1997 and 1998 shown by Shrimp Management Area (SMA), year and gear.

	1997		**1998**		
SMA	**Beam**	**Otter**	**Beam**	**Otter**	**All**
PRD		90	15		105
7IN				4	4
9IN				10	10
QCSND		137	27	348	512
12IN	***108***		***69***	***2***	***179***
A12OUT	***22***		***2***		***24***
14	17	15	11		43
17		3		23	26
18	16		8	11	35
19	25			7	32
FR	27		8		35
GSTE	35				35
23IN	14	14	44		72
23OFF	62	32	62	4	160
124OF	6	57	2		65
125OF		18			18
27IN				1	1
27OFF				22	22
All	**332**	**366**	**248**	**432**	**1378**

Note: Some sets made in 'SMA 12' were research surveys and some data from these may not be comparable to data taken during commercial fisheries.

Table 6. List and percentage of total catch of all species captured in shrimp trawls examined by observers in 1997 and 1998, shown for 5 different sections of the BC coast, and the whole coast. The species are **ranked** from the most frequent (based on total coast) to the least frequent. The first 3 are 'target species'. The remainder are non-target species, except for those marked with an asterisk. The areas correspond to the Prince Rupert District (PRD), Central coast (7/9QCS), including areas 7, 9 and Queen Charlotte Sound, Northern Johnstone Strait (12), West Coast of Vancouver Island (WC), the Strait of Georgia (SOG) and the entire BC coast (ALL). Please see text for further explanation.

COMMON NAME	***Scientific Name***	***AREAS***					
		PRD	**7/9QCS**	**12**	**WC**	**SOG**	**ALL**
Target Species							
SMOOTH PINK SHRIMP	*Pandalus jordani*	1.8703	85.4397	0.3694	84.5603	16.4379	65.4250
PINK SHRIMP	*Pandalus borealis*	8.8311	0.1058	46.4480	0.0158	12.2791	6.5178
SIDESTRIPE SHRIMP	*Pandalopsis dispar*	46.1933	2.3996	12.3001	2.0607	9.3148	6.2561
Non-Target Species (except those marked *)							
EULACHON	*Thaleichthys pacificus*	0.4778	**6.4713**	0.1081	**2.3748**	0.0244	4.0240
UNKNOWN FISH		0.0000	0.1140	**15.9563**	0.2400	0.0000	1.7598
SPOTTED RATFISH	*Hydrolagus colliei*	**7.7497**	0.0320	**3.5113**	1.4380	**4.6547**	1.5306
PACIFIC HAKE	*Merluccius productus*	0.0963	0.5693	1.4965	1.8285	**6.1494**	1.4525
WALLEYE POLLOCK	*Theragra chalcogramma*	1.3745	0.4083	0.2387	0.4100	**10.1568**	1.4012
EELPOUTS	*Zoarcidae (family)*	2.4897	1.4750	1.0700	0.7707	1.3645	1.3276
ARROWTOOTH FLOUNDER	*Atheresthes stomias*	**5.1664**	0.9478	0.6144	0.5849	0.1582	0.9743
SPINY DOGFISH	*Squalus acanthias*	0.2133	0.0058	2.2600	0.3709	4.9278	0.8102
FLATHEAD SOLE	*Hippoglossoides elassodon*	**5.9868**	0.2516	1.4494	0.2406	0.6101	0.6994
*COON STRIPE SHRIMP	Pandalus danae	**0.0000*	*0.0045	*0.2007	*0.0191	*6.8130	*0.6988*
SLENDER SOLE	*Eopsetta exilis*	0.0973	0.4266	0.1020	0.4358	**3.6238**	0.6935
*HUMPBACK SHRIMP	Pandalus hypsinotus	**0.0136*	*0.0003	*5.4926	*0.0001	*0.3041	*0.5983*
ENGLISH SOLE	*Pleuronectes vetulus*	**3.0962**	0.0094	1.0035	0.2952	**2.4892**	0.5725
REX SOLE	*Errex zachirus*	0.9295	0.4582	0.3464	0.7658	0.3944	0.5281
PACIFIC HERRING	*Clupea pallasi*	0.6392	0.0111	0.0401	0.2438	**3.1843**	0.4071
SHINER PERCH	*Cymatogaster aggregata*	0.5846	0.0001	0.1558	0.2018	**2.6548**	0.3494
PRAWN	*Pandalus platycerous*	0.3946	0.0105	1.1638	0.1857	1.5484	0.3371
PLAINFIN MIDSHIPMAN	*Porichthys notatus*	0.0000	0.0001	0.0012	0.3376	2.2952	0.2965
	Pandalus goniurus	*0.0049	*0.0002	*2.5594	*0.0055	*0.1538	*0.2811
PACIFIC SANDDAB	*Citharichthys sordidus*	0.0000	0.0202	0.0020	0.6966	0.7975	0.2343
BIG SKATE	*Raja binoculata*	**4.0065**	0.0000	0.0000	0.0688	0.0407	0.2216
DOVER SOLE	*Microstomus pacificus*	**1.0045**	0.1054	0.1084	0.1982	0.3085	0.1906
SKATES	*Rajidae (family)*	0.3312	0.0000	0.4778	0.1513	0.8398	0.1804
LONGNOSE SKATE	*Raja rhina*	0.2689	0.0343	0.3219	0.3329	0.4033	0.1743
SCULPINS	*Cottidae (family)*	0.3308	0.0020	0.2400	0.0265	1.0383	0.1505
SQUAT SQUID	*Rossia pacifica*	0.0279	0.1855	0.0735	0.0550	0.0306	0.1236
SQUAT LOBSTER	*Munida quadrispina*	0.0000	0.0010	0.0040	0.0008	1.1371	0.1132
	Crangon spp	0.0238	0.0195	0.4973	0.0802	0.2449	0.1039
PACIFIC TOMCOD	*Microgadus proximus*	0.0000	0.0000	0.0250	0.0582	0.7547	0.0891
PANDALID SHRIMP	*Pandalidae (family)*	0.0000	0.0000	0.0000	0.1821	0.4648	0.0836
DUNGENESS CRAB	*Cancer magister*	**1.2548**	0.0000	0.0405	0.0091	0.0549	0.0752
PACIFIC HALIBUT	*Hippoglossus stenolepis*	**0.7410**	0.0193	0.0776	0.0000	0.1183	0.0677
POACHERS	*Agonidae (family)*	0.0103	0.0520	0.0129	0.0378	0.2882	0.0662
ROCK SOLE	*Pleuronectes bilineatus*	0.1274	0.0001	0.0786	0.0134	0.4913	0.0658
PACIFIC COD	*Gadus macrocephalus*	0.0967	0.0022	0.0446	0.0736	0.3533	0.0608
LONGFIN BATFISH	*Platax teira*	0.5647	0.0091	0.0037	0.0182	0.1959	0.0571
SEGMENTED WORMS	*Phylum annelida*	0.0000	0.0329	0.0000	0.0000	0.3833	0.0556
COPPER ROCKFISH	*Sebastes caurinus*	**1.0128**	0.0000	0.0000	0.0000	0.0079	0.0522
SEA CUCUMBERS	*Holothuroidea (class)*	0.3724	0.0546	0.0004	0.0056	0.0144	0.0510
SABLEFISH	*Anoplopoma fimbria*	0.6744	0.0053	0.0375	0.0183	0.0000	0.0447

