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FISH-ASSOCIATED FOODBORNE DISEASE OUTBREAKS IN THE UNITED STATES, 1998-2008

BY

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FISH-ASSOCIATED FOODBORNE DISEASE OUTBREAKS IN THE UNITED STATES, 1998-2008

BY

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MPH, Emory University, 2012
BS, California State University, 1997

An abstract of a thesis submitted to the faculty of the Career MPH program of the Rollins School of Public Health of Emory University in partial fulfillment of the requirements of the degree of Master of Public Health in Applied Epidemiology, 2012

ABSTRACT

Background: The United States is the third largest consumer of seafood in the world. Consumption of seafood has many health benefits, but there are also associated risks. Seafood has the potential to carry chemical and biological toxins that can result in severe cases of foodborne illness and even death. In fact, fish is one of the top 3 food commodities implicated in foodborne disease outbreaks each year. In this paper, we describe the epidemiological traits of fish-associated outbreaks from 1998-2008, as well as seek to elucidate associations between fish type, method of preparation, setting, and geographic location.

Methods: Fish-associated outbreak data from CDC's Foodborne Disease Outbreak Surveillance System were analyzed in this report and included number of illnesses, hospitalizations and deaths, age groups, gender, reporting state, etiology, fish type, setting, and method of preparation. Univariate and multivariate logistic regression were used to identify risk factors for outbreaks and predictors of severe illness.

Results: Hawaii (207/607 outbreaks) and Florida (136/607) reported the most outbreaks with numbers declining overall during the 11-year period. Chemical etiologies, primarily scombroid toxin (317/550) and ciguatoxin (173/550) poisoning, contributed to more outbreaks than other causes, although *Clostridium botulinum* cases showed the highest risk for hospitalization (21 of 32 cases were hospitalized). Tuna (199/607) and mahi mahi (78/607) were the main fish types associated with outbreaks, and more outbreaks occurred from fish prepared in a commercial (339/572) versus home (186/572) setting, with cooking the most common method of preparation (206/368).

Conclusions: The decline in number of outbreaks is largely the result of a decrease in outbreaks in Hawaii, particularly in scombroid toxin poisoning in tuna and mahi mahi fish types. This trend may be attributed to better adherence to food handling guidelines, although consumer education about fishing and observing algal bloom warnings is needed to mitigate the slight rise in illnesses related to naturally occurring algal toxins.

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INTRODUCTION

The United States is the third largest consumer of seafood in the world after China and Japan[1]. Per capita seafood consumption in the U.S. has risen over the past several decades from 12.5 pounds per person in 1980 to 15.8 pounds in 2010[1]. Studies have shown numerous health benefits from eating fish or fish products, which contain omega-3 polyunsaturated fatty acids, essential fatty acids that mammalian cells cannot synthesize [2]. These benefits include providing protective and therapeutic effects for cardiovascular disease [3], aiding brain function to decreasing the risk of Alzheimer's disease [2], helping neuronal and vision development during pregnancy [2], and inhibiting inflammation to prevent arthritis [4]. In some cultures, eating fish also holds important cultural significance, such as in Native American and Pacific Islander societies [5, 6]. There are also certain risks associated with the consumption of seafood. Seafood has the potential to carry chemical and biological toxins, including those originating from natural sources and those fostered during handling, which can result in mild to severe cases of foodborne illness, and even death.

Foodborne diseases are an important public health burden in the United States with an estimated 48 million illnesses occurring each year [7]. A foodborne disease outbreak is defined by the Centers for Disease Control and Prevention (CDC) as the occurrence of two or more similar illnesses resulting from consumption of a common food [8]. Outbreaks are voluntarily reported to CDC's Foodborne Disease Outbreak Surveillance System by the state, local, territorial or tribal health department that investigated the outbreak [8, 9] (Appendix I). In the outbreak reporting system, reported foods are classified into 17 food commodities if they contain a single contaminated ingredient or if all ingredients belong to the same commodity. Within this structure there are 3 main commodity groups: aquatic animals, land animals, and plants [10]. Under this hierarchal scheme, fish and shellfish are classified as commodities within the aquatic animals group. In a 2011 Morbidity and Mortality Weekly Report describing foodborne disease outbreaks of 2008, the latest year for which complete data are available, CDC reported that of the 218 single-commodity attributed outbreaks, poultry (15%), beef (14%) and finfish (14%) were the top commodities implicated [8]. While seafood is one of the top groups associated with foodborne illnesses, it is understudied in the U.S. relative to land animals and plants, with relatively few recent publications. Although recent studies and reports have examined mollusk-associated outbreaks [11-13], finfish is often overlooked even though it accounts for nearly 40% of all bacterial, viral and parasitic attributed seafood outbreaks [14].

Illnesses attributed to fish consumption are most often chemical in nature and frequently related to algal toxins that accumulate in fish, or to bacteria-produced histamine poisoning [15]. As these chemicals are not evident by sight or smell, recognition of contaminated fish is difficult. With no clinical tests available, diagnosis is made based on signs and symptoms and history of fish consumption [15]. Ciguatoxin poisoning is caused by ingestion of certain types of predatory fish that contain an accumulation of a toxin produced by dinoflagellates, and causes gastrointestinal symptoms, neurological problems and a distinctive reversal of hot and cold sensation [16]. Scombroid toxin poisoning, also known as histamine fish poisoning, is often associated with fish of the Scombridae family such as tuna and mackerel, mahi mahi and escolar. These fast-swimming fish contain histidine that when acted upon postmortem by bacteria, is converted to histamine. In a dose-dependent manner, histamine ingestion produces tingling or numbness around the mouth, headache, flushing, sweating and gastrointestinal symptoms [15, 17]. Other illnesses related to contaminated fish consumption are caused by a variety of bacterial, viral and parasitic pathogens [14].

While reports have relayed some information on fish-associated outbreaks, studies have focused mostly on etiology, clinical characteristics, and prevention measures. In this paper, we describe the epidemiological traits of fish-associated outbreaks from the most recent 11 years of available data, as well as seek to elucidate associations between fish type, method of preparation, setting and geographic location.

METHODS

The data used in this report were downloaded from CDC's Foodborne Disease Outbreak Surveillance System on July 25, 2011, and included outbreaks from 1998-2008 based on the date of initial onset of illness for the first case in the outbreak. Fish was the commodity selected for this analysis and as a separate commodity from shellfish, did not include data on outbreaks attributed to crustaceans or mollusks. Fish consists of only finfish and is referred to as fish in this report. The dataset was imported into SAS 9.3 (SAS Institute Inc., Cary, NC) and analyses were carried out on the following variables: date first case ill, number of illnesses, hospitalizations, deaths, age groups, gender, reporting state, etiology, food, cooking method, and where prepared (setting). Tests for significance were carried out at alpha-level .05 and 95% confidence intervals (CI) were used when reporting odds ratios (OR).

Each outbreak report collects gender data as percent male or percent female of the total cases in the outbreak. Age data for each outbreak were gathered in a similar manner, as percentage of cases in each age group: <1, 1-4, 5-19, 20-49, and >50 years. Number of cases, referred to as illnesses, included both lab-confirmed and probable cases. Hospitalizations or deaths were illnesses with that outcome. Severity was defined as the ratio of hospitalizations to illnesses.

When examining etiology, outbreaks stated as histamine fish poisoning were grouped with those specified as scombroid toxin poisoning, and thereafter referred to as scombroid toxin. For modeling etiologic agents as predictors of severity, etiologies other than the one listed as the predictor were grouped and used as the referent.

For this analysis, reported fish types were grouped. Those of the Scombridae family are commonly known as tuna, including albacore, mackerel and ahi, and were grouped together as tuna. The grouper classification included all grouper species and roi fish, both of the Serranidae family. Jack fish included amberjack, kingfish and ulua, from the Carangidae family of fish. Unspecified fish or specified fish types with less than 20 associated outbreaks were grouped into the “other” category for simplicity sake, and included such types as salmon (18 outbreaks), kole (12), and marlin (8) (Appendix II). Modeling analyses with fish type as a predictor of severe illness grouped fish types with low percent hospitalizations as the reference group (tuna, mahi mahi, escolar, jack and other) and compared this “other” group to barracuda and grouper.

For some analyses by state, only those states reporting more than 20 outbreaks were included individually; all other states were grouped as “other”. When referring to seasonal trends, spring was defined as March through May, summer as June through

August, fall as September through November, and winter as December through February.

Setting was classified based on where the food was prepared. Commercial settings included foods prepared in a restaurant, deli or grocery store, while “private home” contained only those fish products prepared at home. Institutions grouped together preparation settings in hospitals, schools or workplaces. Mobile consisted of those foods originating at a fair, festival, camp, picnic or catered event. The Other category included fish from a commercially prepared product or a contaminated import. When examining outbreak settings for modeling predictors of severity, settings other than commercial and private home were grouped.

Method of preparation included various manners and combinations of cooking method (Appendix III). Only outbreaks where a single method of preparation was reported were used in calculations. Those classified as “natural toxicant” included inherently contaminated fish.

Incidence was calculated using U.S. Census Bureau intercensal population estimates for 1998 and 2008 [18, 19] and is expressed as outbreaks per 1,000,000 population. World seafood consumption estimates were based on a disappearance model taking into account a country’s landings, imports and exports [1].

RESULTS

General Epidemiological Characteristics

Over the period from 1998 to 2008, there were 607 fish-associated outbreaks reported in the United States, resulting in 3,317 illnesses, 211 hospitalizations, and 2 deaths. The number of outbreaks per year was relatively steady from 1998 to 2003 with an average of 66 outbreaks before declining to 53 outbreaks in 2004, beginning a general decline to 28 outbreaks in 2008, with an average of 42 outbreaks per year from 2004 to 2008 (Figure 1). This represents a 36% decrease between the averages of the two periods and a 56% decrease in number of outbreaks from 1998 (63 outbreaks) to 2008 (28 outbreaks). Number of illnesses per year was more variable, falling 46% from 442 to 240 illnesses in 1999, remaining steady, then increasing 87% to a peak in 2004 (603 illnesses) before declining by 70% to 175 illnesses in 2005. Levels then remained stable. Overall, the number of outbreaks and illnesses declined over the 11-year period, with a 61% decrease in annual incidence, from 0.23 to 0.09 fish-associated outbreaks per million population from 1998 to 2008.

By month, based on date of first case ill, outbreak numbers increased starting in April (9.2%, 56/607), with most of the 607 total outbreaks reported in the summer months of June (11.0%, 67 outbreaks), July (12.0%, 73) and August (12.5%, 76). Outbreak numbers then declined in the fall through winter months from 52 outbreaks (8.6%) in September to the annual low of 29 outbreaks (4.8%) in February (Figure 2).

