ABSTRACT

Title of Thesis:	MARK-RECAPTURE ASSESSMENT OF THE RECREATIONAL BLUE CRAB (*Callinectes sapidus*) HARVEST IN CHESAPEAKE BAY, MARYLAND
	Robert Francis Semmler, Master of Science, 2016
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In Maryland, commercial blue crab (*Callinectes sapidus*) harvests are monitored through mandatory, annual harvest reporting, but no annual monitoring exists for recreational fishers. This study used a large-scale mark-recapture program to assess relative exploitation between the recreational and commercial fishing sectors in 15 harvest reporting areas of Maryland, then incorporated movement information and extrapolated reported commercial harvest data to generate statewide estimates of recreational harvest. Results indicate spatial variation in recreational fishing, with a majority of recreational harvests coming from tributaries of the Western Shore and the Wye and Miles Rivers on the Eastern Shore. Statewide, recreational harvest has remained approximately 8% as large as commercial harvest despite management changes in 2008, and remains a larger proportion (12.8%) of male commercial harvest. In addition, this study provides detailed spatial information on recreational harvest and the first information on rates of exchange of male crabs among harvest reporting areas.

MARK-RECAPTURE ASSESSMENT OF THE RECREATIONAL BLUE CRAB (*Callinectes sapidus*) HARVEST IN CHESAPEAKE BAY, MARYLAND

By

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Introduction:

The size of the recreational blue crab (*Callinectes sapidus*) harvest in Maryland has been a controversial topic in management of the blue crab fishery, with little data available. While commercial blue crab fishers are required to report their harvest each year to the Maryland Department of Natural Resources, no such reporting system exists for recreational harvest. This study provides an update to prior estimates of recreational harvest, based on surveys of recreational fishers, which were performed in 2001, 2002, 2005, and in 2011 after recreational harvest of female crabs was banned in 2008. Despite consistent estimates of the size of the recreational fishery relative to the commercial fishery both before and after the ban on recreational harvest of females, there remains substantial debate about the size of recreational harvest. The present study used a mark-recapture experiment to evaluate variation in recreational harvest, both temporally across the crabbing season, and spatially across Maryland waters. This approach, distinctly different from prior survey methods, provided a direct, independent estimate that should greatly reduce uncertainty in the size of the recreational harvest.

Blue Crab Biology and Life History:

The blue crab is a widely-dispersed Portunid crab. Its range extends over a wide portion of the Atlantic coast of the Americas, stretching from Nova Scotia to Argentina (Williams 1984). It serves ecologically important roles both as a dominant benthic predator, consuming a wide variety of prey, including bivalves, small fish, and other crustaceans, and as prey for many species (Mansour and Lipcius 1991, Hines 2007). The blue crab preferentially occupies estuaries and coastal bays during juvenile and adult stages. It is considered part of the guild of Estuarine Migrant species, because it spends the majority of its life within estuaries, but also has larval stages that must be completed outside of the estuary (Elliot et al. 2007).

Blue crabs have a complex life history. Blue crab mating occurs primarily in up-estuary lower salinity waters (Epifanio 2007). After mating, female blue crabs move to more saline spawning grounds near the mouths of estuaries (Van Engel 1987) or in the ocean (Gelpi et al. 2009, Ogburn and Habegger 2015). Upon arriving in spawning areas they will extrude their eggs onto the abdomen, fertilizing them with stored sperm (Van Engel 1987). After 2 to 3 weeks of embryonic development, their young will hatch from the abdomen as free swimming larvae called zoea (Kuris 1991, Cargo 1958).

Blue crab zoea hatched at the mouth of estuaries then disperse within coastal pelagic waters (McConaugha et al. 1983, Epifanio et al. 1984). While in open water, zoea feed on prey as they encounter them, and grow through seven zoeal stages. After 31 to 49 days (Costlow and Bookhout 1959), these larvae will molt into a megalopa stage and will recruit back to the estuary via advective transport. Megalopa ingress and settlement in estuaries display a pattern of low, consistent settlement, punctuated by episodic pulses in settlement, directed by wind-driven currents, as well as other physical events such as nighttime floodtides, high pressure systems, or hurricanes (Van Montfrans et al. 1995, Epifanio and Garvine 2001, Ogburn et al. 2009, Ogburn et al. 2011, Biermann et al. 2015).

While inside the estuary, juvenile crabs use seagrasses, coarse woody debris, marsh, and shallow shorelines within these zones as nursery habitat, taking refuge within them against predation (Heck and Spitzer 2001, Ruiz et al. 1993, Dittel et al. 1995, Lipcius et al. 2007). Juvenile crabs appear to seek these structured habitats, changing their swimming behavior and metamorphosis in response to chemical cues indicating their presence (Epifanio 2007). Chemical cues for metamorphosis and settlement identified include salinity, humic acids (Forward et al 1997b), and exudates from species of seagrass (Forward et al. 1996) and macroalgae (Brumbaugh and McConaugha 1994).

After growing to >20 cm, juvenile crabs experience reduced predation risk in unstructured habitat (Pile et al. 1996; Hovel and Lipcius 2001; Lipcius 2007). Juveniles will then undergo secondary dispersal (Pile et al. 1996, Hines et al. 1987, Hines et al. 1990) from structured habitats like seagrass to more open habitats like mud-flats where there are more prey to feed on. While the structured habitats they previously occupied remain safe for larger juveniles, they may maximize their growth by dispersing into zones that are not as densely occupied and will result in less competition for food and resources (Perkins-Viser et al. 1996; Lipcius 2007). While dispersed, juveniles >20 cm will remain within subestuaries, meandering along shorelines and avoiding the deepest waters to reduce their risk of cannibalism by adult blue crabs (Hines and Ruiz 1995, Hines et al. 1995).

The adult blue crab population is characterized by distinct patterns of movement which dictate many aspects of its population dynamics. In addition to the migration pattern of mature spawning females described above, there are also shortterm, non-migratory movement behaviors, which are observed among all adults (Hines 2007). Previous mark-recapture studies have shown adult blue crab rates of movement of 400-900 m per day (Souza et al 1980), with adult males typically exhibiting random, non-directed movements (Fielder 1930, Truitt 1939, Cronin 1949). Small scale-movements in blue crabs may be directed by both orientation with the sun and alignment with the direction of tidal surge (Nishimoto and Herrnkind 1978). Although juveniles will remain in their given sub-estuary to avoid exposure to predation, the rapid movements of adults can take them both out into the mainstem of the Bay, as well as into other sub-estuaries (Wolcott and Hines 1990). Despite the valuable information provided by mark-recapture studies, they only provide the final recapture location of crabs, with no information on the path taken by crabs, or the conditions driving their movement.

The use of ultrasonic telemetry has helped to illuminate some of the mystery behind the paths of small-scale movement behaviors as well as possible motivations for movement. Average movement speeds, as well as habitat selection, vary by season, size and molt stage (Hines 2007, Clark et al.1999a, Wolcott and Hines 1990). Movement speeds are greater in the warmer mid-summer months (15 m/hr) than in the spring or fall (5 m/hr). Despite consistent average speeds, movement patterns observed for the tagged crabs illustrate a clear dichotomy between slow meandering movements that dominate the majority of movement behavior and sudden rapid directional movements that are less frequent (Hines et al. 1995). The distinction between which of these behavior patterns occurs is often a result of foraging characteristics related to habitat quality or competitive interactions. Generally, meandering movements coincided with bouts of feeding, indicating connections between these movements and foraging activity (Wolcott and Hines 1989a). Rapid directional movements, on the other hand, did not coincide with feeding, and may be a result of predator avoidance (Hines and Ruiz 1995), or agonism between competing adult crabs (Clark et al. 1999a).