COMMON NAME	Scientific Name	AREAS					
		PRD	7/9QCS	12	WC	SOG	ALL
HEART URCHINS	*Atelostomata (superorder)*	0.0103	0.0001	0.0008	0.0241	0.3936	0.0445
FLATFISHES	*Pleuronectiformes (order)*	0.0000	0.0248	0.1447	0.0000	0.1627	0.0444
PACIFIC OCEAN PERCH	*Sebastes alutus*	0.2461	0.0586	0.0000	0.0010	0.0000	0.0443
JELLYFISH	*Scyphozoa (class)*	0.0595	0.0268	0.0012	0.0249	0.2180	0.0443
SQUID	*Teuthoidea (order)*	0.2055	0.0065	0.0026	0.0282	0.1959	0.0394
SHRIMP	*Nantantia (order)*	0.0379	0.0005	0.0603	0.0720	0.1337	0.0365
SEA URCHINS	*Echinacea (superorder)*	0.0041	0.0295	0.1353	0.0006	0.0061	0.0308
SHORTSPINE THORNYHEAD	*Sebastolobus alascanus*	0.0016	0.0508	0.0000	0.0000	0.0042	0.0279
STARFISH	*Asteroidea (class)*	0.1435	0.0081	0.0649	0.0017	0.0737	0.0260
PETRALE SOLE	*Eopsetta jordani*	0.0000	0.0147	0.0000	0.0758	0.0089	0.0246
GLASS SHRIMP	*Pasiphaea pacifica*	0.0000	0.0076	0.1436	0.0010	0.0439	0.0235
STARRY FLOUNDER	*Platichthys stellatus*	0.0968	0.0000	0.1693	0.0000	0.0028	0.0227
REDSTRIPE ROCKFISH	*Sebastes proriger*	0.3553	0.0041	0.0062	0.0056	0.0019	0.0222
YELLOWMOUTH ROCKFISH	*Sebastes reedi*	0.4319	0.0000	0.0000	0.0000	0.0000	0.0219
GREENSTRIPED ROCKFISH	*Sebastes elongatus*	0.0000	0.0000	0.0004	0.0031	0.2099	0.0214
DARKBLOTCHED ROCKFISH	*Sebastes crameri*	0.2056	0.0163	0.0000	0.0032	0.0057	0.0204
SPLITNOSE ROCKFISH	*Sebastes diploproa*	0.0000	0.0162	0.0055	0.0020	0.1041	0.0200
SAND SOLE	*Psettichthys melanostictus*	0.0000	0.0035	0.0843	0.0051	0.0744	0.0190
YELLOWTAIL ROCKFISH	*Sebastes flavidus*	0.1340	0.0033	0.0125	0.0373	0.0000	0.0176
ANEMONE	*Actiniaria (order)*	0.1306	0.0000	0.0229	0.0125	0.0425	0.0158
QUILLBACK ROCKFISH	*Sebastes maliger*	0.0298	0.0000	0.0038	0.0231	0.0917	0.0157
SPONGES	*Phylum porifera*	0.2979	0.0000	0.0000	0.0000	0.0004	0.0152
OCTOPUS	*Octopoda (order)*	0.0496	0.0023	0.0287	0.0270	0.0274	0.0150
LINGCOD	*Ophiodon elongatus*	0.0000	0.0018	0.0000	0.0314	0.0706	0.0144
SCALLOP	*Pectinidae (family)*	0.0000	0.0001	0.0008	0.0007	0.1323	0.0133
CHINOOK SALMON	*Oncorhynchus tshawytscha*	0.0000	0.0000	0.0000	0.0437	0.0325	0.0123
ROUGHEYE ROCKFISH	*Sebastes aleutianus*	0.0842	0.0120	0.0000	0.0000	0.0000	0.0107
SHORTRAKER ROCKFISH	*Sebastes borealis*	0.2011	0.0008	0.0000	0.0000	0.0000	0.0106
	Eualus spp	0.0000	0.0016	0.0605	0.0040	0.0228	0.0102
OARFISH	*Regalecus glesne*	0.0000	0.0000	0.0000	0.0000	0.1016	0.0100
SMELTS	*Osmeridae (family)*	0.0000	0.0000	0.0000	0.0412	0.0008	0.0086
SCORPIONFISHES	*Scorpaenidae (family)*	0.0238	0.0016	0.0008	0.0087	0.0216	0.0061
PACIFIC SANDFISH	*Trichodon trichodon*	0.0000	0.0000	0.0000	0.0282	0.0000	0.0059
PRICKLEBACKS	*Stichaeidae (family)*	0.0000	0.0000	0.0058	0.0010	0.0494	0.0057
REDBANDED ROCKFISH	*Sebastes babcocki*	0.0000	0.0083	0.0018	0.0000	0.0000	0.0047
	Crangon communis	0.0000	0.0000	0.0407	0.0000	0.0000	0.0042
TANNER CRABS	*Chionoecetes spp*	0.0745	0.0000	0.0000	0.0000	0.0000	0.0038
PACIFIC SARDINE	*Sardinops sagax*	0.0000	0.0028	0.0000	0.0091	0.0008	0.0035
SNAILFISHES	*Liparinae (subfamily)*	0.0000	0.0000	0.0000	0.0000	0.0338	0.0033
OPAL SQUID	*Loligo opalescens*	0.0000	0.0001	0.0000	0.0149	0.0000	0.0031
BLUESPOT SHRIMP	*Pandalus stenolepsis*	0.0000	0.0000	0.0250	0.0007	0.0004	0.0028
	Crangonidae (family)	0.0000	0.0000	0.0250	0.0000	0.0000	0.0026
KELP POACHER	*Agonomalus mozinoi*	0.0000	0.0000	0.0000	0.0000	0.0249	0.0025
PILE PERCH	*Rhacochilus vacca*	0.0000	0.0000	0.0000	0.0031	0.0173	0.0024
BUTTER SOLE	*Pleuronectes isolepis*	0.0000	0.0000	0.0000	0.0000	0.0232	0.0023
PEANUTWORMS	*Phylum sipuncuida*	0.0041	0.0000	0.0000	0.0000	0.0190	0.0021
CORMORANTS	*Family phalacrocoracidae*	0.0000	0.0000	0.0000	0.0100	0.0000	0.0021
NORTHERN ANCHOVY	*Engraulis mordax mordax*	0.0000	0.0000	0.0000	0.0092	0.0004	0.0020
SPECKLED SANDDAB	*Citharichthys stigmaeus*	0.0000	0.0000	0.0000	0.0027	0.0127	0.0018
BIVALVES	*Bivalvia (class)*	0.0021	0.0015	0.0012	0.0024	0.0021	0.0017
YELLOWLEG SHRIMP	*Pandalus montaqui tridens*	0.0000	0.0000	0.0000	0.0002	0.0165	0.0017
SILVERGRAY ROCKFISH	*Sebastes brevispinis*	0.0000	0.0023	0.0000	0.0000	0.0030	0.0015
SEA PENS	*Pennatulacea (order)*	0.0298	0.0000	0.0000	0.0000	0.0000	0.0015
SHARPCHIN ROCKFISH	*Sebastes zacentrus*	0.0000	0.0007	0.0004	0.0035	0.0032	0.0015
SMOOTHHEAD SCULPIN	*Artedius lateralis*	0.0261	0.0000	0.0000	0.0000	0.0000	0.0013
	Ophiuroidea (class)	0.0041	0.0011	0.0000	0.0013	0.0000	0.0011
DWARF WRYMOUTHS	*Cryptacanthodes aleutensis*	0.0000	0.0008	0.0000	0.0006	0.0040	0.0010
GREENLINGS	*Hexagrammidae (family)*	0.0149	0.0000	0.0016	0.0002	0.0000	0.0010