The median outbreak size was 3 illnesses (range, 2-380), the mode was 2 illnesses, and 91% of outbreaks reported fewer than 10 illnesses. The majority of the 2,250 illnesses reported with age group indicated were in the 20-49 years age group (1,480, 65.8%), with 27.4% (616) in the greater than 50 years age group, 5.3% (119) in the 5-19 years age group, 1.5% (33) in the 1-4 years, and the remaining 0.1% (2) in the youngest age group of less than 1 year. For the 490 outbreaks reporting the gender distribution of cases, the average estimated percent of the total cases per outbreak was nearly equal for males and females with 48.3% male and 51.6% female.

The states with the highest number of outbreaks were Hawaii (34.1%, 207 outbreaks), Florida (22.4%, 136), California (8.6%, 52), New York (7.3%, 44), and Washington (3.3%, 20) (Figure 3). Reported outbreaks in Hawaii rose from 20 outbreaks (9.7%) in 2000 to 35 outbreaks (16.9%) in 2003 before sharply declining to 14 outbreaks (6.8%) in 2004 (Figure 4). By number of illnesses, Hawaii reported the most (20.1%, 666 illnesses), followed by Florida (15.9%, 527), Wisconsin (12.4%, 411), New York (9.1%, 303) and California (8.5%, 283). There were 2 multistate outbreaks (cases reported with exposure in multiple states), in 2002 (21 illnesses, New York and Virginia) and in 2004 (44 illnesses, investigated in Hawaii).

Etiologic Agents and Fish Types

Etiologic Agents

Out of 550 outbreaks (90.6% of all outbreaks) with a known etiologic agent (17 total agents), 92.2% were chemical, 6.4% were bacterial, 1.3% were viral, and 0.2% were parasitic (Table 1). More than half (57.6%) of all fish-associated outbreaks were due to scombroid toxin. Ciguatoxin caused 31.5% of fish-associated outbreaks, with the remaining caused by *Salmonella* (2.0%), *Clostridium botulinum* (1.8%), norovirus (1.1%), and other chemicals (1.5%). Of the 2,121 illnesses with a known etiology, 43.3% were due to scombroid toxin, 23.6% to ciguatoxin, 14.8% to norovirus, and 10.8% to *Salmonella*. Most (77.8%) of the hospitalizations were due to chemical etiologies, of which 47.7% were attributed to ciguatoxin and 28.0% to scombroid toxin.

The overall risk of hospitalization was relatively low as 6.4% (211) of 3,317 illnesses resulted in hospitalization. The etiology with the greatest proportion of hospitalizations was *Clostridium botulinum* with 65.6% (21/32), followed by ciguatoxin at 12.8% (92/719), *Salmonella* at 4.2% (14/331) and scombroid toxin at 4.1% (54/1321). *Clostridium botulinum* was an extremely significant predictor of severity (p-value <0.0001), as those illnesses attributed to *Clostridium botulinum* were 51.1 times more likely to require hospitalization than those attributed to other etiologies (CI 20.1-129.7) (Table 2). When adjusted for setting, *Clostridium botulinum* was still an extremely significant predictor of severe illness (p-value<0.0001) as fish contaminated with this bacteria and prepared in the home had 97.2 times greater risk of resulting in hospitalization than illnesses associated with other etiologic agents (CI 35.3-267.2). Ciguatoxin-related illnesses were 3.3 times as likely as other etiological causes to be severe (CI 2.2-5.1, p-value<0.0001) and were 4.8 times as likely when prepared in the home setting (CI 3.0-7.9, p-value<0.0001). *Salmonella* was a significant predictor of severity (p-value = 0.0011) with those consuming contaminated fish products 3.1 times (CI 1.0-3.2) more likely to be hospitalized from outbreak-related foodborne illness than cases related to other etiologies, regardless of setting. Scombroid toxin related illnesses showed no greater risk for hospitalizations than other etiological agents.

For states with more than 20 outbreaks, with known etiologic agents attributed to 10 or more outbreaks from 1998-2008, the two most common etiologic agents were scombroid toxin and ciguatoxin. In Hawaii, 45.6% and 52.0% of the 204 outbreaks were attributed to scombroid toxin and ciguatoxin, respectively. Florida reported 39.8% of 98 outbreaks due to scombroid toxin and 46.9% to ciguatoxin, while California stated

76.0% of 50 outbreaks were scombroid toxin related and only 6.0% were ciguatoxin related. New York showed a similar proportion to California with 88.4% of 44 outbreaks as scombroid toxin and 7.0% ciguatoxin implicated outbreaks. Of the 155 outbreaks in other states, most were related to scombroid toxin (70.3%) with fewer outbreaks caused by ciguatoxin (9.7%).

The number of scombroid toxin outbreaks rose from 1998 to 2001, dropping in 2002 before peaking in 2003 at 43 outbreaks (Figure 5). The number of outbreaks then decreased steadily with a slight rise (31 outbreaks) in 2006. Ciguatoxin outbreaks reached the highest levels in 2001 at 26 outbreaks before steadily dropping through 2004 to 9 reported outbreaks, remaining fairly constant through 2008. In 2008, there were more ciguatoxin related outbreaks (13) than scombroid toxin related outbreaks (11), for the first time during this 11-year timeframe. Outbreaks due to other causes declined over the 11-year period, from 8 in 1998 to 3 in 2008.

Overall, outbreaks by etiology followed a seasonal pattern, with numbers rising in summer and dropping in fall. The seasonal fluctuations in scombroid toxin related outbreaks alternately rose and fell in the months from April (37 outbreaks) to June (38) to August when outbreak numbers were highest (39); whereas ciguatoxin outbreaks were consistently low in the cooler months, fall through spring, remaining high during the warmer months from May (24 outbreaks) through July (29), before decreasing to 12 outbreaks in October. Outbreaks related to other etiologies peaked in the summer months of July and August.

Fish Types

Tuna was the most common type of fish associated with outbreaks at 32.8% (199/607) of outbreaks, followed by unspecified or other fish (30.5%, 185/607), mahi mahi (12.9%, 78/607), grouper (8.1%, 49/607), escolar (6.4%, 39/607), barracuda (4.9%, 30/607) and jack fish (4.4%, 27/607) (Table 3). "Other" includes a group of fish not separated into distinct types due to lack of specification or small sample size. The median number of illnesses per outbreak was 2 for mahi mahi (range, 2-24) and tuna (range, 2-63). For grouper, jack and other fish, the median was 3 with outbreak sizes ranging from 2-13 for grouper, 2-29 for jack, and 2-380 for other types. The median outbreak size for barracuda was 4 (range, 2-23), while escolar was 5 (range 2-42)(Table 3).

Severity of illness varied by fish type, with most severe illnesses associated with barracuda (28.9% of illnesses, 46/159) and grouper (12.2% of illnesses, 24/197). For barracuda related illnesses, the risk for hospitalization was 12.1 times that of other fish types (CI 7.9-18.8) and after adjusting for setting, the risk was 11.4 times (CI 7.2-17.9) (Table 2). The risk for grouper associated severe illnesses was higher than most other fish types, with 3.1 times the likelihood of an illness becoming severe (CI 1.1-3.1). Both barracuda and grouper were highly significant predictors of severe illness (p-value<0.0001).

The number of outbreaks decreased over time for most fish types including tuna and mahi mahi, while the number increased for barracuda to 6 outbreaks (20%, 6/30) in 2008, up from 0 in 2003 (Figure 6). Tuna outbreaks peaked in 2000 (13.6%, 27/199) and 2004 (12.6%, 25/199), while mahi mahi and grouper outbreaks were highest in

2003 (21.8%, 17/78 mahi mahi; 20.4%, 10/49 grouper). The highest number of escolar outbreaks was reported in 2001 (33.3%, 13/39), whereas outbreaks with fish types in the other group began at a peak of 31 outbreaks (16.8%, 31/185) in 1998.

There were monthly variations in the number of outbreaks by fish type, but reports of fish type associated with outbreaks generally followed a seasonal trend of more outbreaks in summer, less in winter (Figure 7). Outbreaks associated with tuna trended seasonally, but varied considerably month-to-month, reaching the highest number in August (14.6%, 29/199) and lowest in February (4.5%, 9/199) (Figure 7). However, outbreaks related to escolar showed the highest number of outbreaks in spring (25.6%, 10/39, April), while mahi mahi associated outbreaks peaked in both spring and fall (12.8%, 10/78, April and November).

By fish type, Hawaii had the most outbreaks associated with mahi mahi (56.4% of 78 total mahi mahi-related outbreaks), with 21.3% of Hawaii's 207 outbreaks attributed to mahi mahi (Table 3). Among outbreaks where a fish type was specified, Hawaii's outbreaks were next most often associated with tuna (18.8%), then grouper (11.6%), with 40.1% either unspecified or attributed to numerous miscellaneous types (Appendix I). Florida's 136 fish-associated outbreaks were related most often to other or unspecified fish (30.9%), followed by tuna (16.9%), grouper (14.0%) and barracuda (13.2%); which accounted for 60.0% of all 30 barracuda-related outbreaks. Tuna was the fish type most often associated with outbreaks in New York (72.7% of 44), California (48.1% of 52), and in other states combined (47.6% of 168). California reported a higher number of escolar-related outbreaks than any other state, as 28.2% of all 39 escolar outbreaks occurred in California. Jack fish associated outbreaks were found almost exclusively in Hawaii and Florida, with 44.4% of all 27 jack outbreaks reported by each state.

Evaluating fish type by etiologic agent showed that almost all tuna (93.6% of 188), mahi mahi (96.0% of 75), and escolar (89.7% of 39) outbreaks were due to scombroid toxin (Table 3). Ciguatoxin caused most other outbreaks, including 97.7% of 43 grouper outbreaks, 100% of 30 barracuda outbreaks, and 95.8% of 24 jack outbreaks.

Outbreak Setting and Method of Preparation

Outbreak Setting

Of the 572 outbreaks with a specified setting, 59.3% (339) involved food prepared in a commercial establishment such as restaurants, delis or grocery stores, while 32.5% (186) of outbreaks were attributed to fish prepared in private homes. Institutions (hospitals, schools, workplaces) accounted for 2.8% (16) of fish-associated outbreaks and mobile settings such as fairs and catered events were where 2.3% (13) of outbreaks occurred. The remaining 3.1% (18) of outbreaks were the result of consumption of a commercial product or a contaminated import.

The number of outbreaks in both commercial and home settings declined overall, although commercial outbreaks peaked in 2000 (43 outbreaks) and 2003 (42) before dropping to 10 outbreaks in 2008. Outbreaks originating in private homes declined until 2000 (17), rose until 2002 (26), before beginning a decline to 12 outbreaks in 2008.