Habitat shifts by adult crabs, rapid or otherwise, may be a result of shifts in the quality of foraging habitat, or the benefit that habitat provides to the individual. For example, when anoxoic conditions develop, either from phytoplanktion blooms or sudden influxes of anoxic water, crabs may rapidly move shoreward en masse, in a behavior known as a "jubilee" (Loesch 1960). Similar effects can be seen from other factors influencing habitat quality, such as prey density or density of conspecifics. As blue crab prey are distributed in a patchy manner (Clark et al. 2000), their foraging is subject to effects of the size, dispersal, and prey density of patches. Feeding rates generally increase with increasing prey densities, however the functional response observed in blue crabs is not clear and differs based on habitat type and prey item consumed (Lipcius and Hines 1986, Eggleston et al 1992). Nonetheless, crabs preferentially forage upon those prey patches with greater prey densities, and lower densities of conspecifics (Clark et al.1999a, Clark et al. 2000) because they provide a greater benefit to the individual. In patches with a high density of conspecifics, predation is inhibited not only due to faster reductions in prey density but also due to agonistic behaviors interfering with foraging. Crabs in patches with high densities of conspecifics may abandon those patches as a result of these effects (Clark et al. 1999a). These effects were confirmed with enclosed field experiments of optimal foraging under different patch densities and crab densities (Clark et al. 1999a, Clark et al. 2000).

Importance and History of the Fishery:

Blue crabs have been harvested from the Chesapeake Bay and its tributaries as a food source for millennia. Preserved blue crab remains from oyster shell middens have been uncovered that indicate harvest of crabs by Early Woodland Native Americans at least 3200 years ago (Rick et al. 2015). Blue crabs continued to provide subsistence to many groups living in the Chesapeake region, including early European settlers in the 1600s (Wharton 1954; Kennedy et al 2007, Rick et al. 2015). Commercial harvest was established shortly thereafter. However, the market for blue crabs, and in turn the scale of fishery operations, expanded greatly in the late 1800s when improved refrigeration technologies allowed for preservation of crab meat (Donaldson and Nagengast 1994) and construction of rail systems made long-distance transport of crabs possible (Johnson 1988), developing inland markets for their sale. With declines in harvest in New York and New Jersey (Van Engel 1999), as well as new processing technologies, the proportion of harvest coming from the Chesapeake grew, and by the mid-1900s it represented roughly half of U.S. landings. Over the years many different harvest technologies were developed, including push net, scrapes and haul seines (Cargo 1954). However, with the invention of the crabpot in the mid-1900s (Van Engel 1962), the crab pot became the major gear used to harvest crabs in many of the US blue crab fisheries, including the Chesapeake Bay (Pearson 1942, Cronin 1950). Today recreational fishers catch crabs via trotline, or pier-pot (crab pots attached to a dock on the fisher's property) in the tributaries of Maryland

and Virginia, with a smaller fraction of harvest coming in from baited handlines and collapsible traps. Commercial fishers catch hard crabs via trotline in Maryland tributaries and via crab pot in the mainstem areas of Maryland, in both the mainstem and tributaries of Virginia, and in the Potomac River. There is also a fishery for soft crabs, which are caught by crab scrapes (Roberts 1905) or as peelers in peeler pots and held in shedding floats or tanks (Kennedy et al. 2007). Additionally, until recent years, a sizeable portion of crab landings in Virginia came from a wintertime dredge fishery that targeted dormant female crabs overwintering near the mouth of the Bay (Chowning 1990).

From 2008 to the most recent data in 2014, the annual dockside value of crabs landed in the Chesapeake has ranged from roughly $68 million to $108 million. The blue crab fishery is the most valuable fishery in the Chesapeake Bay and its successful operation has a significant impact on both the economy and cultural identity of Maryland and Virginia (NMFS 2014). As such, much effort has been invested by the Chesapeake Bay Program, Chesapeake Bay Stock Assessment Committee (CBSAC) and the three Chesapeake Bay fishery management jurisdictions: Maryland Department of Natural Resources (MD DNR), Virginia Marine Resources Commission (VMRC), and Potomac River Fisheries Commission (PRFC), into understanding the fishery and its proper management. This proves a difficult task as the fishery contains multiple commercial and recreational sectors and effort within the fishery varies both regionally and over the course of the fishing season (Kennedy et al. 2007). Nationally, the commercial blue crab fishery brings in a dockside value ranging from roughly $161 million to $216 million, with the

Chesapeake Bay portion bringing about 40% of all dollars. It is also among the top 10 most lucrative U.S. fisheries by species.

In 2008, following over a decade of low abundance and declining harvest, the Chesapeake Bay Stock Assessment Committee implemented new target and threshold values for the population (CBSAC 2008). Under this assessment strategy a target population of 200 million male and female adult crabs was set with a threshold of 86 million adult crabs, below which the population would be considered overfished. This was based on data from the Winter Dredge Survey (WDS), an annual measure of crab abundance between harvest seasons. The WDS is performed in collaboration between MD DNR and the Virginia Institute of Marine Science. It utilizes a stratified random sampling design of over 1500 sites across the Chesapeake Bay (Sharov et al. 2003). CBSAC proposed that jurisdictional managers meet these new standards by protecting female crabs, in order to improve spawning potential and restore the population. All three management jurisdictions (MD DNR, VMRC, and PRFC) agreed on the recommendation and imposed new harvest restrictions with the goal of reducing the harvest of female crabs by one-third. These included banning the harvest of female crabs by recreation fishers in Maryland, closing of the winter dredge fishery in Virginia, which primarily targeted dormant female crabs, and shortening the female harvest season in the Potomac River (CBSAC 2010).

In the years following these new restrictions, juvenile and adult population size quickly increased, with adult numbers surpassing the target value by 2010. Recently however, the population dropped again, hitting a low of 68.5 million by 2014 (MD DNR 2016). To date there has been no substantial evidence indicating a particular cause for this decline (Nesslage et al. 2015), however possible reasons that have been suggested include harsh abiotic conditions such as a cold snap in the winter of 2013-’14, increased predation from a potentially increasing population of Red Drum (*Sciaenops ocellatus),* and increased disease mortality due to the spread of CsRV1, a blue crab-infecting reovirus (MD DNR 2014, Bowers et al. 2011, Flowers et al. 2016). However, the actual cause or causes of this decline remain unknown. Nonetheless, these concerns have been alleviated to some extent because female spawning stock grew by 46% in 2015, grew by an additional 135% in 2016, and is now near the target value of 215 million spawning females (VIMS 2016).

Current Stock Assessment

The current stock assessment strategy was developed in 2011, which considered males and females separately and set female specific reference points. This assessment also revealed that the declining catches and the extended period of low abundance before 2008 were due to overfishing of female crabs. Currently, population reference points include a target abundance of 215 million age-1+ female crabs, and a threshold abundance of 70 million age-1+ female crabs (CBSAC 2015). Stock status is assessed both by female abundance, and by the fraction of exploitable females (age-1+) harvested in a given season. Reference points for exploitation fraction include a target value of 25.5% and a threshold of 34%. Exploitation fraction is calculated as the number of mature female crabs harvested divided by the predicted abundance of exploitable females before the start of the harvest season. Female harvests are determined from reported commercial catches and exploitable female abundances are determined from the WDS. In the latest version of this assessment, the recreational harvest in Maryland, which has exclusively targeted male crabs since 2008, is estimated as 8% of male commercial catch (CBSAC 2016).