COMMON NAME	Scientific Name	AREAS					
		PRD	7/9QCS	12	WC	SOG	ALL
	Repiantia (suborder)	0.0000	0.0000	0.0000	0.0000	0.0096	0.0009
WHITEBAIT SMELT	*Allosmerus elongatus*	0.0000	0.0000	0.0000	0.0042	0.0000	0.0009
BRITTLE STARS	*Ophiurae (order)*	0.0062	0.0001	0.0000	0.0010	0.0032	0.0009
SPIDER CRABS	*Oxyrhyncha (superfamily)*	0.0000	0.0000	0.0018	0.0000	0.0063	0.0008
CABEZON	*Scorpaenichthys marmoratus*	0.0000	0.0000	0.0000	0.0000	0.0081	0.0008
	Cephalopoda (family)	0.0025	0.0000	0.0000	0.0028	0.0008	0.0008
YELLOWEYE ROCKFISH	*Sebastes ruberrimus*	0.0000	0.0000	0.0000	0.0000	0.0077	0.0008
SMOOTH LUMPSUCKER	*Aptocyclus ventricosus*	0.0000	0.0000	0.0000	0.0000	0.0072	0.0007
STONY CORALS	*Madreporia (order)*	0.0016	0.0000	0.0055	0.0000	0.0000	0.0007
SEASLUGS	*Nudibranchiata (suborder)*	0.0000	0.0000	0.0000	0.0009	0.0046	0.0006
GRENADIERS	*Macrouridae (family)*	0.0000	0.0000	0.0055	0.0000	0.0000	0.0006
JACK MACKEREL	*Trachurus symmetricus*	0.0000	0.0000	0.0000	0.0027	0.0000	0.0006
HYDROID	*Hydrozoa (class)*	0.0107	0.0000	0.0000	0.0000	0.0000	0.0005
GIANT WRYMOUTH	*Cryptacanthodes gigantea*	0.0000	0.0010	0.0000	0.0000	0.0000	0.0005
GUNNELS	*Pholidae (family)*	0.0000	0.0004	0.0000	0.0000	0.0025	0.0005
GHOST SHRIMP	*Upogebiinae (subfamily)*	0.0025	0.0000	0.0004	0.0012	0.0004	0.0005
CANARY ROCKFISH	*Sebastes pinniger*	0.0000	0.0000	0.0000	0.0021	0.0000	0.0004
CHITONS	*Polyplacophora (subclass)*	0.0000	0.0008	0.0000	0.0000	0.0000	0.0004
	Invertebrates	0.0000	0.0005	0.0000	0.0008	0.0000	0.0004
SPINY SIDE SHRIMP	*Lebbeus groenlandicus*	0.0000	0.0000	0.0004	0.0000	0.0038	0.0004
SEA MOUSE	*Aphrodita spp*	0.0000	0.0000	0.0000	0.0000	0.0042	0.0004
CANCER CRABS	*Cancridae (family)*	0.0000	0.0000	0.0000	0.0000	0.0038	0.0004
THREESPINE STICKLEBACK	*Gasterosteus aculeatus*	0.0000	0.0000	0.0000	0.0000	0.0038	0.0004
WIDOW ROCKFISH	*Sebastes entomelas*	0.0000	0.0007	0.0000	0.0000	0.0000	0.0004
GASTROPODS	*Gastropoda (class)*	0.0016	0.0004	0.0000	0.0000	0.0011	0.0004
DECORATOR CRAB	*Oregonia gracilis*	0.0000	0.0000	0.0000	0.0000	0.0038	0.0004
STURGEON POACHER	*Podathecus acipenserinus*	0.0000	0.0007	0.0000	0.0000	0.0000	0.0004
ROCKFISHES	*Sebastinae (subfamily)*	0.0000	0.0000	0.0000	0.0005	0.0025	0.0004
BOCACCIO	*Sebastes paucispinis*	0.0000	0.0002	0.0000	0.0011	0.0000	0.0003
LUMPFISHES/SNAILFISHES	*Cyclopteridae (family)*	0.0000	0.0000	0.0000	0.0009	0.0013	0.0003
	Phylum arthropoda	0.0000	0.0004	0.0000	0.0002	0.0004	0.0003
HARLEQUIN ROCKFISH	*Sebastes variegatus*	0.0000	0.0002	0.0000	0.0002	0.0013	0.0002
GREEN URCHIN	*Strongylocentrotus*	0.0000	0.0000	0.0000	0.0000	0.0025	0.0002
	Chionoecetes tanneri	0.0000	0.0000	0.0000	0.0000	0.0021	0.0002
RED ROCK CRAB	*Cancer productus*	0.0000	0.0000	0.0000	0.0000	0.0021	0.0002
	Chionoecetes bairdi	0.0037	0.0000	0.0000	0.0000	0.0000	0.0002
BOX CRABS	*Lopholithodes spp*	0.0000	0.0000	0.0000	0.0000	0.0019	0.0002
PINK SALMON	*Oncorhynchus gorbuscha*	0.0037	0.0000	0.0000	0.0000	0.0000	0.0002
RED IRISH LORD	*Hemilepidotus hemilepidotus*	0.0037	0.0000	0.0000	0.0000	0.0000	0.0002
	Heptacarpus kincaipi	0.0000	0.0000	0.0018	0.0000	0.0000	0.0002
WRYMOUTHS	*Cryptacanthodidae (family)*	0.0000	0.0000	0.0000	0.0005	0.0008	0.0002
	Spirontocaris spp	0.0000	0.0000	0.0000	0.0000	0.0017	0.0002
BLACK HAGFISH	*Eptatretus deani*	0.0000	0.0000	0.0000	0.0008	0.0000	0.0002
ROCKHEAD	*Bothragonus swani*	0.0000	0.0000	0.0000	0.0000	0.0017	0.0002
	Anomura (section)	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001
REDCLAW CRAB	*Chorilia longipes*	0.0000	0.0000	0.0000	0.0000	0.0013	0.0001
SAND DOLLARS	*Gnathostomata (superorder)*	0.0000	0.0000	0.0000	0.0006	0.0000	0.0001
SPIKE SHRIMP	*Paracrangon echinata*	0.0000	0.0000	0.0000	0.0000	0.0013	0.0001
STURGEONS	*Acipenseridae (family)*	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001
AMPHIPODS	*Amphipoda (order)*	0.0000	0.0000	0.0000	0.0005	0.0000	0.0001
LUMPFISHES	*Cyclopterinae (subfamily)*	0.0000	0.0000	0.0000	0.0005	0.0000	0.0001
PACIFIC HAGFISH	*Eptatretus stouti*	0.0000	0.0000	0.0000	0.0005	0.0000	0.0001
POLYCHAETE WORMS	*Polychaeta (class)*	0.0000	0.0000	0.0000	0.0000	0.0011	0.0001
	Spirontocaris prionota	0.0000	0.0000	0.0000	0.0000	0.0008	0.0001
CRUSTACEANS	*Crustacea (class)*	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001
LEFTEYE FLOUNDERS	*Bothidae (family)*	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001
PROWFISH	*Zaprora silenus*	0.0000	0.0000	0.0000	0.0000	0.0008	0.0001
THORNYHEADS	*Sebastolobinae (subfamily)*	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001

COMMON NAME	Scientific Name	AREAS					
		PRD	7/9QCS	12	WC	SOG	ALL
TUBE WORMS	*Sedentaria (subclass)*	0.0000	0.0000	0.0000	0.0004	0.0000	0.0001
FISH EGGS		0.0008	0.0000	0.0000	0.0000	0.0000	0.0000
	Pugettia gracilis	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
ANCHOVIES	*Engraulidae (family)*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
BARNACLES	*Cirripedia (subclass)*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
BASKET STARS	*Euryalae (order)*	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000
BIGFIN LANTERNFISH	*Symbolophorus californiensis*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
C-O SOLE	*Pleuronichthys coenosus*	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
CHUB MACKEREL	*Scomber japonicus*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
ECHINODERMS	*Phylum echinodermata*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
GIANT SQUID	*Moroteuthis robusta*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
LARGESCALE SUCKER	*Catostomus macrocheilus*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
MUSSELS	*Mytilidae (family)*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
PYGMY POACHER	*Odontopyxis trispinosa*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
QUILLFISH	*Ptilichthyidae (family)*	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000
RAGFISHES	*Icosteidae (family)*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
RED SQUID	*Berryteuthis magister*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
SAILFIN SCULPIN	*Nautichthys oculofasciatus*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
SEA LILIES/FEATHER STARS	*Crinodea (class)*	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
SEPIOLEA AND CUTTLEFISH	*Sepiodea (order)*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
TOAD CRAB	*Hyas lyratus*	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000
BROWN BULLHEAD	*Ameiurus nebulosus*	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MISSING SAMPLE		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 7. Summary of the different bycatch estimates, by Shrimp Management Area (SMA), year and gear. The SMA is abbreviated as shown in Table 1. Large discrepancies between the MI-ratio and PI-ratio are underlined. The two lines indicated with an asterisk are from special research surveys and the data are not strictly comparable.