The number of outbreaks for the most common settings rose in April, with commercial-originating outbreaks peaking in July (40) and home-based outbreaks peaking in August (24) before declining throughout the fall months.

As shown in Figure 8, most tuna outbreaks involved food prepared in a commercial setting (82.6% of tuna outbreaks), as did mahi mahi (75.0%), and escolar (84.2%). Conversely, grouper, barracuda and jack associated outbreaks more often originated in private homes with 63.0% of grouper, 85.7% of barracuda, and 59.3% of jack outbreaks in the home setting. When tuna was the fish type implicated in the outbreak, the food preparation site was 4.8 (CI 3.2-7.1) times as likely to be commercial than other settings, whereas when it was mahi mahi, the likelihood of occurring in a commercial setting were 2.4 (CI 1.3-4.1) times that of other settings (Table 4). Escolar was 4.0 (CI 1.7-9.2) times more likely to be prepared in a commercial setting as compared with other settings. Outbreaks associated with grouper, barracuda and jack fish, however, were more likely to be reported as originating in a private home setting. Barracuda related outbreaks were the type most commonly prepared in the home at 10.4 (CI 4.2-25.9) times the probability of other settings, along with both grouper, which was 3.8 (CI 2.1-6.8) times as likely and jack fish, which was 3.6 (CI 1.6-7.8) times more likely.

Hawaii, had a greater proportion of outbreaks originating in the home (56.1%) versus the commercial setting (36.2%) (Table 5). In Florida, 65.9% of outbreaks implicated fish prepared in a commercial setting while 28.7% were from private homes. California and New York had an even higher proportion of commercial outbreaks to home outbreaks, at 74.5% commercial preparation to 15.7% home preparation, and 85.4% to 7.3%, respectively.

Seventy-eight percent (78.2%) of outbreaks originating in private homes were related to ciguatoxin poisoning while only 15.3% were due to scombroid toxin (Figure 9). Conversely, with food prepared in commercial and institutional settings, 91.1% and 92.9% (respectively) of outbreaks were caused by scombroid toxin and only 7.7% and 7.1% (respectively) were due to ciguatoxin. A more even combination of etiologic agents was found in mobile settings with 41.7% of outbreaks due to each of scombroid toxin and ciguatoxin poisoning, and 16.7% due to *Salmonella*. When scombroid toxin was the etiology, the outbreak-associated fish was 7.8 (CI 5.4-11.2) times as likely to have been prepared in a commercial setting as in other settings (Table 4). Conversely, when ciguatoxin was the etiology, the fish implicated in the outbreak was 24.3 (CI 15.4-38.3) times as likely to have been prepared in the private home setting, and with *Clostridium botulinum*, the fish was 21.7 (CI 2.7-172.2) times as likely to have been prepared in the private home setting versus all other settings.

Method of Preparation

Of the 368 outbreaks with a single method of preparation reported, the most common cooking method or method of preparation in outbreaks was cook and serve preparation (e.g., fish fillet), (206 outbreaks, 56.0%). Natural toxicant was implicated in 27.4% (101 outbreaks) of single preparation method outbreaks and raw or lightly cooked fish was third most common at 9.2% (34 outbreaks). The remaining 7.4% were either could not be categorized (8 outbreaks, 2.2%), or were attributed to other preparations including sandwiches (7 outbreaks, 1.9%), commercially processed foods (3 outbreaks, 0.8%), and salads (3 outbreaks, 0.8%).

In commercial settings, cook and serve preparation accounted for 58.9% of 352 outbreaks, while natural toxicant contributed 22.9% and lightly cooked/raw made up 12.6%. With private home outbreaks, the cook and serve method accounted for 52.3% of 107 outbreaks, natural toxicant 35.5%, and lightly cooked/raw 3.7%. Institutions (7/10 outbreaks) and mobile settings (7/8 outbreaks) were predominantly related to cook and serve preparation. Foods prepared raw or lightly cooked were 3.9 times as likely to occur in a commercial setting as in other settings (CI 1.02-2.02), while cook and serve preparation was 1.4 times as likely to occur in a commercial setting (CI 1.6-9.1) (Table 4).

Cook and serve preparation was also the cooking method associated with the majority of outbreaks in all types of fish except barracuda, in which a natural toxicant was more common, attributing to 9 of 16 (56.3%) barracuda outbreaks (Table 3). Tuna was the fish type found in 61.8% of outbreaks related to consumption of raw or undercooked fish, while other fish (unspecified or various types) were implicated in 32.4% of raw or lightly cooked preparations.

Taking into account etiology, it was found that 123 (67.2%) of 183 outbreaks using cook and serve preparation were related to scombroid toxin, with 50 (27.3%) attributed to ciguatoxin (Figure 10). Natural toxicant related outbreaks were due almost equally to scombroid toxin (50.0%) and ciguatoxin (49.0%), while 19 (59.4%) of 32 raw or lightly cooked fish outbreaks were caused by scombroid toxin and only 2 (6.3%) were ciguatoxin related.

Looking at outbreaks in each state, cook and serve preparation produced 56.0% (206/368) of all states combined fish outbreaks, however in New York, 71.9% (23) of 32 outbreaks were attributed to consumption of natural toxicants (Figure 11). California had a higher percentage of outbreaks with raw or lightly cooked fish than other states, with 35.5% (11) of 35 outbreaks, while only 4.9% of 131 outbreaks in Hawaii and 6.8% of 80 outbreaks in Florida involved raw or lightly cooked fish.

Grouping outbreaks by preparation and looking at each month, a pattern developed for outbreaks involving cook and serve preparation in which they alternated in frequency, high one month, low the next. The greatest increase occurred from the lowest in March (9 outbreaks) to the highest in April (25 outbreaks). Those outbreaks involving raw or lightly cooked fish followed a similar alternating low-high pattern from spring into fall, peaking at 8 outbreaks in August, but remaining relatively low from fall into spring, with only 0-2 outbreaks per month. Natural toxicant related outbreaks rose from a low of 3 outbreaks in January to the highest levels in May (17 outbreaks) through summer, declining again from September through April.

Cook and serve preparation related outbreaks rose dramatically from 2001 (9 outbreaks) to 2003 (39) before declining, and other than a smaller peak (25) in 2006 decreased overall to 9 outbreaks in 2008 (Figure 12). Natural toxicant-related preparation caused more outbreaks in 2001 (17) and in 2008 (12) than cook/serve preparation, and steadily increased during the period from 2006 to 2008 when cook/serve declined. Outbreaks related to consumption of raw or lightly cooked fish gradually rose from no outbreaks in 1998, leveling at 5 outbreaks in each of 2007 and 2008.

DISCUSSION

The number of outbreaks related to fish declined 56% from 1998 to 2008, decreasing an average of 3.5 outbreaks per year. The overall decline in outbreaks was driven by a decline in outbreaks in Hawaii (Figure 4), particularly in tuna and mahi mahi related outbreaks. This was reflected in a concurrent decline in scombroid toxin attributed outbreaks, cook and serve preparation and in both commercial and private home settings. Better adherence to food storage and handling guidelines regarding maintaining fish at low temperatures may have contributed to this decline [20]. During this same period, the number of outbreaks in Florida rose and in 2006 surpassed the number of outbreaks in Hawaii. This was due to an increase in outbreaks attributed to barracuda, reflected in the rise of ciguatoxin related outbreaks and of natural toxicant related outbreaks.

Overall foodborne disease outbreaks attributed to fish tended to be small, most often consisting of 2-3 ill individuals, although variations related to fish type were observed. Outbreaks attributed to consumption of escolar and barracuda tended to be larger than those attributed to other fish types. In February of 2004, there was a large norovirus outbreak in Wisconsin attributed to consumption of fish salad (type unspecified) that sickened 380 individuals and accounts for the spike in illnesses observed in 2004. Most outbreaks were not severe as among these reported outbreaks, only 6% of those ill were hospitalized and 0.06% died. Among those with *Clostridium botulinum*, the risk of hospitalization was 65.6%. As a general rule, the odds ratio (OR) is a good estimate of the risk ratio when disease is rare. For analyses on hospitalization associated with *Clostridium botulinum*, the ORs will overestimate the risk ratio.

Children were rarely affected, as most cases were 20 years of age and older, which may be a result of less fish consumption by children in general [21]. Gender was not a contributing factor with the proportion of male to female approximately equally distributed.

The number of outbreaks typically peaked in summer and was lowest in winter. This correlates with greater numbers of visitors to Hawaii [22] and Florida [23] during summer, states with the highest numbers of outbreaks, and could be related to an overall increase in fish consumption due to tourists. There were some exceptions, however, in regards to fish type. Outbreaks related to escolar fish were highest in spring and occurred in California, while mahi mahi related outbreaks peaked in spring and fall and were mostly reported in Hawaii. Mahi mahi are known to spawn year-round, but in greater numbers in spring and fall, which is also when catches are higher in Hawaii [24].

Hawaii and Florida reported considerably more outbreaks and related illnesses than other states and were most often due to ciguatoxin poisoning, followed by California and New York, which were most often related to scombroid toxin. The type of fish associated with the most outbreaks was tuna, except in Hawaii where mahi mahi was associated with more outbreaks. In 2003, number of outbreaks peaked in Hawaii, due to scombroid toxin poisoning from mahi mahi consumption. Most of the tuna, mahi mahi and escolar related outbreaks were attributed to scombroid toxin poisoning, while grouper, barracuda and jack fish were almost completely ciguatoxin related. Thus, most outbreaks (92%) had chemical etiologies rather than bacterial or viral. This is also reflected in the size of outbreaks being relatively small when compared to outbreaks related to viral or bacterial causes. The incubation period of scombroid toxin and ciguatoxin poisoning are only 1-2 hours, whereas *Salmonella* and norovirus related symptoms typically take 12-48 hours to manifest [25]. A common-source foodborne outbreak involving a chemical etiology is likely to be recognized and mitigating measures implemented in a shorter span of time, thereby reducing the number of individuals affected.

More outbreaks originated in commercial versus private home settings, with far fewer reported in institutional and mobile locations. It was interesting that of the two most common etiologies, there was a significant difference in the setting in which the fish was prepared. Nearly all commercial and institutional outbreaks were attributed to scombroid toxin (91-93%), while the vast majority (78%) of private home outbreaks were caused by ciguatoxin. Since ciguatoxin poisoning is related to consumption of fish having a bioaccumulation of algal toxins, it is possible that outbreaks occurred during times when there were vast accumulations of dinoflagellates that can arise in warmer than normal waters [26]. These accumulations are not typical surface algal blooms, but rather form dense submerged masses not easily visible [27]. If the public was not aware of periods when it was dangerous to consume caught fish, this could explain the high incidence of ciguatoxin outbreaks in private homes. In some areas, signs are posted along beaches during these times to deter fishing, or email bulletins from the National Oceanic and Atmospheric Association (NOAA) are sent to subscribers. However, such notifications may be insufficient. Unfortunately, information on the source of the implicated fish products is not systematically collected and thus we do not know if the contaminated fish was self-caught or purchased or when the fish was acquired.