In addition to female specific reference points, managers have also implemented male conservation triggers, or thresholds of adult male exploitation which would necessitate management practices to conserve males as well as females (CBSAC 2015). It was determined that male conservation measures will be implemented if either the male exploitation fraction exceeds 33%, or if a total exploitation fraction of 53% of males and females is reached despite not meeting the female overfishing threshold. 33% was chosen as the primary trigger as this was the second highest exploitation fraction observed since 1990, allowing a buffer around the highest observed exploitation. Neither trigger has been reached since the new harvest restrictions in 2008, so no male conservation actions have been put in place to date.

Assessment of Recreational Fishing

The most recent assessment of recreational fishing in Maryland was performed in 2011, and was a continuation of prior surveys performed in 2001, 2002, and 2005. The sampling methods for the initial survey was based off of a pilot study in 2001 which assessed different sampling designs and their statistical efficacy (Miller et al. 2001). The survey design based on this work assessed recreational effort and harvest levels through a combination of telephone surveys, intercept interviews at public fishing sites, and log-books maintained by coastal households (Ashford and Jones 2001). After 2001 a standard set of survey methods was used, incorporating telephone and intercept methods (Ashford and Jones 2002, Ashford and Jones 2005, Ashford and Jones 2011). Telephone surveys involved random digit dialing from lists of households in coastal counties, recreational crabbing license holders, and waterfront property owners. The survey determined that, when corrected for public vs private access biases, recreational crabbers in Maryland took a total of roughly 523,000 trips and caught a total of roughly 3,195,000 crabs in that year (Ashford and Jones 2002). These values were found to be substantially higher than those in Virginia (109,000 trips and 720,547 crabs), indicating that while recreational fishing may make up a significant portion of harvest in Maryland, it may not be as important in Virginia. In total, baywide recreational harvests were estimated to be 5.3% to 8.5% as large as commercial harvests in 2002, and an 8% ratio of recreational to commercial harvest was assumed across all zones of the Bay in the stock assessment model (CBSAC 2011). Since 2008, recreational harvest is assumed to be 8% of males in Maryland and 8% of total harvest in other jurisdictions (CBSAC 2016).

Telephone surveys, intercept interviews, and log-books are subject to particular biases, and a combination of these methods was used in order to adjust for inaccuracies that can occur when any of these methods is performed individually. Telephone surveys are often the simplest and cheapest method of surveying anglers, however they can be prone to recall bias, or error and inaccuracy in harvest values recalled by fishers (Ashford and Jones 2001). Intercept surveys conducted at public piers as fishers return to shore are less affected by recall bias, because they involve interviewing anglers as they are landing their catch. Intercept surveys also allow surveyors to ensure proper identification of the target species, which, while not a significant concern in the Chesapeake Bay blue crab fishery, could cause errors in catch rate. However, intercept surveys are subject to their own sampling biases becuase they are performed solely at public access piers. Use of intercept survey data alone requires the assumption that fishers in both private and public fishing locations behave similarly. This assumption was not met for the crab fishery, because public access fishers generally had greater catch per trip than those with private access (Ashford et al. 2010a). In Maryland, 61% of recreational boat trips for crabs were from private access sites (Ashford et al. 2010b). In Virginia, this figure was even greater, making up 83% of boat trips. As a result, survey methods which solely use intercept sampling at public access docks significantly overestimate recreational harvest. Lastly, log-book surveys are subject to less recall bias than telephone surveys, but it is possible to undersample those who only participate in the recreational fishery infrequently.

Combined, the telephone, pier intercept, and log book surveys provide a broad understanding of recreational harvest in Chesapeake Bay, and has shown that the level of recreational harvest has been stable over the four years surveyed (2001, 2002, 2005, 2011). However, because all four years of the study share the same methods, there is no way to independently assess the impact of known biases. Therefore, there is some uncertainty in the survey results and concerns that recreational harvest may be underestimated in the stock assessment (Addison 2011, Dichmont 2011, Ernst 2011). These concerns led to the inclusion of recreational harvest assessment as a critical research need (Fogarty and Lipcius 2007; Miller et al. 2011; CBSAC 2013), and were the justification for conducting the present study.

Unlike fisher surveys, mark-recapture methods provide a direct method for estimating the fraction of harvest by recreational fishers. Direct estimates of harvest avoid potential biases due to self-reporting that can be difficult to account for in surveys of fishers. Mark-recapture estimation methods use the act of capture of a marked organism as the basis for their calculations, rather than self-reported harvest values. In this way, a mark-recapture assessment provides independent evidence that can be used to support or refine survey based methods. However, mark-recapture methods are also subject to potential biases (unequal reporting of marked individuals, mortality of marked individuals, and tag loss through physical disturbance or molting), each of which must be addressed. Here I describe a mark-recapture experiment performed in 2014 and 2015 in Maryland to assess the size and scope of the recreational blue crab fishery. The study focused on recreational harvest of male crabs, as recreational harvest of females was banned in Maryland.

The present study had three specific objectives: 1) to determine how recreational and commercial exploitation vary temporally over the course of the fishing season, 2) to determine how recreational and commercial exploitation and the number of hard male crabs harvested vary spatially across the different harvest reporting areas in Maryland, and 3) to determine how the statewide ratio of recreational to commercial harvests has changed for males since it was last assessed in 2011. The overall goal was to understand whether the observed exploitation ratio is still consistent with the value which is used in the current stock assessment model, which is 8% of male commercial harvest (CBSAC 2016). This analysis also included a novel approach to calculate the ratio of recreational to commercial harvest that accounted for the movement of tagged crabs among harvest reporting areas and further refined statewide estimates of the recreational harvest fraction.

Methods:

Study Site:

A large population of blue crabs exists within the Chesapeake Bay, the largest estuary in the United States. From its history as a river valley drowned by rising sea levels in the early Holocene, the Chesapeake Bay has developed a unique geomorphology which is shallow and wide (USGS 1998). With a large, branched network of tributaries, the Chesapeake has over 7,400 kilometers of tidal shoreline (Lippson and Lippson 1984). This geography benefitted the development of nearshore structured habitats like submerged aquatic vegetation, marshes and other wetland habitats. Today, the Chesapeake Bay contains over 600,000 hectares of productive wetland habitats (NOAA n.d.) and supports a large blue crab population. The Maryland waters of the Chesapeake Bay span several thousand square kilometers and support roughly half (~51%) of hard crab landings by weight in the Bay (NMFS 2014). Commercial and recreational crab fishing within these waters is managed by the Maryland Department of Natural Resources. For commercial catch reporting purposes, these waters are broken down into 25 different harvest reporting areas (Fig. 1). These include a few large zones in the mainstem Bay which account for a large portion of commercial fishing, as well as many smaller tributary reporting areas.

Mark-recapture study:

In 2014 and 2015, a large-scale mark-recapture study was conducted to investigate the relative contributions of recreational and commercial sectors of Maryland's blue crab fishery. In the first summer, the goal was to quantify seasonal changes in the ratio of recreational to commercial exploitation. To do this, I tagged crabs in four harvest reporting areas, three times each over the course of the blue crab harvest season (Fig. 2). Crabs were tagged in early summer, late summer, and fall in Rhode River, South River, Eastern Bay, and the Little Choptank River. In the second summer, the goal was to quantify spatial differences in the ratio of recreational to commercial exploitation. To do this, crab tagging was performed once in each of 15 different harvest reporting areas in Maryland (Fig. 2). Sites were chosen to best represent the variation in location and fishery characteristics of the 25 harvest reporting areas, ensuring both broad spatial coverage of habitat types and perceived local harvest conditions.

Tagging of crabs was performed in a manner that maximized survival of tagged crabs post-release, as follows. The study involved collaboration with local fishers to catch crabs so they could be tagged and returned to the water. Roughly 450-500 crabs were purchased for each tagging event with a goal of obtaining 400 healthy crabs for tagging. In year 1 it was our goal to obtain an even mix of male and female crabs (200 of each) for each release so that patterns of harvest and movement could be identified for both sexes. In year 2, it was our goal to tag primarily male crabs to ensure a majority of crabs released were subject to recreational harvest. The remainder of this thesis focuses exclusively on recreational harvest, and only data from male crabs are used because recreational harvest of females is prohibited in Maryland.