SMA	Number of Sets	Cumulative hours towed (h)	Avg. Tow duration (h)	Total Bycatch (kg)	Eulachon Bycatch (kg)	Shrimp Catch (kg)	Mean Catch Rates Eulachon (Kg/h)	Mean Catch Rates Non-Target (Kg/h)	Mean Catch Rates Shrimp (Kg/h)	Mean Catch Ratios *MI-ratio*	Mean Catch Ratios *PI-ratio*	Pooled Catch Rates PPE-rate	Pooled Catch Rates PPS-rate	Pooled Catch Rates PPN-rate
1997 Beam Trawl														
12IN	108	89.23	0.8262	3719.97	1.250	7581.93	0.017	61.28	141.06	0.156	0.0165	0.01	84.97	41.69
*A12OUT	22	9.13	0.4150	1042.40	0.100	541.93	0.009	117.79	55.82	0.075	0.0185	0.01	59.36	114.17
23IN	14	32.83	2.3450	602.46	24.330	2440.29	0.600	17.22	65.56	0.901	0.9970	0.74	74.33	18.35
23OFF	62	116.53	1.8795	1470.16	240.040	6050.31	1.990	13.15	50.13	4.610	3.9674	2.06	51.92	12.62
124OF	6	14.87	2.4783	256.01	2.010	1572.27	0.137	16.28	104.12	0.138	0.1278	0.14	105.73	17.22
14	17	29.58	1.7400	666.88	0.900	796.09	0.036	21.78	27.72	0.044	0.1131	0.03	26.91	22.54
18	16	20.59	1.3727	190.33	0.000	1047.11	0.000	9.78	53.07	0.000	0.0000	0.00	50.86	9.24
19	25	34.53	1.3812	920.44	0.000	1281.23	0.000	31.02	35.63	0.000	0.0000	0.00	37.10	26.66
GSTE	35	64.03	1.8832	1175.71	0.100	1858.93	0.001	17.70	35.34	0.021	0.0054	0.00	29.03	18.36
FR	27	23.16	1.9300	320.26	0.000	238.63	0.000	24.11	11.31	0.000	0.0000	0.00	10.30	13.83
1998 Beam trawl														
PRD	15	28.59	1.9060	809.32	3.160	716.71	0.108	26.50	25.84	0.682	0.4409	0.11	25.07	28.31
QCSND	27	54.32	2.0119	460.80	181.920	4499.00	3.433	8.69	80.48	4.464	4.0436	3.35	82.82	8.48
12IN	69	51.25	0.7428	2570.89	7.750	8363.26	0.253	76.15	222.69	0.441	0.0927	0.15	163.19	50.16
*A12OUT	2	1.00	0.5000	175.00	0.000	45.00	0.000	175.00	45.00	0.000	0.0000	0.00	45.00	175.00
23IN	44	54.88	1.2473	449.07	13.650	2161.37	0.348	10.41	46.68	0.865	0.6315	0.25	39.38	8.18
23OFF	62	99.97	1.6124	543.37	41.720	2957.84	0.408	9.82	30.07	6.614	1.4105	0.42	29.59	5.44
124OF	2	2.38	1.1900	6.55	0.000	0.00	0.000	3.17	0.00	--	--	0.00	0.00	2.75
14	11	19.50	1.7727	136.90	0.000	450.90	0.000	6.02	25.93	0.000	0.0000	0.00	23.12	7.02
18	8	15.00	1.8750	514.50	0.000	332.00	0.000	34.29	24.15	0.000	0.0000	0.00	22.13	34.30
FR	8	20.29	2.5362	276.20	0.000	420.80	0.000	15.29	19.75	0.000	0.0000	0.00	20.74	13.61
1997 Otter trawl														
PRD	90	109.34	1.2149	4264.62	46.750	5843.43	0.511	64.68	54.95	1.283	0.8000	0.43	53.44	39.00
QCSND	137	262.90	1.9190	9555.86	6753.620	40064.12	25.771	35.78	150.96	21.212	16.857	25.6	152.39	36.35
23IN	14	23.09	1.7762	401.32	170.110	2562.72	11.213	21.32	122.92	6.465	6.6379	7.37	110.99	17.38
23OFF	32	46.91	1.4659	700.07	269.880	5976.80	5.818	13.30	137.20	4.716	4.5155	5.75	127.41	14.92
124OF	57	102.01	1.7896	887.96	130.030	12627.02	1.445	8.99	122.96	5.253	1.0298	1.27	123.78	8.70
125OF	18	17.76	0.9867	73.03	43.100	1402.99	2.366	4.77	71.60	17.171	3.0720	2.43	79.00	4.11
14	15	16.17	1.0780	169.62	1.350	1319.21	0.077	10.31	81.73	0.148	0.1023	0.08	81.58	10.49
17	3	3.62	1.2067	177.00	0.000	21.72	0.000	53.00	6.65	0.000	0.0000	0.00	6.00	48.90
1998 Otter Trawl														
7IN	4	2.00	0.5000	42.10	0.400	124.00	0.205	20.29	57.72	1.590	0.3226	0.20	62.00	21.05
9IN	10	4.78	0.4780	101.30	2.600	543.10	0.520	20.80	112.74	0.471	0.4787	0.54	113.62	21.19
QCSND	348	575.24	1.6530	5441.66	1447.510	68756.59	3.974	11.51	114.43	9.478	2.1053	2.52	119.53	9.46
12IN	2	2.75	1.3750	289.65	17.700	458.65	6.200	108.60	163.93	3.611	3.8592	6.44	166.78	105.33
23OFF	4	8.00	2.0000	52.96	38.720	342.56	4.825	6.52	41.43	16.368	11.303	4.84	42.82	6.62
27IN	1	0.95	0.9500	18.14	0.000	4.54	0.000	19.09	4.78	0.000	0.0000	0.00	4.78	19.09
27OFF	22	21.65	0.9841	322.78	15.070	1789.89	0.594	13.48	80.40	0.765	0.8420	0.70	82.67	14.91
17	23	11.38	0.4948	2022.70	2.800	260.30	0.243	176.39	22.77	0.417	1.0757	0.25	22.87	177.74
18	11	5.25	0.4773	1465.50	0.400	68.20	0.091	272.29	12.80	1.924	0.5865	0.08	12.99	279.14
19	7	3.50	0.5000	1179.90	0.200	198.70	0.057	337.11	56.77	0.340	0.1007	0.06	56.77	337.11

Table 8. Estimates of eulachon bycatch from the 1997 and 1998 shrimp fisheries. Total hours fished (h), mean eulachon catch rates (kg/h) and estimated eulachon bycatch (kg) are shown for each Shrimp Management Area (SMA), year and gear. Asterisks indicate no observer estimates. Columns with zero's indicate that the eulachon bycatch was zero.

	Beam Trawl 1997			Otter Trawl 1997			Beam Trawl 1998			Otter Trawl 1998		
SMA	**Hours Fished** (h)	**Catch Rate** (kg/h)	**Eulachon Bycatch** (kg)	**Hours Fished** (h)	**Catch Rate** (kg/h)	**Eulachon Bycatch** (kg)	**Hours Fished** (h)	**Catch Rate** (kg/h)	**Eulachon Bycatch** (kg)	**Hours Fished** (h)	**Catch Rate** (kg/h)	**Eulachon Bycatch** (kg)
10IN	175	*	*	0	*	*	7	*	*	1	*	*
11IN	0	*	*	0	*	*	75	*	*	0	*	*
124OFF	477	0.137	**65.35**	1570	1.445	**2268.7**	78	0.000	0.00	232	*	*
125OFF	14	*	*	493	2.366	**1166.4**	8	*	*	906	*	*
126OFF	1	*	*	1	*	*	0	*	*	17	*	*
12IN	1290	0.017	**21.93**	0	*	*	1140	0.253	**288.42**	82	6.200	**508.4**
12OUT	962	*	*	0	*	*	933	*	*	13	*	*
14	2290	0.036	**82.44**	296	0.077	**22.8**	4940	0.000	0.00	244	*	*
17	886	*	*	13	0.000	0.0	999	*	*	0	0.243	0.0
18	3010	0.000	0.00	21	*	*	4070	0.000	0.00	162	0.091	**14.7**
19	1220	0.000	0.00	1	*	*	533	*	*	2	0.057	0.1
20	0	*	*	0	*	*	4	*	*	0	*	*
21OFF	0	*	*	29	*	*	11	*	*	12	*	*
23IN	2810	0.600	**1686.00**	236	11.213	**2646.3**	1660	0.348	**577.68**	24	*	*
23OFF	4240	1.990	**8437.60**	1390	5.818	**8087.0**	7990	0.408	**3259.92**	1800	4.825	**8685.0**
24IN	21	*	*	31	*	*	10	*	*	0	*	*
25IN	33	*	*	1	*	*	0	*	*	3	*	*
26IN	0	*	*	0	*	*	0	*	*	18	*	*
27IN	144	*	*	0	*	*	166	*	*	0	0.000	0.0
27OFF	2	*	*	105	*	*	14	*	*	236	0.594	**140.2**
3IN	456	*	*	101	*	*	134	*	*	137	0.205	**28.1**
5IN	5	*	*	33	*	*	10	*	*	3	0.520	1.6
5OFF	0	*	*	7	*	*	0	*	*	2	*	*
6IN	134	*	*	493	*	*	115	*	*	282	*	*
6OFF	0	*	*	0	*	*	25	*	*	40	*	*
7IN	81	*	*	48	*	*	181	*	*	159	3.974	**631.9**
8IN	0	*	*	11	*	*	27	*	*	69	*	*
9IN	22	*	*	97	*	*	974	*	*	345	*	*
DXE	0	*	*	8	*	*	0	*	*	0	*	*
FR	6330	0.000	0.00	115	*	*	7690	0.000	0.00	10	*	*
GSTE	3890	0.001	**3.89**	147	*	*	4010	*	*	21	*	*
-none-	21	*	*	0	*	*	1	*	*	0	*	*
PRD	3940	*	*	2270	0.511	**1160.0**	2920	0.108	**315.36**	2910	*	*
QCI	20	*	*	8	*	*	236	*	*	50	*	*
QCSND	6	*	*	2360	25.771	**60819.6**	184	3.433	**631.67**	5080	3.974	**20187.9**
Sums:			***10297***			***76171***			***5073***			***30198***

Table 9a. Summary of the hailed shrimp catches (kg) and the estimated eulachon bycatch (kg - bold italics) in **Otter trawls** corresponding to the mean and pooled in-season catch ratios (MI-ratio and PI-ratio). To comply with confidentiality requirements catches in some areas cannot be shown and are indicated by the number symbol (#).