The propensity of outbreaks where food was prepared in a commercial setting to be scombroid toxin poisoning may be due to improper storage or handling temperatures related to longer periods of time from when fish is caught to when it is served. When fish are not continually stored at low temperatures from time of death, bacteria are able to produce an enzyme that catalyzes a histidine to histamine conversion within the fish, providing the impetus for illness when consumed [28]. Commercial institutions such as restaurants and grocery stores typically receive their products from suppliers, a process that requires storage periods and transportation stages from the point of capture to receipt by consumers. During these times, if fish products are not properly stored before consumption, illness can result.

Fish type showed trends that correlated with etiology regarding setting, with tuna, mahi mahi and escolar fish outbreaks attributed more often to commercial locales, while grouper, barracuda and jack fish outbreaks were more frequently reported in private homes. Setting generally paralleled etiological trends when considering geographic location, as Hawaii reported more private home outbreaks than commercial, while Florida, California and New York outbreaks involved mostly commercial locations. Although the most common method of food preparation involved in outbreaks was cook and serve, regardless of setting, nearly one-third of outbreaks reported in California were associated with raw or lightly cooked fish. Tuna was the most common fish served raw or lightly cooked that resulted in illness and correspondingly, scombroid toxin poisoning was most often implicated in this type of preparation.

The CDC Foodborne Disease Outbreak Surveillance System from which the data in this report were obtained has some limitations. Not all foodborne illnesses are recognized as associated with an outbreak and thus outbreaks in general are likely to be underreported [8]. In addition, the system relies on voluntary reporting by state and territorial health departments which may in turn rely on local health departments for reporting. Variable reporting among states can affect data reliability. Moreover, outbreak reports often contain empty data fields when information was not collected, so not all recorded outbreaks used in this study contained complete reports. Since this is a dynamic surveillance system, the contents of the database may change as new records are added and old ones are modified after initial entry into the system. However, the data in this report are current through December 2008, so it is unlikely records have substantially changed since the data were downloaded in July 2011.

Information not noted on report forms that would have helped in analyses and interpretation of results include source of contaminated fish, such as whether home caught, store bought, or purchased from local fishermen or a commercial fish farm. Point of contamination was also not collected for most outbreaks and would have helped with food safety recommendations. Finally, not all etiologies were lab confirmed and in some cases they can’t be, relying on clinical symptoms and history of fish consumption for diagnoses.

As most outbreaks occurred in a commercial setting and were due to scombroid toxin poisoning, intervention measures should address storage and handling of fish products, particularly in restaurants, delis and grocery stores. Scombroid toxin poisoning is preventable by consistently maintaining fish at low temperatures, below 4 degrees Celsius, from the point of capture until cooking or consumption if served raw [20]. The FDA instituted the Seafood Hazard Analysis Critical Control Point (HACCP) program in 1995 to implement such guidelines for preventing fish-associated illnesses, but because the majority of the United States' seafood is imported, compliance is low and inspections are of inadequate frequency to regulate proper protocols [20]. Until compliance improves, commercial and personal consumers must therefore be aware of proper handling procedures and practice them upon delivery of fish goods. Although histamine testing is available, it must be simple, cost-effective and time-efficient in providing the results in order to have an impact on reducing histamine-related outbreaks [28].

Ciguatoxin poisonings were most prevalent in private home outbreaks and may be related to insufficient education on dinoflagellate bioaccumulation in predatory fish, or unawareness of algal bloom advisories when certain fish should not be consumed [26]. Ciguatoxin is not detectable by sight or smell, nor is it neutralized by heat, eliminating cooking as a prevention technique [29]. It has no known biomarker for testing and no known antidote; treatment with mannitol is the most common therapy [29]. Consumer education on the risks connected with consumption of fish caught during periods of algal blooms, especially with grouper, barracuda and jack fish, would be beneficial, as illnesses associated with algal-produced toxins have a higher risk of being severe. Additionally, educating clinicians to recognize illnesses related to consumption of fish products would aid in treatment and rapid detection of potential outbreaks.

Prevention of future outbreaks will depend on consumer awareness, commercial attention to safety measures, and improved reporting of outbreaks. Being aware of risks associated with particular fish types, methods of preparation and where the fish are prepared, will help to mitigate further outbreaks. While consumption of fish has established health benefits, the associated risks must be taken into account and recommended guidelines followed to receive the full benefit.

TABLES AND FIGURES

TABLE 1. Etiologic agents of fish-associated outbreaks, United States, 1998-2008.

Etiologic Agent	No. (%) of Outbreaks	No. (%) of Illnesses	No. (%) of Hospitalizations	No. (%) of Deaths
Chemical				
Scombroid toxin	317 (57.6)	1,321 (43.3)	54 (28.0)	0 (0)
Ciguatoxin	173 (31.5)	719 (23.6)	92 (47.7)	1 (50)
Other chemical*	8 (1.5)	40 (1.3)	0 (0)	0 (0)
Paralytic shellfish poison	5 (0.9)	30 (1.0)	4 (2.1)	0 (0)
Other natural toxins	3 (0.6)	9 (0.3)	0 (0)	0 (0)
Heavy metals	1 (0.2)	2 (0.1)	0 (0)	0 (0)
SUBTOTAL	**507 (92.2)**	**2121 (69.6)**	**150 (77.8)**	**1 (50)**
Bacteria				
Salmonella	11 (2.0)	331 (10.8)	14 (7.3)	0 (0)
Clostridium botulinum	10 (1.8)	32 (1.0)	21 (10.9)	1 (50)
Bacillus cereus	4 (0.7)	19 (0.6)	0 (0)	0 (0)
Staphylococcus	5 (0.9)	12 (0.4)	0 (0)	0 (0)
Shigella sonnei	2 (0.4)	55 (1.8)	6 (3.1)	0 (0)
Campylobacter	1 (0.2)	3 (0.1)	0 (0)	0 (0)
Vibrio	1 (0.2)	2 (0.1)	0 (0)	0 (0)
Other bacterial	1 (0.2)	5 (0.2)	0 (0)	0 (0)
SUBTOTAL	**35 (6.4)**	**459 (15.0)**	**41 (21.3)**	**1 (50)**
Virus				
Norovirus	6 (1.1)	453 (14.8)	0 (0)	0 (0)
Rotavirus	1 (0.2)	5 (0.2)	2 (1.0)	0 (0)
SUBTOTAL	**7 (1.3)**	**458 (15.0)**	**2 (1.0)**	**0 (0)**
Parasite				
Anisakidae	1 (0.2)	14 (0.5)	0 (0)	0 (0)
SUBTOTAL	**1 (0.2)**	**14 (0.5)**	**0 (0)**	**0 (0)**
TOTAL	**550 (100)**	**3,052 (100)**	**193 (100)**	**2 (100)**

*Gempylotoxin (1/8) and unspecified chemical toxins (7/8)

TABLE 2. Univariate and multivariate logistic regression modeling of etiologic agent and fish as predictors of severe illness in fish-associated outbreaks, United States, 1998-2008.

	Odds of predictor resulting in severe illness			
	Univariate Analysis		*Multivariate Logistic Regression Model**	
Predictor	***Crude OR***	***95% CI***	***Adjusted OR***	***95% CI***
Etiologic Agent				
Other^	1.0	Reference	1.0	Reference
Scombroid toxin	1.0	0.6-1.5	1.0	0.6-1.5
Ciguatoxin	3.3	2.2-5.1	4.8	3.0-7.9
Salmonella	3.1	1.6-6.1	3.1	1.6-6.1
Clostridium botulinum	51.1	20.1-129.7	97.2	35.3-267.2
Fish Type				
Other°	1.0	Reference	1.0	Reference
Barracuda	12.1	7.9-18.8	11.4	7.2-17.9
Grouper	3.1	1.9-5.1	2.9	1.8-4.9

*Model controls for setting

^Etiologic agents other than scombroid toxin, ciguatoxin, *salmonella*, and *Clostridium botulinum*

°Fish types other than barracuda and grouper

N = 2,222 observations

OR = odds ratio

CI = confidence interval

TABLE 3. Outbreak state, etiology, setting and preparation by fish type, United States, 1998-2008.

	FISH TYPE						
	Tuna	**Mahi Mahi**	**Grouper**	**Escolar**	**Barracuda**	**Jack**	**Other***
No. of Outbreaks *(Total = 607)*	199	78	49	39	30	27	185
No. of Illnesses *(Total = 3,317)*	837	270	197	321	159	166	1,367
No. of Hospitalizations *(Total = 211)*	32	7	24	21	46	10	58
No. of Deaths *(Total = 2)*	–	–	–	–	–	–	2
Median Outbreak Size (Range)	2 (61)	2 (22)	3 (11)	5 (40)	4 (21)	3 (27)	3 (378)
Outbreaks (No.)							
Highest Year	2000 (27)	2003 (17)	2003 (10)	2001 (13)	2008 (6)	2002 (7)	1998 (31)
Lowest Year	2008 (9)	2007, 2008 (2)	1998 (2)	2008 (0)	2000, 2003 (0)	2004, 2006 (0)	2008 (6)
Highest Month	Aug (29)	Apr, Nov (10)	Jun (9)	Apr (10)	Jul, Aug (7)	Jun, Jul (5)	Jul (28)
Lowest Month	Feb (9)	Mar (1)	Jan, Nov, Dec (1)	Jan, Jun, Nov (1)	Apr, Oct (0)	Apr, Dec (0)	Feb, Mar (9)
State				**No. of Outbreaks (%)**			
Hawaii	39 (19.6)	44 (56.4)	24 (49.0)	1 (2.6)	4 (13.3)	12 (44.4)	83 (44.9)
Florida	23 (11.6)	16 (20.5)	19 (38.8)	6 (15.4)	18 (60.0)	12 (44.4)	42 (22.7)
California	25 (12.6)	6 (7.7)	1 (2.0)	11 (28.2)	–	–	9 (4.9)
New York	32 (16.1)	1 (1.3)	–	1 (2.6)	3 (10.0)	–	7 (3.8)
Other**	80 (40.2)	11 (14.1)	5 (10.2)	20 (51.3)	5 (16.7)	3 (11.1)	44 (23.8)
TOTAL (per fish type)	199	78	49	39	30	27	185
Total States = 607							
Etiology							
Scombroid	176 (93.6)	72 (96.0)	1 (2.3)	35 (89.7)	–	1 (4.2)	32 (21.2)
Ciguatoxin	–	1 (1.3)	42 (97.7)	–	30 (100.0)	23 (95.8)	77 (51.0)
Salmonella	3 (1.6)	–	–	–	–	–	8 (5.3)
Clostridium botulinum	1 (0.5)	–	–	–	–	–	9 (6.0)
Norovirus	2 (1.1)	–	–	–	–	–	4 (2.6)
TOTAL (per fish type)	188	75	43	39	30	24	151
Total Etiology = 550							
Setting							
Commercial	157 (83.5)	57 (77.0)	15 (33.3)	32 (86.5)	2 (7.1)	9 (33.3)	67 (38.7)
Private Home	16 (8.5)	6 (8.1)	29 (64.4)	2 (5.4)	24 (85.7)	16 (59.3)	93 (53.8)
Institutions	6 (3.2)	7 (9.5)	–	1 (2.7)	–	–	2 (1.2)
Mobile	2 (1.1)	3 (4.1)	–	–	1 (3.6)	–	7 (4.0)
Other***	7 (3.7)	1 (1.4)	1 (2.2)	2 (5.4)	1 (3.6)	2 (7.4)	4 (2.3)
TOTAL (per fish type)	188	74	45	37	28	27	173
Total Setting = 572							
Preparation (Single Method)							
Cook and Serve	64 (49.2)	42 (77.8)	18 (54.5)	15 (57.7)	7 (43.8)	15 (75.0)	45 (50.6)
Natural Toxicant	33 (25.4)	9 (16.7)	12 (36.4)	9 (34.6)	9 (56.3)	4 (20.0)	25 (28.1)
Raw, lightly cooked	21 (16.2)	–	1 (3.0)	1 (3.8)	–	–	11 (12.4)
TOTAL (per fish type)	130	54	33	26	16	20	89
Total Single Preparation = 368							