Commercial fishers caught crabs for tagging using standard commercial harvest gear that varied by location due to differences in permitted gear types. In tributaries, crabs were caught by trotline. In bay mainstem zones, crabs were caught by crabpot. Crabs were then transferred to SERC researchers aboard a separate boat for tagging. Crabs were kept shaded and covered with wet burlap prior to tagging. Information recorded for each crab included size, sex, limb loss and molt stage. Additionally, environmental data were recorded for each site, including surface and bottom water temperature, dissolved oxygen, and salinity. Crabs were not tagged if 1) crabs were unresponsive or injured, 2) carapace width was < 128 mm, 3) females were immature, or 4) if both chelipeds, both swimming legs, or > 3 walking legs were missing. Excluding these crabs maximized post-release survival and ensured that the study was restricted to legal-sized crabs.

Crabs were tagged with 2.5 cm x 5 cm vinyl discs attached to their dorsal surface with stainless steel wire tied around the lateral spines (Aguilar et al. 2005, Turner et al. 2003, Fig. 3). Each tag used for this study had a unique identification number and listed the contact information for our research lab, so that caught crabs could be reported either by phone or web form. Commercial and recreational fishers received a reward of either $5 or $50 for reporting recaptures. Tags listed information for fishers to record and report, including tag number, date, GPS coordinates, capture depth, and crab sex. Fishers that reported these tags were asked preliminary questions regarding recapture date, location and fishery sector. Along with an invoice for their reward, they were sent a more in-depth survey that included a map for them to plot the precise location where the recapture occurred. The surveys also included whether or not female crabs were carrying eggs, repeated questions from the phone survey for confirmation purposes, and included a section for the fisher to leave any other comments they had about the study or the crab they caught.

Tag Reporting Period:

The recapture data used in this study were collected from the first date of tagging in 2014 through the end of the fishing season in 2015. The cutoff at the end of the fishing season was justified by the fact that only 2.6% of all recaptures from the 2014 summer releases occurred in the following year. The percentage of recaptures which occurred in the year following the 2015 releases cannot yet be calculated because the fishing season was still open at the time of writing. For both years combined, 98.1% of recaptures occurred within the first two months post-release, with 85.7% of those occurring within the first month. Thus, I calculated exploitation rates for each release for the first two months post-release. Because of this, exploitation rates in this study are slightly conservative.

Calculation of Statewide Recreational Harvest Ratio

The statewide ratio of recreational to commercial harvest was estimated by comparing reported commercial harvest levels to levels of recreational harvest estimated through this tagging study. The desired value here is recreational harvest expressed as a percent of commercial harvest (P_R) :

$$P_R = 100 \ x \ \frac{H_R}{H_C}$$

H_C is state-wide total commercial harvest of male and female crabs in 2015, and H_R is state-wide recreational harvest of male hard crabs in 2015 estimated with tagging data. Statewide recreational harvest was calculated as follows:

$$H_R = \sum_{i}^{29} \sum_{m}^{9} \frac{uR_{i,m}}{uC_{i,m}} * hC_{i,m}$$

where *hC* is the total commercial harvest of male and female hard crabs in 2015, in each of the 29 harvest regions (*i*) for each of the 9 months (*m*) of crab harvest season, and *uR* and *uC* are the recreational and commercial exploitation rates, respectively, estimated from tagging data for each region. The ratios of recreational to commercial exploitation ($\frac{uR_{i,m}}{uC_{i,m}}$) for each harvest reporting area and month were calculated in two ways that are typical of mark-recapture experiments, as well as a third novel approach which accounted for the movement of crabs between harvest reporting areas.

The first method used to calculate the ratio of recreational to commercial exploitation was based on comparing recreational and commercial exploitation rates of tagged crabs that were released in each reporting area (Fig. 4A) as follows:

$$\frac{uR}{uC} = \frac{uR_{i,m}}{uC_{i,m}}$$

where $uR_{i,m}$ and$uC_{i,m}$ represent the recreational and commercial exploitation rates for the given harvest reporting area (i) and month (m), respectively. Recreational and commercial exploitation rates were calculated for each release based on all crabs released at the given site, regardless of where they were captured, as follows:

$$uSector_{i,m} = \frac{cSector_{i,m}}{a_{i,m}}$$

Where $uSector_{i,m}$ represents the exploitation for the given harvest reporting area (i) during the given month (m), $cSector_{i,m}$ represents the number of crabs caught from that release during the given month, and $a_{i,m}$ represents the number of crabs available to be caught from the given release during the given month. Catch and availability components took into account both reporting rates and sources of tag loss, further detailed below. I hypothesized that this first method would be a more conservative approach, and would under-estimate recreational fishing because estimates would include all crabs released at the given site, regardless of their recapture location. Therefore, these exploitation estimates could be skewed by the movement of crabs from largely recreational harvest areas in tributaries to areas of high commercial harvest in the bay mainstem. Using this method, the ratio of recreational to commercial exploitation was calculated for the 15 sites where tagging was conducted.

The second method used to calculate the ratio of recreational to commercial exploitation was based on using all tags recaptured at a given site regardless of where they were initially released (Fig. 4B) as follows:

$$\frac{uR}{uC} = \frac{cR_i}{cC_i}$$

where cR_i indicates the number of captures by recreational fishers which occurred within the given harvest reporting area over the harvest season, and cC_i indicates the number of captures by commercial fishers. I hypothesized that calculating the ratio of recreational to commercial exploitation in this way would provide a higher value and will better represent the ratio of exploitation within each harvest reporting area. This is because the second method should account for large subsides of crabs out of the tributaries and into areas in the mainstem bay with much lower recreational harvest. For areas with very few recaptures, a difference of only one recreational or commercial recapture could have a great effect on the ratio of exploitation estimated for a site. Because of this, the minimum number of recaptures at a particular harvest reporting area required for this assessment was set at 15. This condition was met for all sites at which crabs were tagged. None of the harvest reporting areas where tagging did not occur had enough recaptures to support this analysis. A drawback of this approach is that is doesn't account for the number of tagged crabs available to be caught in each reporting area.

The third method to calculate the ratio of recreational to commercial exploitation incorporated information about crab movements to inform exploitation rate calculations (Fig. 4C) as follows:

$$\frac{uR^*}{uC^*} = \frac{{uR_{i,m}}^*}{{uC_{i,m}}^*}$$

Where ${uR_{i,m}}^*$ is a movement-transformed estimate of recreational exploitation within the given reporting area (i) during the given month (m), and ${uC_{i,m}}^*$ is a movement-transformed estimate of commercial exploitation. Traditionally, an exploitation rate is calculated as the number of tagged individuals caught (c), divided by the number of tagged individuals available to be caught (a). For this method, both the catch and availability components of each exploitation rate were adjusted to reflect crab movements, as follows:

$$uSector_{i,m} = \frac{cSector_{i,m}}{a_{i,m}} \rightarrow uSector_{i,m}{}^{*} = \frac{cSector_{i,m}{}^{*}}{a_{i,m}{}^{*}}$$

where $uSector_{i,m}$ refers to the exploitation rate for a release within a particular reporting area for either the first or second month post-release, $cSector_{i,m}$ indicates the number of crabs caught from the release during that month, and $a_{i,m}$ indicates the number of crabs available to be caught during that period. The catch component was adjusted to reflect captures that occurred within the reporting area during the month. First, captures from the release which occurred in other reporting areas were subtracted off. Then, captures from other releases which occurred in the reporting area were added in. Catch adjustment was calculated as follows:

$$a_{i,m}{}^{*} = a_{i,m} + \left(\sum_{b=1}^{14} cSector_{b,i}\right) - \left(\sum_{c=1}^{28} cSector_{i,c}\right)$$

where the first sum represents the number of crabs released at each of the 14 other release areas and were caught in the given reporting area during the given month (moving from any of the 14 reporting areas where crabs were released (b), to the given reporting area (i)). The second sum indicates the number of crabs released within the given reporting area which were captured within each of the 28 other harvest reporting area during the given month (moving from the given reporting area (i), to any of the 28 other reporting areas used in this study (c)). Transformation of the catch component occurred before catch adjustment via reporting rates.