	1997	**Otter Trawl**				**1998**	**Otter Trawl**			
SMA	Hailed Shrimp Catch	MI-ratio	PI-ratio	***Eulachon Bycatch (MI-ratio)***	***Eulachon Bycatch (PI-ratio)***	Hailed Shrimp Catch	MI-ratio	PI-Ratio	***Eulachon Bycatch (MI-ratio)***	***Eulachon Bycatch (PI-ratio)***
10IN	0					0	0	0	***0***	***0***
11IN	0					0	0	0	***0***	***0***
124OFF	355,811	5.253	1.0298	***18691***	***3664***	32,186	0	0	***0***	***0***
125OFF	#	17.171	3.072	***2792***	***499***	187,788	0	0	***0***	***0***
126OFF	#	0	0	***0***	***0***	#	0	0	***0***	***0***
12IN	0	0	0	***0***	***0***	9,169	3.611	3.8592	***331***	***354***
12OUT	0	0	0	***0***	***0***	0	0	0	***0***	***0***
14	10,137	0.148	0.1023	***15***	***10***	15,525	0	0	***0***	***0***
17	#	0	0	***0***	***0***	0	0.417	1.0757	***0***	***0***
18	#	0	0	***0***	***0***	2,678	1.924	0.5865	***52***	***16***
19	#	0	0	***0***	***0***	#	0.34	0.1007	***0***	***0***
20	0	0	0	***0***	***0***	0	0	0	***0***	***0***
21OFF	0	0	0	***0***	***0***	0	0	0	***0***	***0***
23IN	29,396	6.465	6.6379	***1900***	***1951***	#	0	0	***0***	***0***
23OFF	311,885	4.716	4.5155	***14709***	***14083***	277,644	16.368	11.3031	***45445***	***31382***
24IN	#	0	0	***0***	***0***	0	0	0	***0***	***0***
25IN	#	0	0	***0***	***0***	#	0	0	***0***	***0***
26IN	0	0	0	***0***	***0***	#	0	0	***0***	***0***
27IN	0	0	0	***0***	***0***	#	0	0	***0***	***0***
27OFF	#	0	0	***0***	***0***	47,693	0.765	0.842	***365***	***402***
3IN	#	0	0	***0***	***0***	2,940	0	0	***0***	***0***
5IN	#	0	0	***0***	***0***	4,679	0	0	***0***	***0***
6IN	7,709	0	0	***0***	***0***	8,079	0	0	***0***	***0***
6OFF	0	0	0	***0***	***0***	25,594	0	0	***0***	***0***
7IN	#	0	0	***0***	***0***	4,222	1.59	0.3226	***67***	***14***
8IN	#	0	0	***0***	***0***	#	0	0	***0***	***0***
9IN	#	0	0	***0***	***0***	17,501	0.471	0.4787	***82***	***84***
DXE	0	0	0	***0***	***0***	0	0	0	***0***	***0***
FR	#	0	0	***0***	***0***	0	0	0	***0***	***0***
GSTE	#	0	0	***0***	***0***	#	0	0	***0***	***0***
PRD	34,606	1.283	0.8	***444***	***277***	87,139	0	0	***0***	***0***
QCI	0	0	0	***0***	***0***	15,843	0	0	***0***	***0***
QCSND	478,290	21.212	16.857	***101455***	***80625***	848,478	9.478	2.1053	***80419***	***17863***
	Total Catch			***140005***	***101109***	**Total Catch**			***126761***	***50114***

Table 9b. Summary of the hailed shrimp catches (kg) and the estimated eulachon bycatch (kg - bold italics) in **Beam** trawls corresponding to the mean and pooled in-season catch ratios (MI-ratio and PI-ratio). To comply with confidentiality requirements catches in some areas cannot be shown and are indicated by the number symbol (#).

	1997 Beam					**1998 Beam**				
SMA	Hailed Shrimp Catch	MI-ratio	PI-ratio	***Eulachon Bycatch (MI-ratio)***	***Eulachon Bycatch (PI-ratio)***	Hailed Shrimp Catch	MI-ratio	PI-ratio	***Eulachon Bycatch (MI-ratio)***	***Eulachon Bycatch (PI-ratio)***
10IN	9,050	0.0000	0.0000	***0***	***0***	346	0	0	***0***	***0***
11IN	#	0.0000	0.0000	***0***	***0***	#	0	0	***0***	***0***
124OFF	#	0.1380	0.1278	***13***	***12***	0	0	0	***0***	***0***
125OFF	#	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
126OFF	0	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
12IN	94,393	0.1560	0.1650	***147***	***156***	165,539	0.441	0.0927	***730***	***153***
12OUT	17,551	0.0185	0.0185	***3***	***3***	10,380	0	0	***0***	***0***
14	31,485	0.0440	0.1131	***14***	***36***	74,860	0	0	***0***	***0***
17	7,760	0.0000	0.0000	***0***	***0***	11,844	0	0	***0***	***0***
18	46,024	0.0000	0.0000	***0***	***0***	73,895	0	0	***0***	***0***
19	24,192	0.0210	0.0054	***5***	***1***	19,242	0	0	***0***	***0***
20	0	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
21OFF	0	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
23IN	123,508	0.9010	0.9970	***1113***	***1231***	63,388	0.865	0.6315	***548***	***400***
23OFF	421,678	4.6100	3.9674	***19439***	***16730***	592,696	6.614	1.4105	***39201***	***8360***
24IN	217	0.0000	0.0000	***0***	***0***	#	0	0	***0***	***0***
25IN	#	0.0000	0.0000	***0***	***0***	#	0	0	***0***	***0***
26IN	0	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
27IN	0	0.0000	0.0000	***0***	***0***	#	0	0	***0***	***0***
27OFF	0	0.0000	0.0000	***0***	***0***	1,580	0	0	***0***	***0***
3IN	10,541	0.0000	0.0000	***0***	***0***	3,246	0	0	***0***	***0***
5IN	#	0.0000	0.0000	***0***	***0***	854	0	0	***0***	***0***
6IN	#	0.0000	0.0000	***0***	***0***	#	0	0	***0***	***0***
6OFF	0	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
7IN	1,155	0.0000	0.0000	***0***	***0***	7,063	0	0	***0***	***0***
8IN	#	0.0000	0.0000	***0***	***0***	2,365	0	0	***0***	***0***
9IN	0	0.0000	0.0000	***0***	***0***	24,590	0	0	***0***	***0***
DXE	#	0.0000	0.0000	***0***	***0***	0	0	0	***0***	***0***
FR	67,598	0.0000	0.0000	***0***	***0***	142,712	0	0	***0***	***0***
GSTE	66,012	0.0210	0.0054	***14***	***4***	97,425	0	0	***0***	***0***
PRD	39,019	0.0000	0.0000	***0***	***0***	70,119	0.682	0.4409	***478***	***309***
QCI	0	0.0000	0.0000	***0***	***0***	9,151	0	0	***0***	***0***
QCSND	0	0.0000	0.0000	***0***	***0***	6,686	4.464	4.0436	***298***	***270***
	Total Catch			***20748***	***18172***	***Total Catch***			***41256***	***9493***

Figure 1 in Separate File. See file, “Fig_1.PDF

Fig. 2. Comparison of the mean in-season catch ratio (MI-ratio) versus the pooled in-season catch ratio (PI-ratio) for eulachons. Each point represents the estimated bycatch of eulachons for the same ‘area-gear-year’ combination representing one SMA (Shrimp Management Area), gear type (otter or beam trawl) and year (1997 or 1998). Points close to the dotted line show close agreement between the 2 estimates. The data labels indicate each ‘area-gear-year’. The small letter is either an ‘o’ for ‘otter’ or ‘b’ for ‘beam’. The next number is either a ‘7’ or ‘8’ for ‘1997 or 1998’; the next letters indicate the SMA. The cluster of points and data labels close to the origin cannot be differentiated. Nearly every MI-ratio point is above the line, indicating that MI-ratio estimates (based on the means of individual tows) are higher than PI-ratio estimates those based on the sums of catches aggregated over the season, for each SMA and gear.