*Unspecified fish or specified fish types with less than 20 associated outbreaks

**All states not named above, including Washington D.C., Guam, and Puerto Rico

***Commercially prepared or contaminated import

TABLE 4. Setting as predictor of fish type, etiologic agent and method of preparation in fish-associated outbreaks, United States, 1998-2008.

	Odds of setting predicting outbreak associated factor			
	Commercial		***Private Home***	
	OR	***95% CI***	***OR***	***95% CI***
Fish Type				
Tuna	4.8	3.2-7.1	0.1	0.1-0.2
Mahi mahi	2.4	1.4-4.1	0.2	0.1-0.4
Grouper	0.3	0.2-0.6	3.8	2.1-6.8
Escolar	4.0	1.7-9.2	0.1	0.0-0.5
Barracuda	0.1	0.0-0.2	10.4	4.2-25.9
Jack	0.4	0.2-0.9	3.6	1.6-7.8
Etiologic Agent				
Scombroid toxin	7.8	5.4-11.2	0.1	0.0-0.1
Ciguatoxin	0.1	0.0-0.1	24.3	15.4-38.3
Clostridium botulinum	0.0	0.0-0.6	21.7	2.7-172.2
Method of Preparation				
Cook and Serve	1.4	1.0-2.0	*ns*	
Raw, lightly cooked	3.9	1.6-9.1	0.3	0.1-0.8

N = 607 observations
OR = odds ratio
CI = confidence interval
*All associations significant at p<0.05

TABLE 5. Outbreak fish type, etiology, setting and preparation, by state, United States, 1998-2008.

	STATE				
	Hawaii	**Florida**	**California**	**New York**	**Other***
No. of Outbreaks *(Total = 607)*	207	136	52	44	168
No. of Illnesses *(Total = 3,317)*	666	527	283	303	1,536
No. of Hospitalizations *(Total = 211)*	35	42	12	4	118
No. of Deaths *(Total = 2)*	1	–	1	–	–
Outbreaks (No.)					
Highest Year	2003 (35)	2001 (18)	2001 (8)	1999 (6)	2000 (21)
Lowest Year	2007 (4)	2008 (7)	2008 (1)	2001-3 (2)	2005 (7)
Highest Month	May (25)	Aug (18)	Aug (9)	Aug (9)	Jun, Aug (22)
Lowest Month	Feb (7)	Nov (5)	Dec (2)	Jan (0)	Feb, Mar (6)
Fish Type	**No. of Outbreaks (%)**				
Tuna	39 (18.8)	23 (16.9)	25 (48.1)	32 (72.7)	80 (47.6)
Mahi mahi	44 (21.3)	16 (11.8)	6 (11.5)	1 (2.3)	11 (6.5)
Grouper	24 (11.6)	19 (14.0)	1 (1.9)	–	5 (3.0)
Escolar	1 (0.5)	6 (4.4)	11 (21.2)	1 (2.3)	20 (11.9)
Barracuda	4 (1.9)	18 (13.2)	–	3 (6.8)	5 (3.0)
Jack	12 (5.8)	12 (8.8)	–	–	3 (1.8)
Other**	83 (40.1)	42 (30.9)	9 (17.3)	7 (15.9)	44 (26.2)
TOTAL (per state)	207	136	52	44	168
Total Fish Type = 607					
Etiology					
Scombroid	93 (45.6)	39 (40.0)	38 (76.0)	38 (88.4)	109 (70.3)
Ciguatoxin	106 (52.0)	46 (46.9)	3 (6.0)	3 (7.0)	15 (9.7)
Salmonella	–	1	–	2 (4.7)	8 (5.2)
Clostridium botulinum	–	–	2 (4.0)	–	8 (5.2)
Norovirus	–	–	1 (2.0)	–	5 (3.2)
TOTAL (per state)	204	98	50	43	155
Total Etiology = 550					
Setting					
Commercial	71 (36.2)	85 (65.9)	38 (74.5)	35 (85.4)	110 (71.0)
Private Home	110 (56.1)	37 (28.7)	8 (15.7)	3 (7.3)	28 (18.1)
Institutions	6 (3.1)	1 (0.8)	1 (2.0)	1 (2.4)	7 (4.5)
Mobile	6 (3.1)	3 (2.3)	1 (2.0)	–	3 (1.9)
Other***	3 (1.5)	3 (2.3)	3 (5.9)	2 (4.9)	7 (4.5)
TOTAL (per state)	196	129	51	41	155
Total Setting = 572					
Preparation (Single Method)					
Cook and Serve	89 (67.9)	52 (65.0)	14 (40.0)	8 (25.0)	43 (47.8)
Natural Toxicant	28 (21.4)	17 (21.3)	6 (17.1)	23 (71.9)	27 (30.0)
Raw, lightly cooked	6 (4.6)	5 (6.3)	11 (31.4)	1 (3.1)	11 (12.2)
TOTAL (per state)	131	80	35	32	90
Total Single Method Preparation = 368					

*All states not named, including Washington D.C., Guam, and Puerto Rico

**Unspecified fish or specified fish types with less than 20 associated outbreaks

***Commercially prepared or contaminated import

FIGURE 1. Reported fish-associated outbreaks and illnesses, United States, 1998-2008.

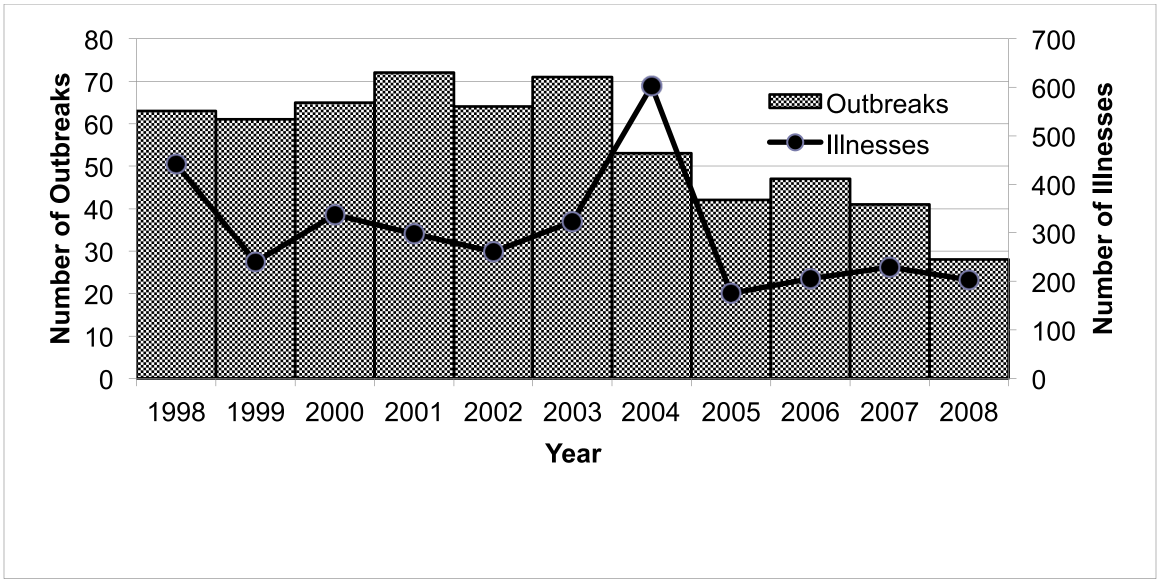


FIGURE 2. Reported fish-associated outbreaks and illnesses by month, United States, 1998-2008.

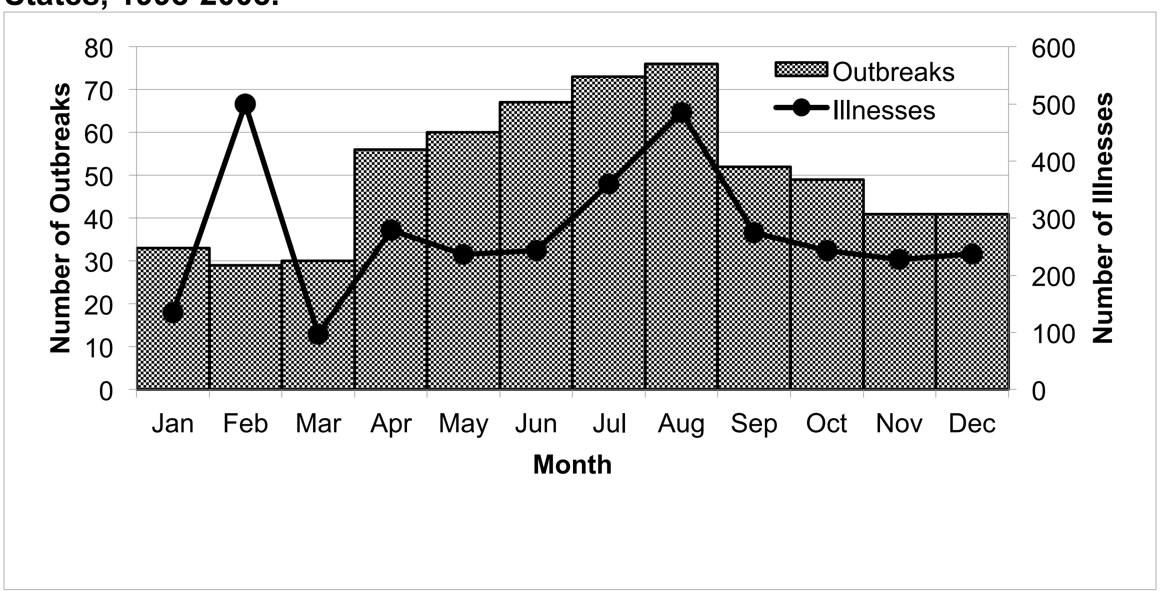


FIGURE 3. Reported fish-associated outbreaks by state, United States, 1998-2008.