The availability component of each exploitation rate was adjusted to reflect crabs remaining to be caught within the harvest reporting area in a given month. First, the total number of tagged crabs predicted to leave the reporting area were subtracted off. Then the total number of tagged crabs predicted to arrive in the harvest reporting area from other areas is added in. Availability adjustment was calculated as follows:

$$a_{i,m}{}^{*} = a_{i,m} + \left(\sum_{b=1}^{14} a_{b,m} * P_{b,i}\right) - \left(\sum_{c=1}^{28} a_{i,m} * P_{i,c}\right)$$

where the first sum represents the predicted number of tagged crabs moving into the given reporting area during the given month from the 14 other release areas. It is a function of the crabs available in the given month (m), at each of the fourteen sites (b) where crabs were released ($a_{b,m}$), and the proportion of crabs at each of those sites expected to move to the given reporting area (i), ($P_{b,i}$). The second sum indicates the number of crabs predicted to move from the given reporting area to each of the 28 other harvest reporting areas in the given month. It is a function of the crabs available in the given month (m) at the given reporting area (i), ($a_{i,m}$), and the proportion of crabs in the given reporting area (i) expected to move to each of the 28 other harvest reporting areas used (c), ($P_{i,c}$). It was assumed that the proportion of tagged crabs moving out of each harvest reporting area was equivalent to the proportion of tagged crabs caught within or outside the release location. For this third method as well, catch and availability components took into account both reporting rates and sources of tag loss, further detailed below

For all three methods of estimating the ratio of recreational to commercial exploitation, there were some circumstances where the ratio for a particular reporting area could not be determined directly. However, in order to provide a statewide estimate of recreational harvest, an estimate of recreational harvest was needed for each harvest reporting area. In these cases, the ratio of recreational to commercial exploitation used was the ratio estimated for another reporting area, based on similarity in the relative size of its recreational fishery. These decisions were based on our best professional judgement, and took into account discussions with fishery managers, characteristics such as proximity to the site to be estimated, and the level of residential development along its coastline, estimates visually using Google Earth. For example, the proportion of harvest by recreational fishers in the Manokin River was assumed to be similar to that estimated for the Nanticoke River. The full list of substitutes for sites with no direct estimate of exploitation is included as Table 1.

Exploitation Rate Calculation:

Exploitation rates for the first and third methods of estimation were calculated separately for each of the first two 30-day periods after each release. Once calculated, exploitation rates were then assigned to the calendar month they primarily occupied. Calculating two exploitation rates for each release provided greater temporal resolution for the assessment of seasonal trends in harvest. Monthly exploitation rates were calculated as the number of crabs recaptured as a proportion of the crabs remaining available to be caught. In the first month no crabs were treated as having molted, died, or lost their tag. Exploitation by a particular sector in the first month was calculated as follows:

$$uSector = \frac{RP_m \;/\; RR}{RL}$$

where RP_m is the number of tagged males reported as captured in the given month (m), RR is the reporting rate of tags caught by that sector, and RL is the number of tagged males released. In the second month crabs were removed from the number of tagged crabs available to be caught if they were predicted to have died, molted or lost their tag during the first month. Exploitation in the second month was calculated as follows:

$$uSector = \frac{RP_m \ / \ RR}{\left(RL - (M_{m-1} + D_{m-1} + L_{m-1})\right)}$$

where RP_m is the number of tagged males reported as captured in the given month (*m*), RR is the reporting rate of tags caught by that sector, RL is the number of tagged males released, and $M_{m-1}, D_{m-1},$ and L_{m-1} are the number of tagged males expected to have molted, died or lost their tag in the time leading up to month *m*. Given that the number of tagged crabs remaining at large decreased with time, exploitation calculations for both months were then somewhat conservative. This is due to the fact that calculations only accounted for tag loss, molting or mortality which occurred prior to the 30 day period, ignoring any losses which occurred during the period of calculation.

Reporting Rate:

Low and high value reward tags were used to estimate tag reporting rates for the crab fishery overall, or for specific sectors or tagging locations (Pollock et al. 2001). Assuming that 100% of high value tags were reported, we compared the ratio of high value tags released to the ratio of high value tags returned to estimate reporting rates for standard tags. Standard tags were marked “Reward” and had a reward value of $5, however 5% of tags had a reward value of $50 that was clearly marked on the tag with “$50”. A preliminary study using both $50 and $100 tags indicated that a \$50 reward is high enough that an equal proportion of \$50 and \$100 tags are reported (Hines unpublished data). The \$50 high value amount used in the present study was similar to studies involving finfish and waterfowl (Taylor et al. 2006, Nichols et al. 1991).

The reporting rate calculation is expressed by the equation:

$$RR = (R_s/N_s) / (R_r/N_r) = R_sN_r/R_rN_s$$

where RR represents the proportion of caught crabs which are reported, N_s is the number of standard \$5 tags released, N_r is the number of high-value \$50 tags released, R_s is the number of standard tags returned, and R_r is the number of high-value tags returned (Pollock et al. 2001). Calculated reporting rates were then in turn used to adjust observed numbers of recaptures, to control for the effects of reporting bias. In particular, for the first year of releases, reporting rates were estimated for each release area. In the second year, reporting rates were estimated for both the recreational and commercial sectors statewide because high value recaptures were too few ($N < 10$) in some locations for robust calculations of reporting rate by harvest area.

Mechanical Tag Loss:

Previous work has shown that the possibility of mechanical tag loss is negligible. The proportion of crabs that lost their tags prior to the second month was calculated as 30 times the daily rate of tag loss ($0.00067d^{-1}$) calculated from tank holding experiments (Hines, unpublished data). Tank holding experiments were performed at the Smithsonian Environmental Research Center in the summer and fall of 2007. Experiments involved tagging of harvested crabs, which were then kept on site in ambient-temperature water tanks for a maximum period of 60 days. Any crabs that lost their tag during the period were recorded and the resulting rate of tag loss was calculated.