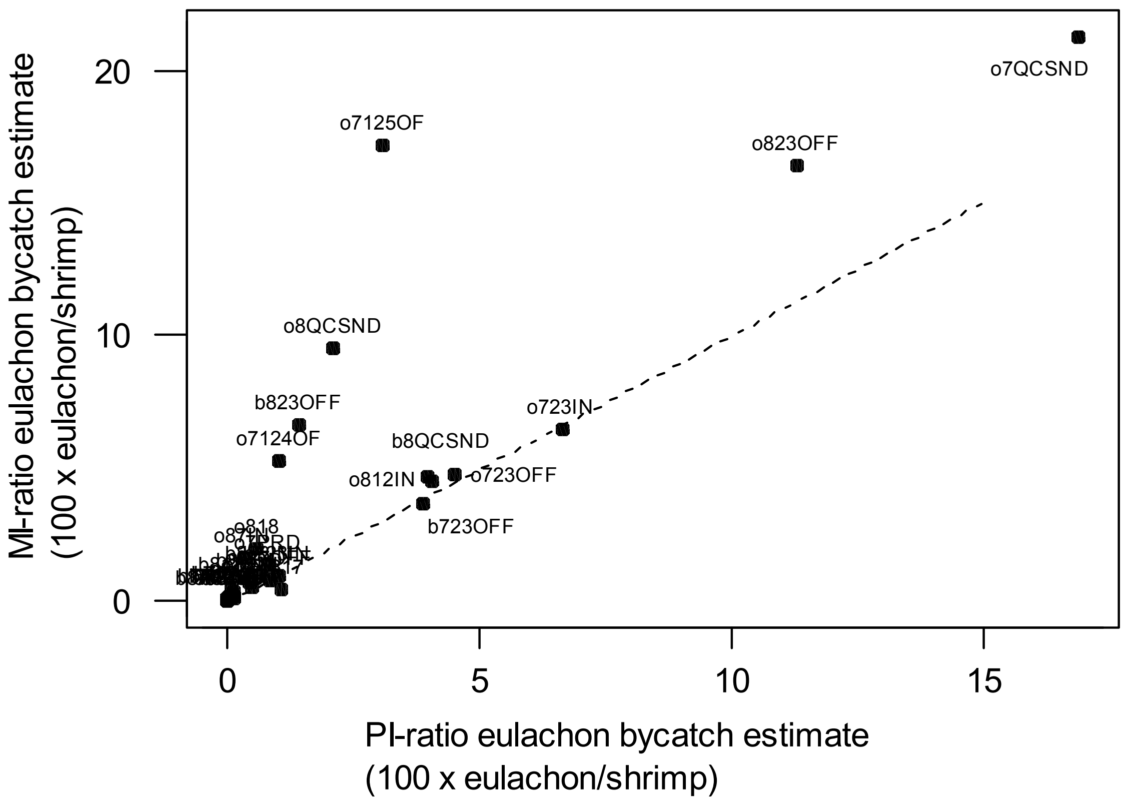


Fig. 3ab. Comparison of bycatch ratios and rates. The MI-ratio (mean in-season catch ratio) versus the MP-rate (mean post-season catch rate) in Fig 3a and PI-ratio versus the PP-rate (post-season catch rate) in Fig 3b. Each point represents the estimated bycatch of eulachons for the same 'area-gear-year' combination representing one SMA (Shrimp Management Area), gear type (otter or beam trawl) and year (1997 or 1998). Points close to the dotted line show close agreement between the 2 estimates. The data labels indicate each 'area-gear-year'. The small letter is either an 'o' for 'otter' or 'b' for 'beam'. The next number is either a '7' or '8' for '1997 or 1998', the next letters indicate the SMA. The cluster of points and data labels close to the origins cannot be differentiated. In Fig. 3a the scattered points indicate generally poor agreement between the two estimates. In Fig. 3b the points are less scattered, indicating closer agreement between the estimates calculated for the sums of aggregated catches.

Fig 3a.

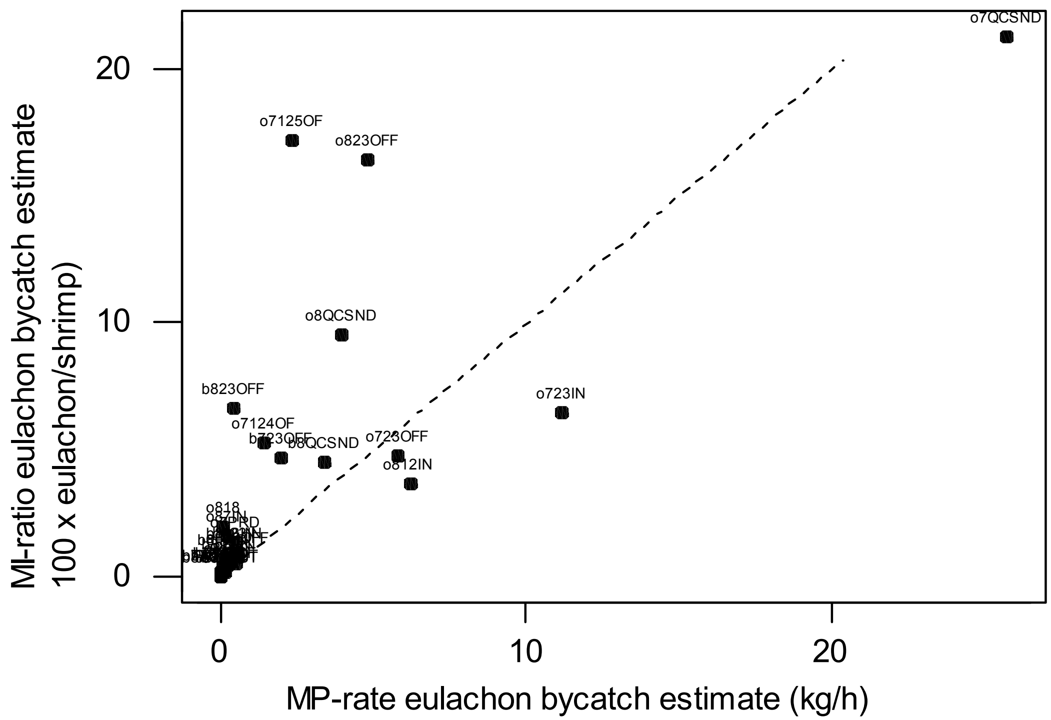


Fig 3b.

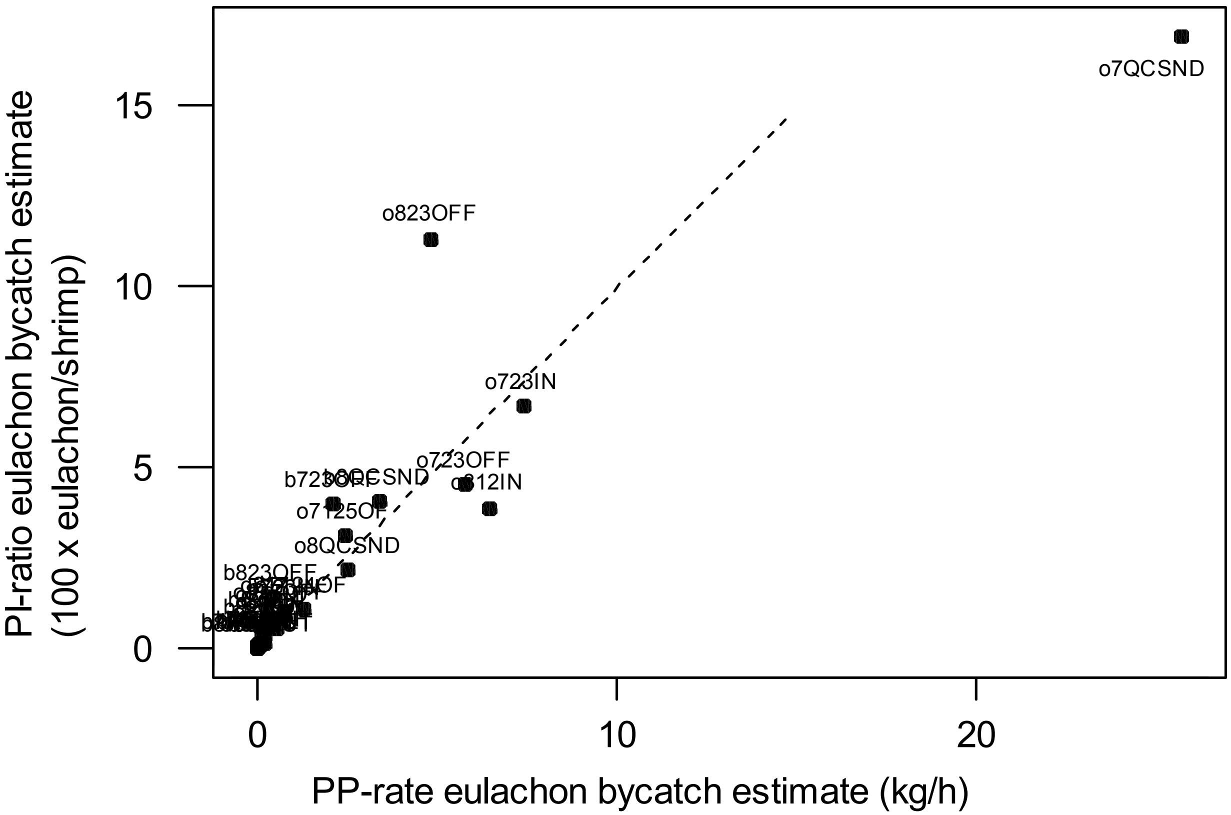

PI-ratio eulachon bycatch estimate
(100 x eulachon/shrimp)
PP-rate eulachon bycatch estimate (kg/h)
0
5
10
15
0
10
20
o7QCSND
o823OFF
o723IN
o723OFF
o8QCSND
b823OFF

Fig. 4abc. Comparison of the mean and pooled post-season bycatch rates (MP-rate and PP-rate) for eulachons (Fig. 4a), all non-target species (Fig 4b) and shrimp (Fig 4c). Each point represents the estimated bycatch of eulachons for the same 'area-gear-year' combination representing one SMA (Shrimp Management Area), gear type (otter or beam trawl) and year (1997 or 1998). Points close to the dotted line show close agreement between the 2 estimates. The data labels indicate each 'area-gear-year'. The small letter is either an 'o' for 'otter' or 'b' for 'beam'. The next number is either a '7' or '8' for '1997 or '1998', the next letters indicate the SMA. The cluster of points and data labels close to the origin cannot be differentiated. In general the two estimates of mean and pooled rates are very similar for all species in all areas.