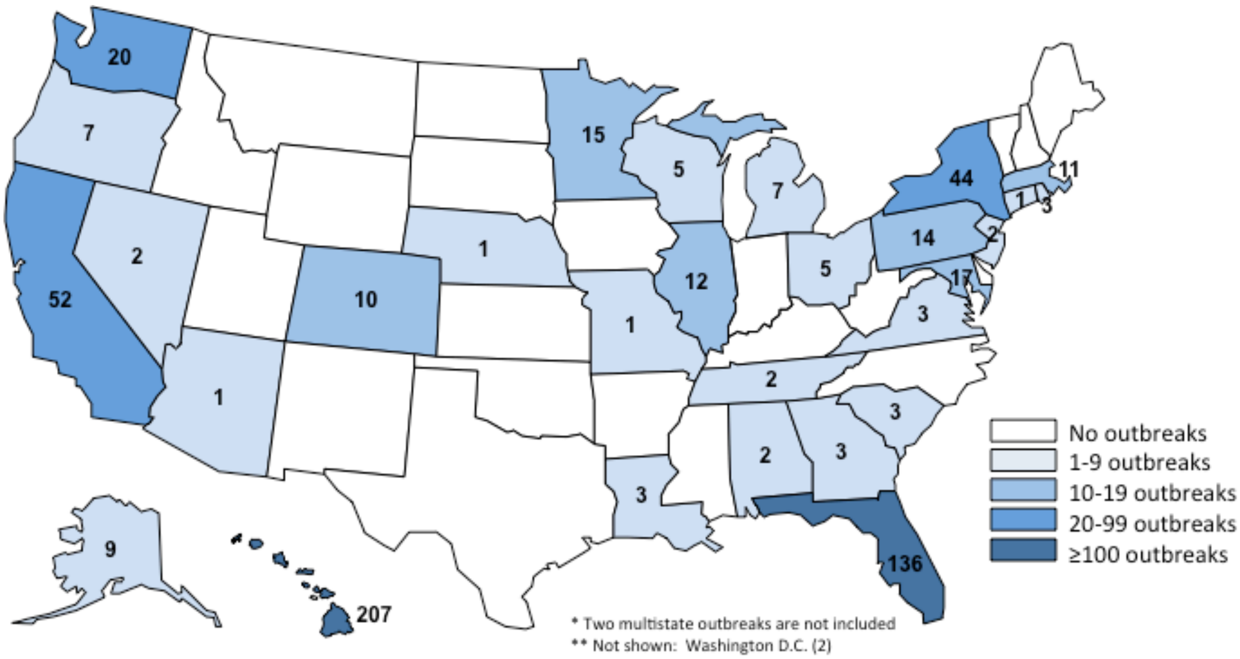


FIGURE 4. Number of fish-associated outbreaks per state by year, United States, 1998-2008.

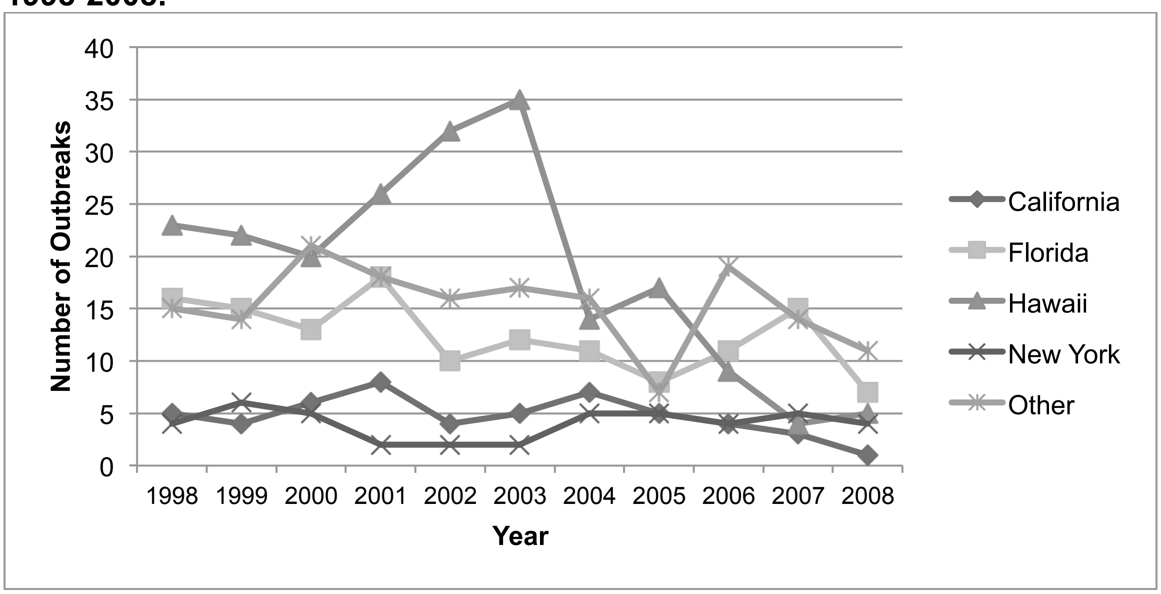


FIGURE 5. Etiologic agents scombroid toxin, ciguatoxin and others combined, of fish-associated outbreaks, United States, 1998-2008.

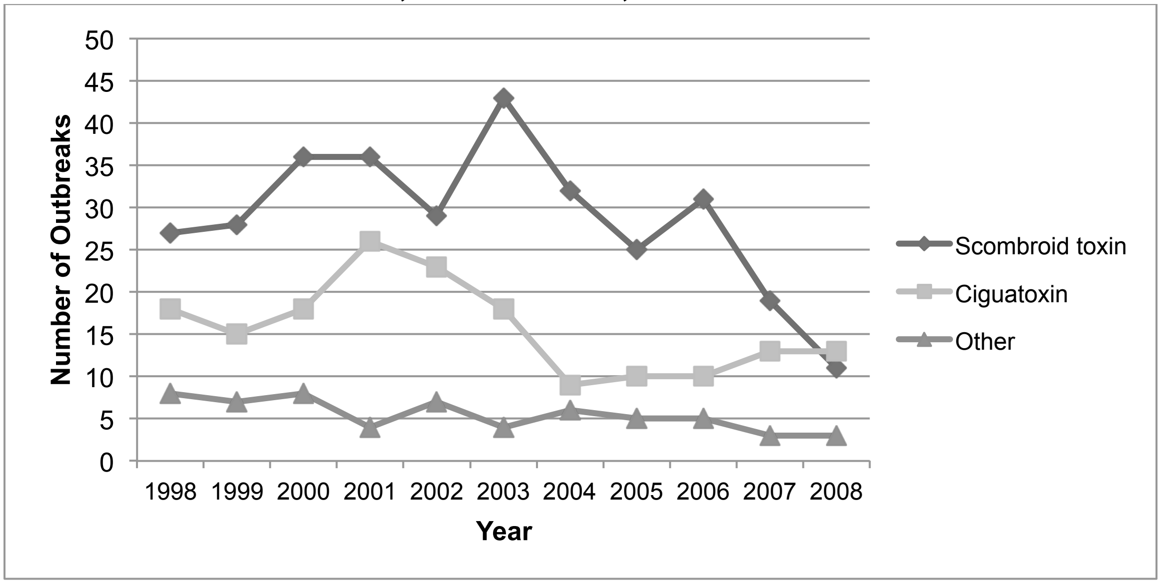


FIGURE 6. Fish type associated with outbreaks by year, United States, 1998-2008.

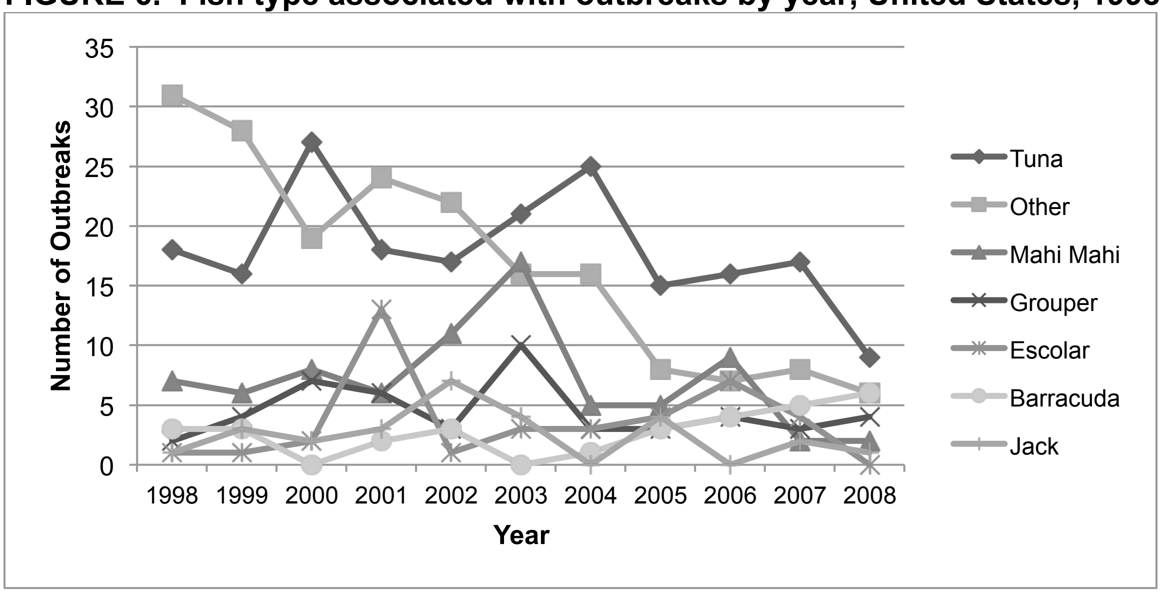


FIGURE 7. Fish type associated with outbreaks by month, United States, 1998-2008.