Molting:

Tag loss also may occur as a result of molting. Female crabs were tagged after the molt to maturity, which is a functional terminal molt (Hines et al. 2007). Molting of males was minimized by avoiding tagging crabs expected to molt soon after tagging based on the color and condition of their shell. The proportion of crabs that had molted prior to the second month after each release was estimated as a function of degree days. Data representing the mean and standard deviation of the intermolt period in days, based on data by from Tagatz (1968b), for crabs 130-139 cm CW were converted to degree days, for use in a probabilistic model. This size range was selected as it was the size class which best represented the legal size crabs used in this study. Mean monthly water temperature data were obtained from the long term monitoring buoy northeast of Cove Point, Maryland (DNR Eyes on the Bay). In the case of blue crab molting physiology, a degree day is calculated as the number of days over the threshold temperature for molting (8.9˚C), multiplied by the number of degrees above that threshold temperature (Tagatz 1968b, Smith 1997). The mean degree days between molting, and the standard deviation around that value, were used to calculate the proportion of crabs that are expected to have molted during the first month. A normal distribution function was used to calculate the probability of molting (P_M) (Fig. 5a):

$$P_M = e^{\frac{-\left((DD-\overline{DD})^2\right)}{2(\sigma^2)}}$$

where DD is the number of degree days since the crab's last molt, $\overline{\text{DD}}$ is the mean number of degree days between molts, estimated from Tagatz (1986b) to be 693 degree days for the size range of crabs used, and σ^2 is the variance around the mean, estimated to be 162 degree days (Tagatz 1968b). The integral of this equation was then taken in order to generate a cumulative distribution function describing the proportion of crabs that had molted (p_M) after a given number of degree days (Fig. 5b). The resulting integrated expression, adjusted to give values from 0 to 1, was:

$$p_M = -0.5\big(ERF(3.01994 - 0.0043584\ DD)\big) + 0.5.$$

Then, for each release, the number of degree days that have passed in the first month are plugged into this function to calculate proportion of crabs that have molted in the first month. This is then multiplied by the number of crabs in the release in order to determine the number that have molted (M_{T-1}).

Natural Mortality:

Tagged crabs may also be removed from the system as a result of natural mortality. The proportion of crabs that died from natural mortality prior to the second month was calculated from published natural mortality rates, as follows:

$$N_M = N_0 - (N_0 e^{\left(\frac{M}{12}\right)})$$

where N_M is the number of crabs remaining in the system, N_0 is the initial amount of crabs in that month, and M is the estimate of instantaneous natural mortality of 0.9 used in the current stock assessment model (Miller et al. 2011).

Seasonal Patterns in Harvest:

For all three methods of estimation, average ratios of recreational to commercial harvest for two months post-release at each harvest reporting area were assigned to the first calendar month following tagging. This was generally near the middle of the harvest season in July and August, when recreational fishing was expected to represent the greatest proportion of harvests. Prior tagging studies have shown a marked increase in recreational exploitation during the middle of the harvest season (Hines unpublished data). As a result, the ratio of recreational to commercial exploitation may fluctuate to some degree over the course of the harvest season. It was hypothesized that there would also be a humped relationship in the ratio of recreational to commercial harvest, with the ratio of recreational to commercial exploitation highest in the middle of the harvest season and lower in spring and fall. In order to account for this variation, and calculate the ratio of recreational to commercial harvest at other months, a seasonal trend in the ratio of recreational to commercial harvest was estimated.

The seasonal trend in the ratio of recreational to commercial harvest was estimated by directly comparing the total number of recreational and commercial recaptures in each month across the 12 releases in 2014, as well as releases in 2015 from the four sites where crabs were tagged in 2014. The resulting relationship in the ratio of recreational to commercial recaptures was divided by the ratio of recreational to commercial harvest during the month following each release (ie. July, August, and September). The resulting relationship would indicate the magnitude of the ratio of recreational to commercial harvest in a particular month, relative to the ratio observed in the month following release. These values were then multiplied by the ratio of recreational to commercial exploitation during the month after release, to estimate the ratio of recreational to commercial exploitation in all other months of the harvest season.

Sensitivity Analyses:

To explore the reliability of recreational harvest estimates, several sensitivity analyses were performed. These analyses were conducted primarily to account for potential commercial tag underreporting on both a state-wide and a site-by-site basis. Analyses were also performed to determine whether recreational harvest estimates could be skewed by patterns of reported commercial harvest specific to the 2015 harvest season.

One important assumption in exploitation calculations was that 100% of high-value tags that were caught were actually reported. However, we know from personal communication with fishers that there were a small but unknown number of commercial fishers who chose not to report any tags. Thus, commercial reporting rates may be biased low in some areas, particularly in the mainstem Bay, Choptank River, and lower Eastern shore, where most commercial harvest occurs. To account for this we recalculated exploitation rates assuming different reporting conditions for crabs caught commercially. Specifically, instead of assuming that 100% of high value tags caught commercially were reported, we simulated commercial exploitation under the assumptions that only 95%, 90%, or 85% of caught high-value tags were reported. This resulted in a 5%, 10%, or 15% reduction in the calculated commercial reporting rate (67.2%). This analysis was conducted for the movement transformed calculations only, as these likely best represented crab exploitation within Maryland.

We also tested the sensitivity of our recreational harvest estimates to variation in the ratio of recreational to commercial exploitation calculated from the mark-recapture experiment. Because some harvest reporting areas account for a greater proportion of the state's recreational landings, and because our estimates of the ratio of recreational to commercial harvest within a particular reporting area may be used to estimate recreational harvest in other zones, small errors in our estimates for particular reporting areas may lead to substantial changes in our statewide value. This could especially be a concern if there was significant underreporting of commercial recaptures in any of these important reporting areas. To account for this we recalculated the statewide estimate of recreational harvest assuming a 5.26% increase in commercial exploitation (equivalent to a 5% in the ratio of recreational to commercial exploitation) for each release location individually. This analysis was also conducted using movement transformed calculations of exploitation.

Another consideration is that the results might be affected by spatial patterns of reported commercial harvest specific to 2015, but which might not represent typical spatial patterns. If a greater proportion of commercial harvests in 2015 came from sites which saw substantial recreational harvest, then recreational harvest could be overestimated in other years. To ensure that this was not occurring, the statewide ratio of recreational to commercial harvest was also calculated separately using average reported commercial harvests for each site over the 5 years prior (2010-2014). If the statewide ratio calculated using 2015 was substantially different, then this would indicate an effect on our results by harvest patterns specific to the 2015 harvest season.

Results:

Releases

A total of 8,741 male and female crabs were tagged and released during the two years of the mark-recapture experiment. In year 1, 3,229 tagged crabs were released across all sites, of which 2,261 (70.0%) were males and 968 (30.0%) were mature females (Table 2). During some tagging days, particularly those early in the harvest season, it was difficult to obtain the expected 400 crabs (200 each of males and females) to tag due to poor harvest rates. The number of crabs tagged ranged from 57 for the early season release in the Rhode River to 414 for the late season release in the Little Choptank River. It was also difficult to obtain a large number of female crabs to tag, particularly in summer. In year 2, 5,512 tagged crabs were released across all sites. 4,539 (82.3%) were males and 973 (17.7%) were mature females (Table 3). Crab abundances had improved substantially from the low values seen in the previous year, and it was much easier to obtain 400 tagged crabs at most sites. The number of crabs tagged ranged from 211 in the Severn River to 400 in many tagging areas.

Recaptures

A total of 2,037 male and female crabs were recaptured and reported during the two years of the mark-recapture experiment. Of the 3,229 tagged crabs released in year 1, 803 (25.2%) were recaptured and reported prior to the end of the crabbing season, 594 (74.0%) were captured by commercial crabbers, 203 (25.3%) by recreational crabbers, and 5 (0.6%) by unidentified crabbers. Additionally, there were 12 secondary recaptures in cases when the crab was released by the fisher after reporting, with the tag still on it. These secondary recaptures were not used in analyses. Of the 3085 $5 tags released in year 1, 786 (25.5%) were recaptured. Of the 163 $50 tags released, 47 (28.8%) were recaptured. This resulted in an overall reporting rate of 88.4% across the fishery. Sector specific reporting rates in year 1 were 93.3% for the commercial fishery and 75.1% for the recreational fishery. Reporting rates calculated for each site tagged in year 1 ranged from 80.2% in South River to 98.5% in Eastern Bay.