Fig 4a

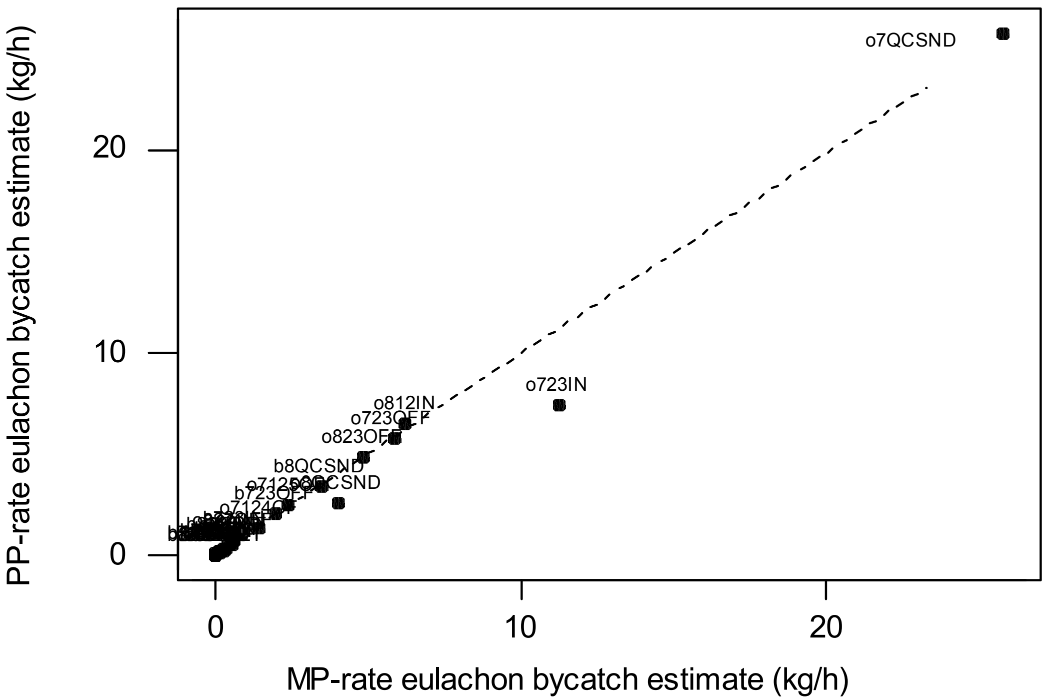
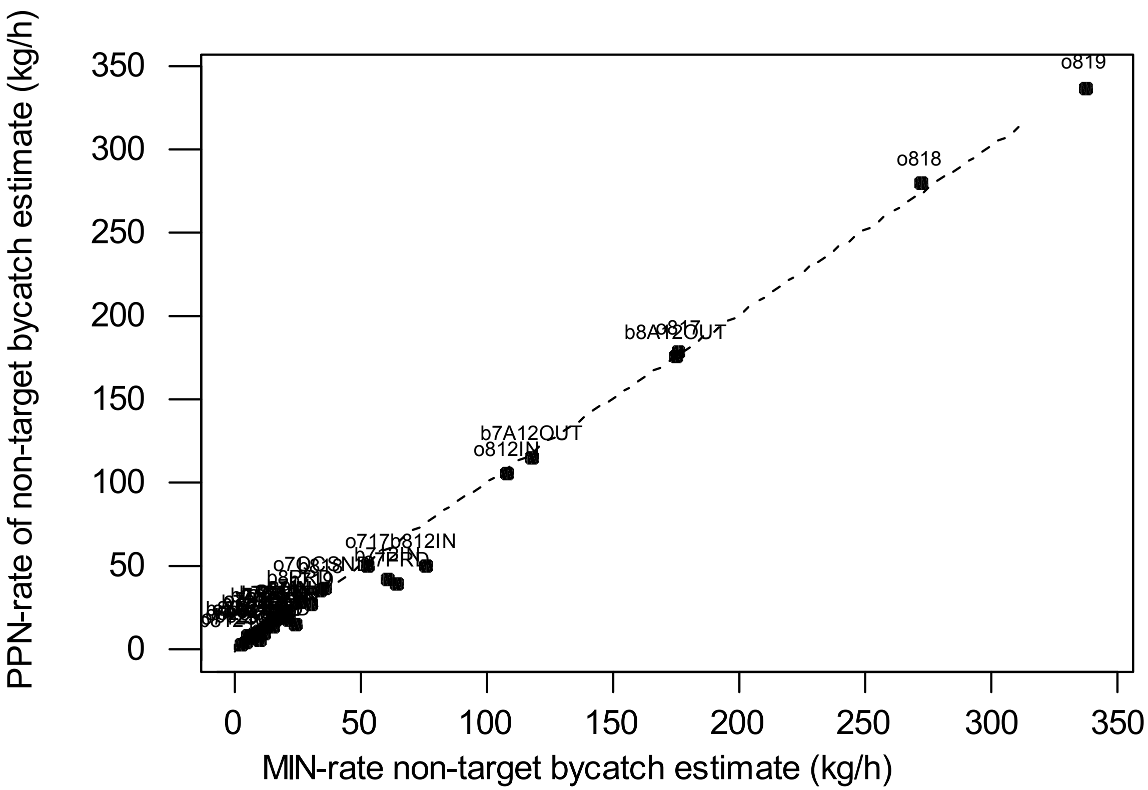
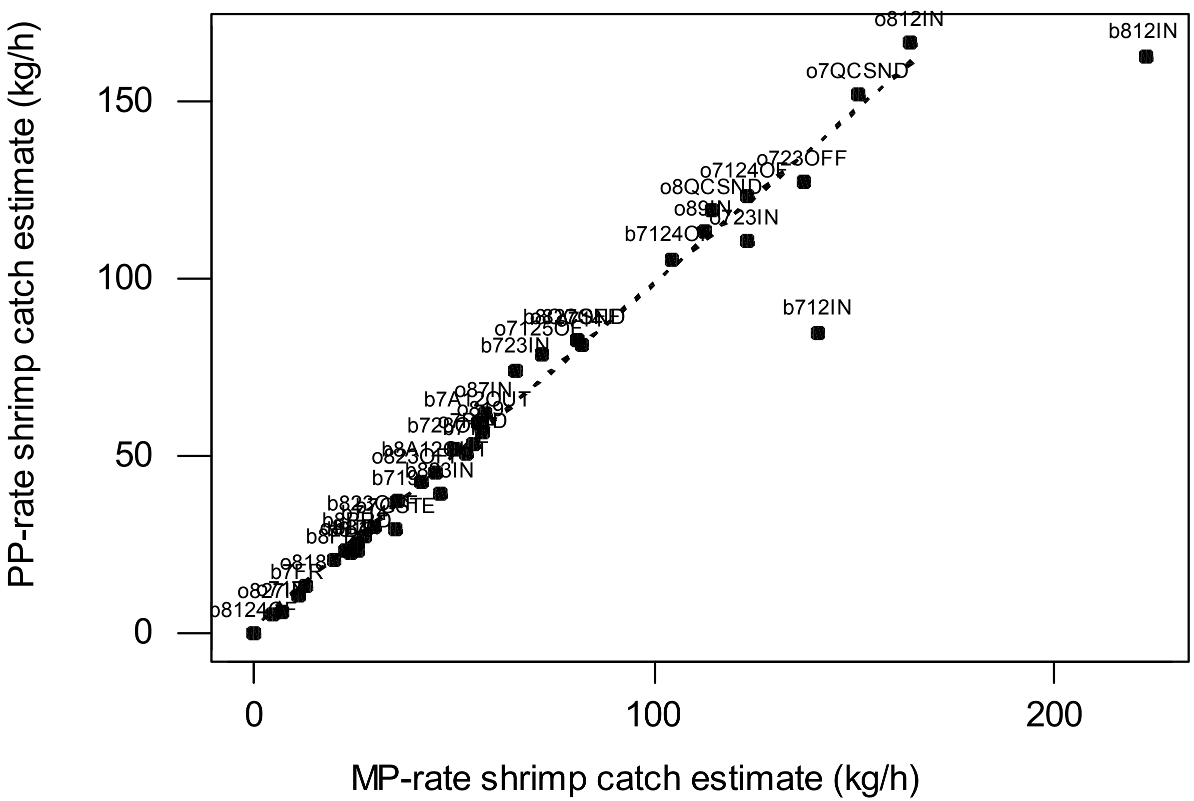


Fig. 4b.



o819
o818
b8A12OUT
o817
b7A12OUT
o812IN
o717
b812IN
PPN-rate of non-target bycatch estimate (kg/h)
MIN-rate non-target bycatch estimate (kg/h)
0
50
100
150
200
250
300
350

Fig. 4c.