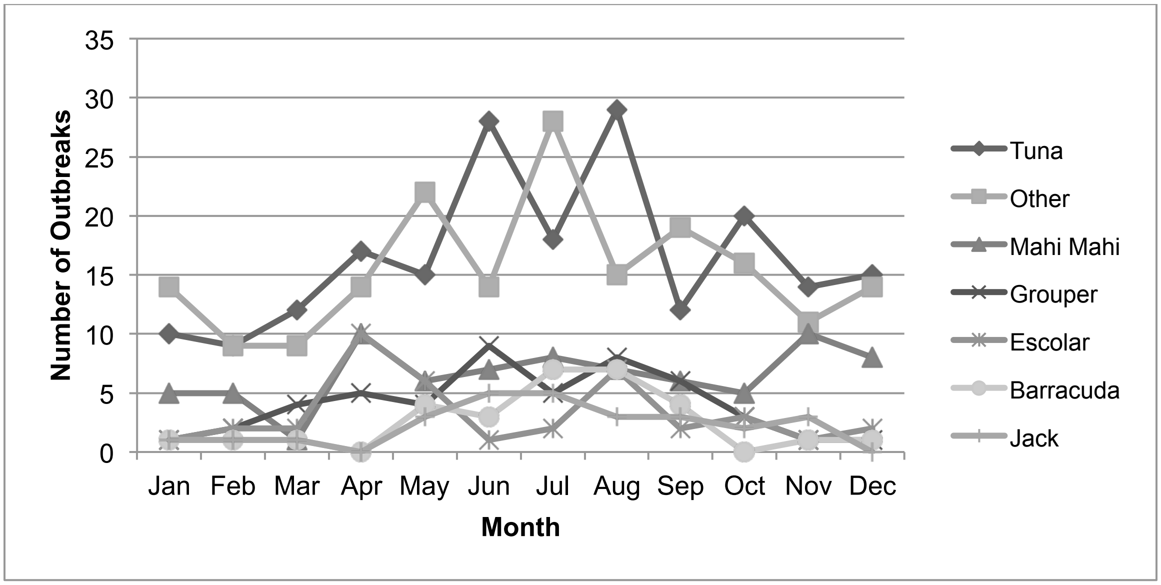


Figure 8. Setting of fish-associated outbreaks by fish type, United States, 1998-2008.

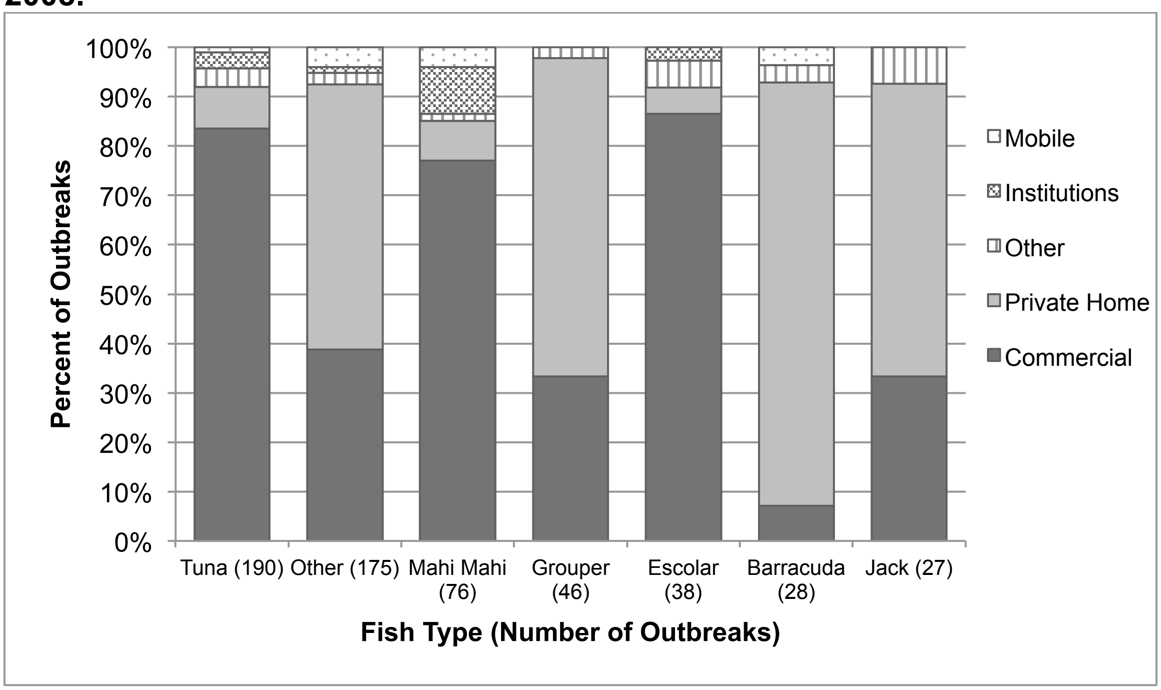


Figure 9. Etiologic agent of fish-associated outbreaks by setting, United States, 1998-2008.

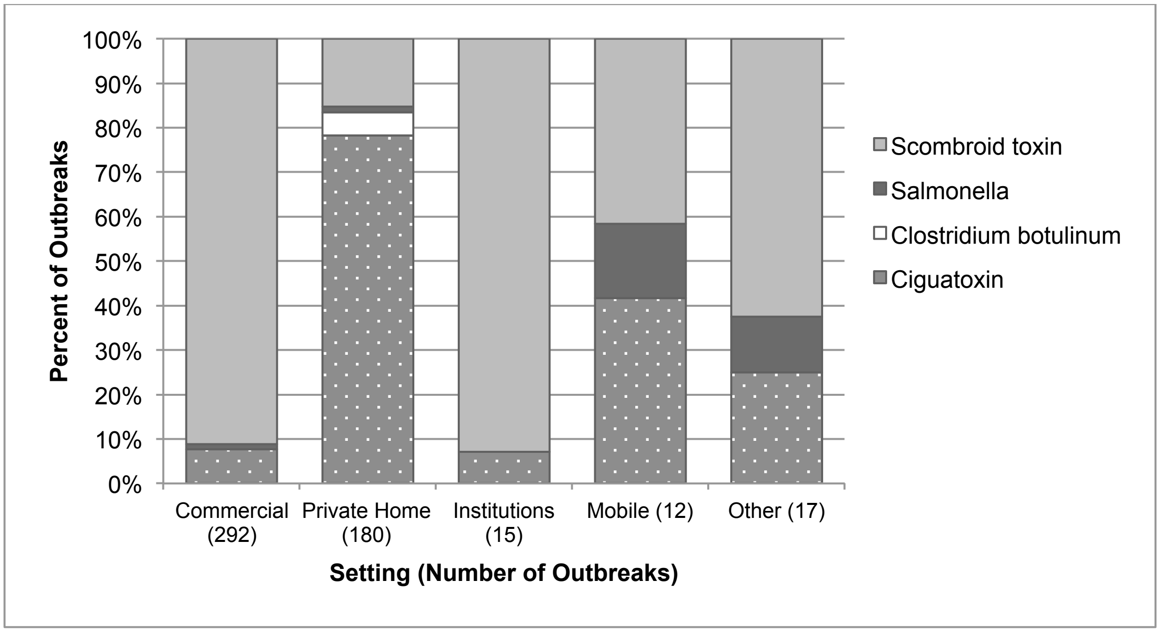


Figure 10. Method of preparation of fish-associated outbreaks by etiology, United States, 1998-2008.

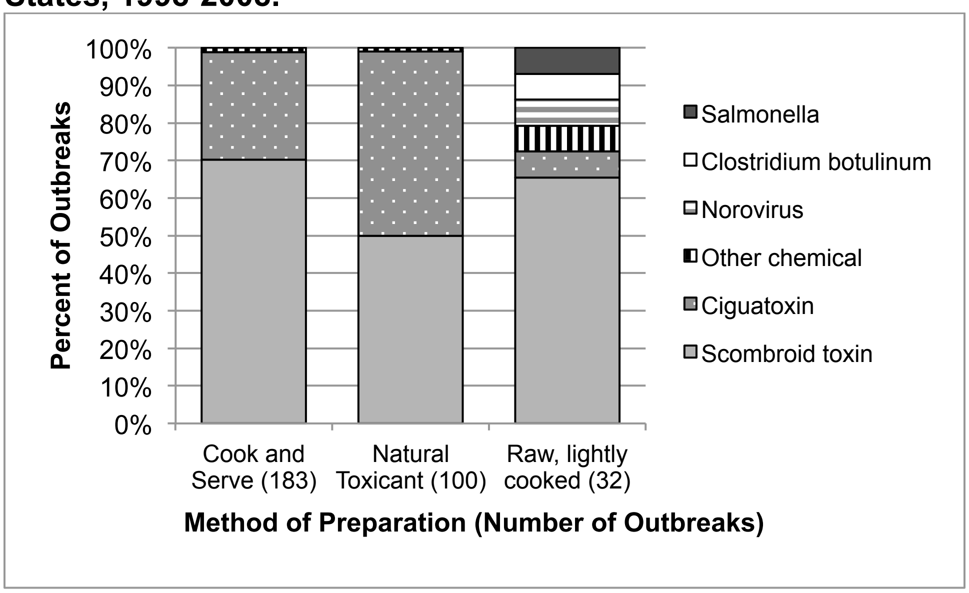


Figure 11. Method of preparation of fish-associated outbreaks by state, United States, 1998-2008.