Of the 5512 tagged crabs released in year 2, 1234 (22.4%) were recaptured and reported prior to the end of the crabbing season, 958 (79.3%) were captured by commercial crabbers, 241 (19.5%) by recreational crabbers, 34 (2.8%) by unidentified crabbers. Additionally, in year 2 there were 31 secondary recaptures. Of the 5244 $5 tags released in year 2, 1159 (22.1%) were recaptured. Of the 276 $50 tags released, 84 (30.4%) were recaptured. This resulted in an overall reporting rate of 72.6% across the fishery. Sector specific reporting rates in year 2 were 67.2% for the commercial fishery and 85.3% for the recreational fishery. There were not enough recaptures in individual harvest reporting areas to produce estimates of a reporting rate for each area. Physical locations of recaptures by recreational and commercial fishers are indicated in Figure 6.

Calculation of Statewide Harvest Ratio

Commercial landings of males reported by anglers to the MD DNR exhibited substantial spatial variation. Commercial landings were greatest at reporting areas within the Bay mainstem, and in most cases were far greater in these areas than in nearby tributaries (Fig. 7). Notable exceptions included the Chester and Choptank Rivers, where commercial harvest was similar in size to the nearest mainstem reporting area. Overall in 2015, 43.9% of the commercial harvest of males in Maryland came from mainstem areas, whereas 56.1% came from tributaries. In comparison, on average from 2010-2014 46.2% of commercial males harvested came from mainstem areas, and 53.8% came from the tributaries.

Recreational landings of males calculated in the present study also varied substantially across the different harvest reporting areas, and with a different spatial pattern from that of commercial harvest (Fig. 8). Recreational landings were low in reporting areas within the Bay Mainstem, and in areas along the southern portion of the Eastern Shore (Fig. 8). Tributaries with high recreational landings included the Miles, Patuxent and Wye Rivers. Using 2015 commercial harvest data, 5,407,195 to 6,864,299 adult male crabs were estimated to be harvested by recreational crabbers across Maryland depending on the method of calculation used (Table 4). Using the reported commercial harvest of 48,281,596 male hard crabs, this results in a level of recreational ranging from 11.2% – 14.2% of commercial harvest, respectively (Table 4). Using the movement transformed data likely the most reliable estimate, resulted in a harvest estimate of 6.654 million crabs, which is 13.8% of commercial harvests when considering male hard crabs.

Seasonal Variation in Exploitation

There was overall a humped relationship in the ratio of recreational to commercial recaptures when all releases from all sites in 2014 were combined (Fig. 9). Recaptures of tagged crabs generally declined from summer to fall, but there were marked seasonal differences between the four sites at which crabs were tagged in 2014. A large proportion of harvest in the South and Rhode Rivers came from recreational fishers (mean uR/uC*100 = 51.7% (+/- 16.8%) and 96.2% (+/- 138.0%), respectively). For South River, the ratio of recreational to commercial exploitation exhibited a humped relationship, with a peak in August, whereas in the Rhode River, the ratio of recreational to commercial harvest declined quickly after the greatest recreational exploitation in July (Fig. 10a,c). In the South and Rhode Rivers, total exploitation (uT), and commercial exploitation (uC) both exhibited a humped relationship with a peak in all forms of exploitation in August (Fig. 11a,c, Fig. 12a,c). These sites also had high total exploitation rates (mean uT = 0.360 m^{-1} and 0.197 m^{-1}, respectively). In contrast, a smaller proportion of harvest in Eastern Bay and the Little Choptank River came from recreational fishers (mean uR/uC*100 = 24.4% (+/- 4.7%) and 4.8% (+/- 6.8%), respectively). For Eastern Bay the ratio of recreational to commercial exploitation was relatively stable across the harvest season. In the Little Choptank River, due to zero recreational recaptures in August and October, the ratio of recreational to commercial exploitation peaked in July and was zero or undefined (divided by zero) thereafter (Fig. 10b,d). In Eastern Bay, total exploitation (uT), commercial exploitation (uC), and recreational exploitation (uR) all exhibited a humped relationship with a peak in all forms of exploitation in August (Fig. 11b, Fig. 12b). In the Little Choptank River, total exploitation (uT) peaked early in July, with little exploitation seen from either sector in the months following (Fig. 12d). These two sites also had the lowest exploitation rates (mean uT = 0.129 m^{-1} and 0.084 m^{-1}, respectively).

When all releases from South River, Rhode River, Eastern Bay and the Little Choptank River were added together, the ratio of recreational to commercial recaptures across months exhibited a clear humped relationship, with the greatest ratio of recreational to commercial recaptures observed in August and September (Fig. 9A). This relationship was also scaled as a proportion of the three potential release months in Year 2 (Fig. 9B). Resulting values of the ratio of recreational to commercial exploitation are listed in Table 5.

Spatial Variation in Exploitation

Exploitation rate varied substantially by harvest reporting area, and patterns were influenced by the method of calculating exploitation rates. Total, commercial and recreational exploitation rates were calculated based on release location and using the movement method. Note that calculations using recapture location only provided an estimate of the ratio of recreational to commercial harvest. When exploitation rates were transformed to account for movement information, total exploitation increased at a majority of sites relative to calculations by release location, while decreasing or remaining roughly the same in a few others (Fig. 13). Total exploitation generally increased in reporting areas where a large portion of crabs left the area, reducing the amount available to be caught, such as in the Magothy or Severn Rivers. Total exploitation also increased in reporting areas where a substantial fraction of the crabs that were captured there originally were released elsewhere, such as in both mainstem reporting areas. For example, total exploitation was greatly reduced in West River as many of the crabs released there were caught elsewhere.

More importantly, accounting for movement information resulted in differences in sector-specific exploitation, the ratio of recreational to commercial exploitation, and estimated recreational harvest for each site (Fig. 14). Commercial exploitation greatly appeared to be higher in the Magothy River and the Bay Mainstem S when movements were taken into account compared to when they were not (Fig. 14A). For the Magothy River this increase was a result of decreases in the number of crabs available to be caught, because many left the area. In the case of the Bay Mainstem S, however, this increase in commercial exploitation was due to the large number of crabs leaving other areas becoming caught by commercial fishers in the Bay Mainstem. Commercial exploitation decreased in South and West Rivers, because a large amount of crabs caught commercially from these releases were caught by fishers in the Bay Mainstem (Fig. 14A). Recreational exploitation increased in West, South and Severn Rivers, due to reductions in the crabs available to be caught in these systems. As a result of changes in recreational and commercial exploitation in these areas, the ratio of recreational to commercial exploitation greatly increased in the Magothy, Severn, and South Rivers. Lastly, estimated recreational harvest greatly increased in the Severn, Miles and Patuxent Rivers. Because the movement method provided much more realistic estimates of exploitation by harvest area, spatial patterns in exploitation described below used the movement transformed estimates of recreational and commercial exploitation.

There were marked differences in recreational and commercial exploitation rates among the 15 harvest reporting areas at which crabs were tagged. The most noticeable differences were observed between tributary sites along the Western Shore of the Bay, Eastern Bay, and the Miles and Wye Rivers where recreational fishing was greatest, and areas of the Bay Mainstem, where recreational harvest was limited (Fig. 15). Mean total exploitation per month varied substantially by site, ranging from 0.076 m^{-1} in Fishing Bay to 0.704 m^{-1} in the Wicomico River tributary of the Potomac River (Fig. 16). Notably high rates of total exploitation were seen in the Wicomico River, Magothy River (0.675 m^{-1}), South River (0.492 m^{-1}), and West River (0.357 m^{-1}). Mean commercial exploitation per month ranged from 0.041 m^{-1} in the Patuxent River to 0.479 m^{-1} in the Wicomico River tributary of the Potomac River (Fig. 17). Notably high rates of commercial exploitation were observed the Wicomico River (0.479 m^{-1}), Magothy River (0.338 m^{-1}), and West River (0.292 m^{-1}). Mean recreational exploitation per month ranged from 0 m^{-1} in both the Honga River and Fishing Bay to 0.338 m^{-1} in the Magothy River (Fig. 17). Notably high rates of recreational exploitation were seen in the Magothy River and in South River (0.288 m^{-1}). The mean ratio of recreational to commercial exploitation per month ranged from 0% in both the Honga River and Fishing Bay to 213% in the Severn River (Fig. 15). The mean ratio of recreational to commercial exploitation was greater than 8% at nine out of the fifteen sites where tagging took place. The breakdown of exploitation by recreational and commercial sectors for the 15 reporting areas where tagging occurred is given in Figure 18. Lastly, crabs entering mainstem harvest reporting areas from other zones faced 3-4 times greater exploitation than crabs released in these harvest reporting areas (Table 6).