PP-rate shrimp catch estimate (kg/h)
MP-rate shrimp catch estimate (kg/h)
0
50
100
150
0
100
200
o812IN
b812IN
o7QCSND
o723OFF
o7124OF
o8QCSND
o89IN
o723IN
b7124OF
b712IN
o7125OF
b723IN
o87IN
b8A12IN
b719

Fig. 5. Comparison of the mean MP-rate (mean post-season catch rate) of eulachons by Shrimp Management Area. The estimates for beam and otter trawls are indicated by circles and squares respectively. Estimates for 1997 and 1998 are indicated by solid and open symbols, respectively.

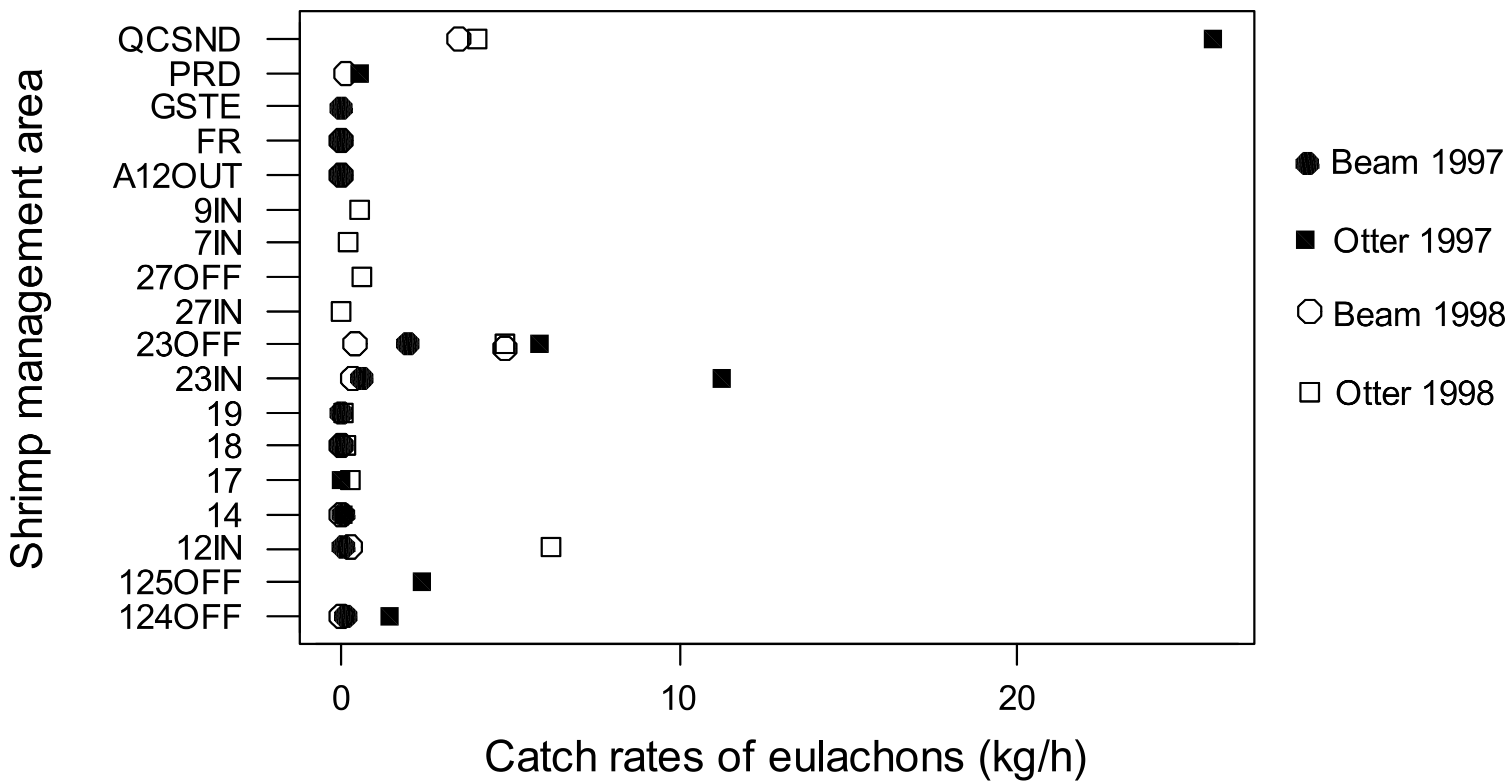


Fig. 6. Comparison of the mean MP-rate (mean post-season catch rate) of all non-target species by Shrimp Management Area. The estimates for beam and otter trawls are indicated by circles and squares respectively. Estimates for 1997 and 1998 are indicated by solid and open symbols, respectively.

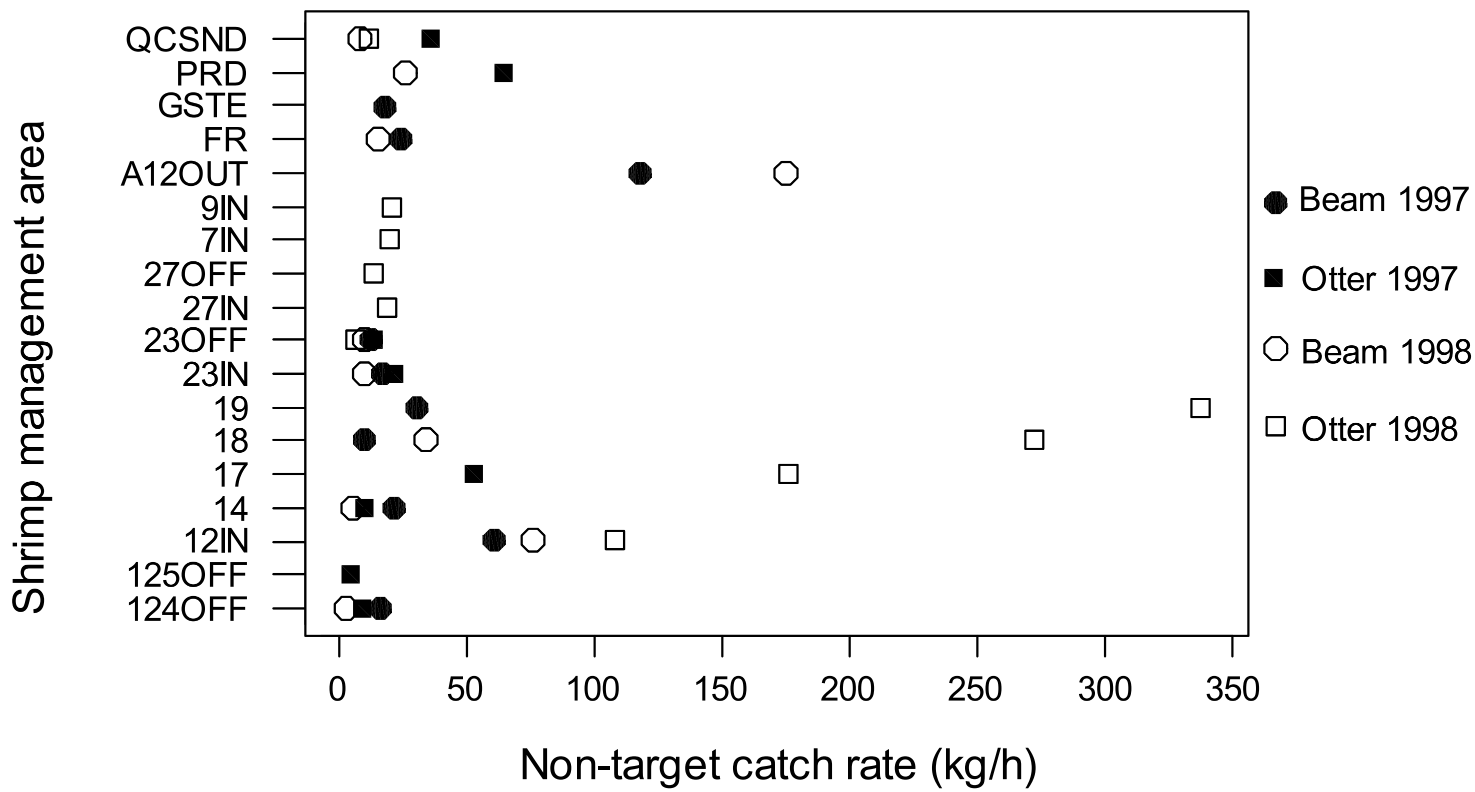


Fig. 7. Comparison of the mean post-season catch rate of all non-target species (kg/h) by the mean post-season catch rate of shrimp (kg/h) based on observer analyses of catches. The estimates for beam and otter trawls are indicated by circles and squares respectively. Estimates for 1997 and 1998 are indicated by solid and open symbols, respectively. The dotted lines indicate the approximate ratio of target catches between target (shrimp) and all non-target species (percentages in parentheses). Points close to the lower right corner indicate relatively low rates of bycatch; those on the upper left indicate high rates of bycatch. In a few instance the ratio of non-target species exceeds 4:1 (i.e. 80% bycatch by weight). Some of the data points may be based on a few number of observations and could be misleading.