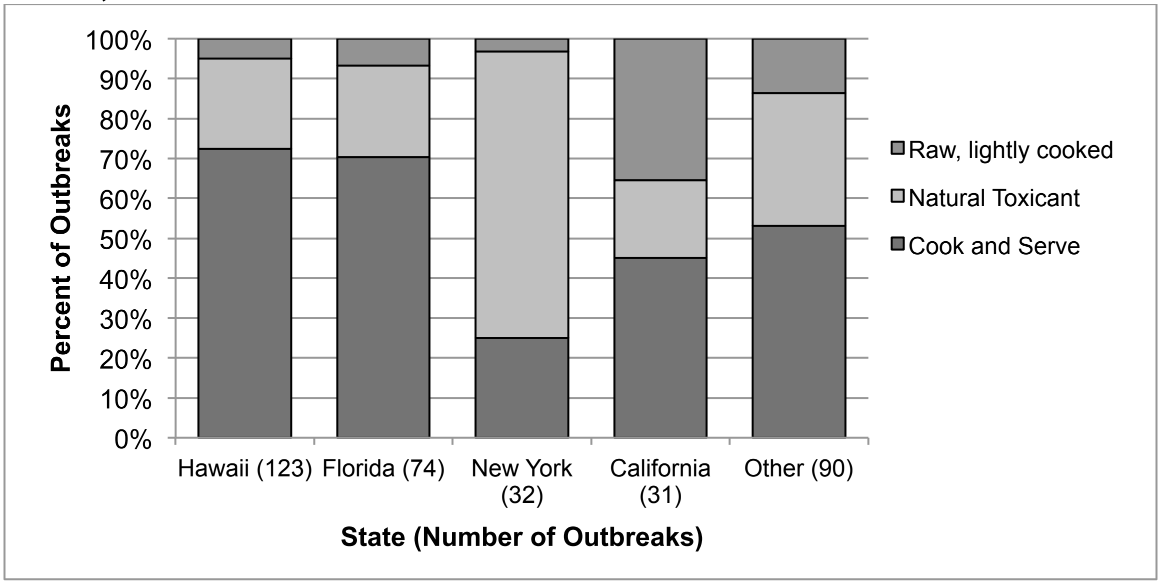
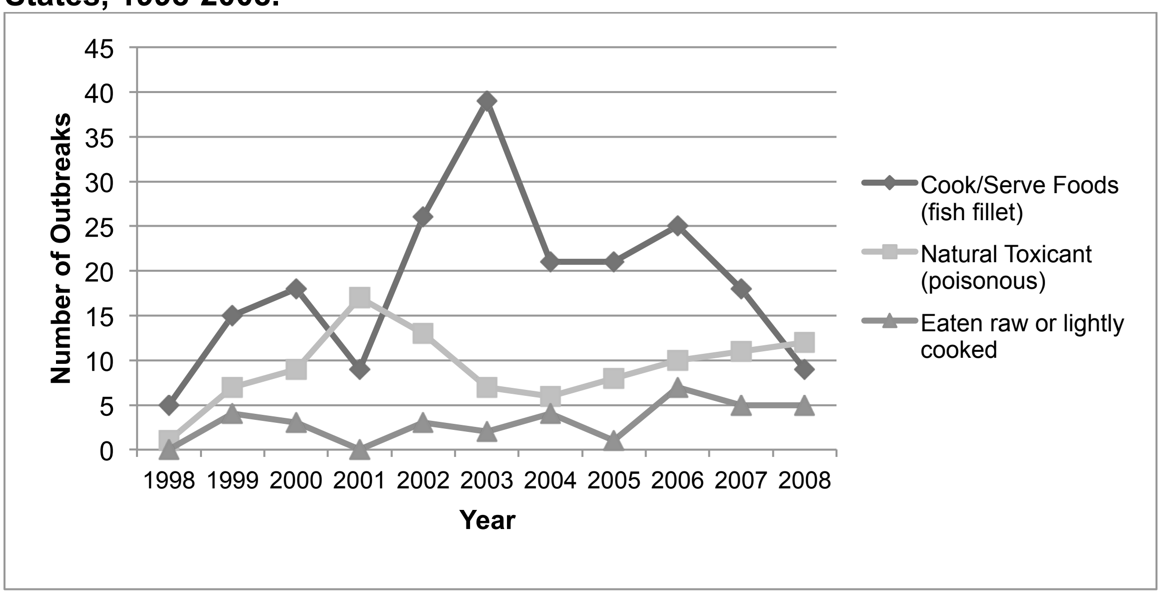


Figure 12. Method of preparation of fish-associated outbreaks by year, United States, 1998-2008.



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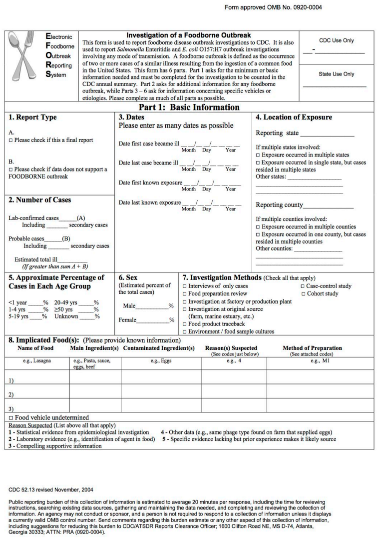
APPENDICES

Appendix I. Electronic Foodborne Outbreak Reporting System (eFORS) form.



Form approved OMB No. 0920-0004

Electronic Foodborne Outbreak Reporting System

Investigation of a Foodborne Outbreak

This form is used to report foodborne disease outbreak investigations to CDC. It is also used to report *Salmonella* Enteritidis and *E. coli* O157:H7 outbreak investigations involving any mode of transmission. A foodborne outbreak is defined as the occurrence of two or more cases of a similar illness resulting from the ingestion of a common food in the United States. This form has 6 parts. Part 1 asks for the minimum or basic information needed and must be completed for the investigation to be counted in the CDC annual summary. Part 2 asks for additional information for any foodborne outbreak, while Parts 3 – 6 ask for information concerning specific vehicles or etiologies. Please complete as much of all parts as possible.

CDC Use Only ___-___________

State Use Only ___________

Part 1: Basic Information

1. Report Type

A.
□ Please check if this a final report

B.
□ Please check if data does not support a FOODBORNE outbreak

2. Number of Cases

Lab-confirmed cases______(A)
Including _______ secondary cases

Probable cases______(B)
Including _______ secondary cases

Estimated total ill__________
(If greater than sum A + B)

3. Dates
Please enter as many dates as possible

Date first case became ill __ __/__ __/__ __ __ __ (Month Day Year)

Date last case became ill __ __/__ __/__ __ __ __ (Month Day Year)

Date first known exposure __ __/__ __/__ __ __ __ (Month Day Year)

Date last known exposure __ __/__ __/__ __ __ __ (Month Day Year)

4. Location of Exposure

Reporting state ______________

If multiple states involved:
□ Exposure occurred in multiple states
□ Exposure occurred in single state, but cases resided in multiple states
Other states: ______________

Reporting county______________

If multiple counties involved:
□ Exposure occurred in multiple counties
□ Exposure occurred in one county, but cases resided in multiple counties
Other counties: ______________

5. Approximate Percentage of Cases in Each Age Group

<1 year _____% 20-49 yrs _____%
1-4 yrs _____% ≥50 yrs _____%
5-19 yrs ____% Unknown _____%

6. Sex
(Estimated percent of the total cases)

Male___________%

Female___________%

7. Investigation Methods (Check all that apply)
□ Interviews of only cases
□ Food preparation review
□ Investigation at factory or production plant
□ Investigation at original source (farm, marine estuary, etc.)
□ Food product traceback
□ Environment / food sample cultures
□ Case-control study
□ Cohort study

8. Implicated Food(s): (Please provide known information)

Name of Food	Main Ingredient(s)	Contaminated Ingredient(s)	Reason(s) Suspected (See codes just below)	Method of Preparation (See attached codes)
e.g., Lasagna	e.g., Pasta, sauce, eggs, beef	e.g., Eggs	e.g., 4	e.g., M1
1)				
2)				
3)				

□ Food vehicle undetermined

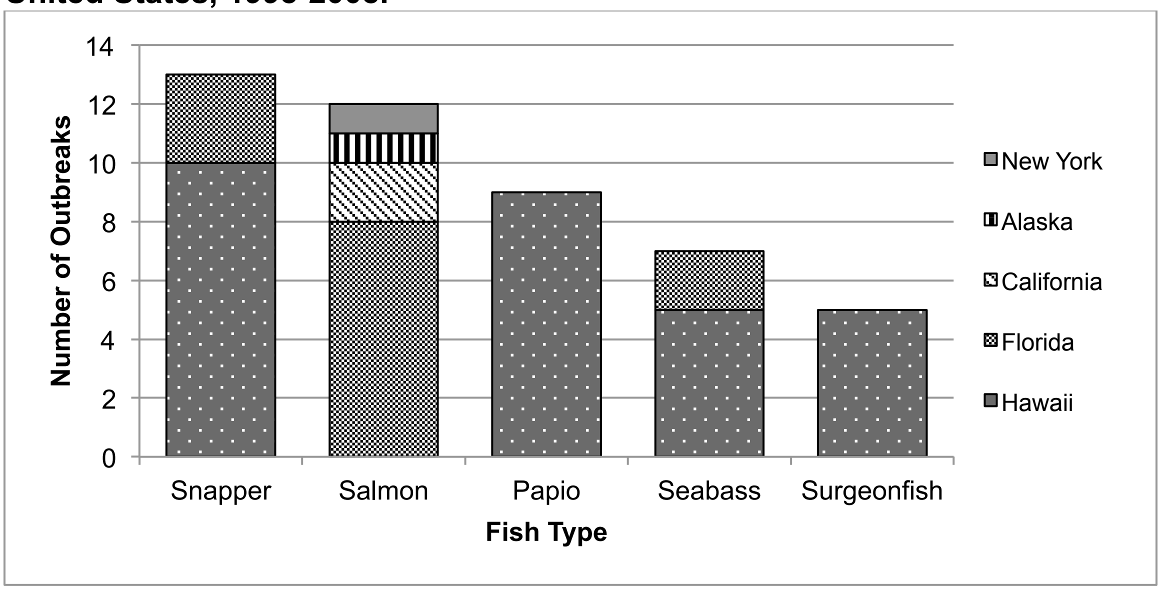
Reason Suspected (List above all that apply)
1 - Statistical evidence from epidemiological investigation
2 - Laboratory evidence (e.g., identification of agent in food)
3 - Compelling supportive information
4 - Other data (e.g., same phage type found on farm that supplied eggs)
5 - Specific evidence lacking but prior experience makes it likely source

CDC 52.13 revised November, 2004

Public reporting burden of this collection of information is estimated to average 20 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to CDC/ATSDR Reports Clearance Officer; 1600 Clifton Road NE, MS D-74, Atlanta, Georgia 30333; ATTN: PRA (0920-0004).

The complete 6-page CDC eFORS form, used through 2008, may be found at www.cdc.gov/outbreaknet/toolkit/efors_form.pdf.

Appendix II. Reported outbreaks with fish types from "other" category by state, United States, 1998-2008.



"Other" fish type reported with at least one associated outbreak include: bass, bluefish, catfish, cod, eel, flounder, gifilte, goatfish, haddock, knifejaw, kole, marlin, milkfish, mullet, parrot, perch, puffer, seabass, skate, snapper, sole, surgeonfish, swordfish, tilapia, trout, whale, whitefish.

Appendix III. Methods of preparation reported in fish-associated outbreaks.
The following methods were reported as associated with at least one fish-associated outbreak: foods eaten raw or lightly cooked, solid masses of potentially hazardous foods, multiple foods, cook/serve foods, natural toxicant, salads prepared with one or more cooked ingredients, liquid or semi-solid mixtures of potentially hazardous foods, chemical contamination, commercially processed foods, sandwiches, salads with raw ingredients, other/does not fit into other categories.