Sensitivity analysis

Simulated underreporting of high-value tags by commercial fishers resulted in underestimates of the proportion of recreational harvest. Applying these differences to the movement-transformed statewide estimate of the ratio of recreational to commercial harvest resulted in values of 13.1%, 12.4%, and 11.7% when using commercial harvest values from 2015 (Table 7). Compared to the movement-transformed estimate of 13.8%, these values simply represent a 5%, 10%, or 15% reduction in the estimated statewide ratio of recreational to commercial harvest.

Simulated underreporting of tags by the commercial sector had little impact on statewide recreational harvest estimates. Statewide ratios under these assumptions ranged from 13.5% for commercial underestimation in the Patuxent River (<1% decrease) to 13.8% for commercial underestimation in Fishing Bay and the Honga River (0% decrease due to uR of 0 in both areas) (Fig. 19).

Using commercial harvest data from prior years resulted in only a small change in the state wide estimate of recreational harvest. Using the average commercial landings of the 5 years prior produces a ratio of recreational to commercial harvest of 10.4% – 13.1%, respectively. Compared to values calculated with 2015 commercial harvest, this represents a 7% - 8% decrease in the ratio of recreational to commercial harvest.

Discussion:

Recreational harvest of male hard crabs in Maryland in 2015 was estimated at 13.8% the size of commercial male hard crab harvests. Using reported commercial harvest values, this was equivalent to 6.65 million male crabs, or roughly 8% of total male and female crab harvest in Maryland. This harvest ratio was determined from analyses incorporating crab movement information. Ratios calculated using only release (11.2%) or recapture (14.2%) location can be considered as upper and lower bounds around this estimate. Prior studies in 2001, 2002, 2005 and 2011 using creel survey methods (Ashford and Jones 2001, 2002, 2005, 2011) estimated that the ratio of recreational to commercial harvest within Maryland remained roughly around this value, averaging 11.6% of commercial male hard crab harvests and 5.8% of total commercial harvests (Table 8). Harvest ratios estimated in the present study were within the range of individual values observed since 2001. Given that the present study produced a similar result with an entirely different set of methods, creel surveys are likely to have produced reliable estimates of the size of Maryland's recreational crab fishery. Additionally, our estimate of the ratio of recreational to total commercial harvest of 8.0% falls in line with the value used in stock assessment prior to the moratorium on recreational harvest of female crabs in Maryland in 2008 (Miller et al. 2011). However, after 2008, recreational harvest was thought to be better calculated as 8.0% of male harvests (CBSAC 2016). While this may have been the case in 2011 (Table 8), our estimated harvest ratio of 12.8% of male crabs in 2015 represents a 52% increase over the harvest ratio in 2011. Instead, it appears that the limitation of recreational harvest to male crabs has resulted in a shifting of recreational fishing effort onto male crabs, rather than simply removing females from the recreational harvest.

The increased ratio of recreational harvest of male crabs observed in the present study has the potential to impact management of male crabs within the Chesapeake Bay. If shifting of recreational fishing efforts onto male crabs has resulted in an increase in male exploitation, then this may affect the state of male conservation triggers. The exploitation fraction of adult males has not exceeded 33% in recent history, a threshold level above which male harvest restrictions would need to be put in place (CBSAC 2015). In many years, male exploitation fractions have been as low as 21.6 – 22.2% (CBSAC 2015). However, in 2011 male exploitation was assessed to be 32% (CBSAC 2015), and might have exceeded 33% if male recreational harvest was underestimated. It should also be noted that survey data indicated recreational harvest were 8.5% as large as total commercial harvest in 2011. The ratio of recreational harvest of male crabs observed in the present study should be incorporated into and evaluated in the next blue crab stock assessment in Chesapeake Bay. Conducting both survey and mark-recapture estimates in the same year would also be valuable for conducting a direct comparison of estimates.

Considering the harvest of both male and female crabs, the results of this study suggest that recreational crabbers take in roughly 7 – 9% percent of all crabs landed in Maryland. This is slightly greater than, but largely comparable to, many other temperate and subtropical crab fisheries. For example, in Louisiana, which has the second largest commercial blue crab fishery by state, recreational crabbers take in roughly 5% of all blue crabs (Guillory 1999b, LDWF 2011), and similar results

(5.6%) were observed for recreational blue crab fishers in Galveston Bay, Texas (TPW 2007). In Oregon, 5.6% of landings in the Dungeness crab fishery are taken by recreational crabbers (ODFW 2014). In contrast, there are some temperate crab fisheries which are much more subject to recreational exploitation. In particular, in Washington, 41% of all Dungeness crabs landings are by recreational crabbers (WDFW 2016). Additionally, many temperate and subtropical crab fisheries, including Atlantic Jonah Crabs and California Dungeness Crabs, do not have reliable enough recreational harvest data in order to make similar comparisons (ASMFC 2015, CA OPC 2014).

One important consideration is what factors might cause recreational harvest to remain consistent with commercial harvest. It can be seen that if recreational harvests closely track commercial harvests, even when the population is low, then the economic and social factors controlling effort in both of these sectors must also be consistent to some degree. For both sectors, harvest is limited by the standing population size of crabs, as well as the amount of fishing effort expended. However, for both sectors there is an upper limit on effort to some extent. For the case of commercial fishers, they can only set out a limited amount of gear over a limited number of hours. This is also true for recreational fishers, who are also subject to possession limitations per person or per vessel. Based on personal experience, one would expect that even if population sizes are low, commercial fishers will attempt to maximize their effort expended as scarcity will drive crab prices up. The same could potentially be said for recreational fishers, who may stay out later if it means meeting their possession limits.

Estimated ratios of recreational to commercial harvest based solely on release location did not isolate exploitation pressure to specific harvest reporting areas, but did fully represent the exploitation pressure of each sector on male crabs that recruit to the fishery (reaching harvestable size) in different nursery tributaries of Chesapeake Bay. Tag returns indicated that nursery habitats in tributaries supplied a substantial fraction of crabs to harvest areas in the Mainstem Bay, which are then likely to be harvested in the commercial pot fishery (Appendix A). Commercial fishers in the Mainstem Bay target this movement, with pot fishing efforts concentrated at the mouths of tributaries (Slacum et al. 2007, Bilkovic et al. 2016, Appendix A). This relationship is also substantiated by the fact that crabs entering bay mainstem faced much higher exploitation than crabs released in these areas. This first method of estimating exploitation also provides a good baseline of comparison against exploitation rates calculated in other studies where movement is not incorporated. However, because a majority of crab movements in the present study were directed from areas where recreational harvest is common, to areas where commercial harvest dominates, this method provided an underestimate of the ratio of recreational to commercial harvest, and serves as a lower bound on the estimates provided.

Estimating ratios of recreational to commercial harvest based on tags returned in a given harvest reporting area provided a better estimate of the relative harvest pressure from each sector within that area. However, this method did not account for the number of crabs released, or the various other sources of tag removal from the system (ie. molting, mortality, and physical tag loss), and thus was not a true estimate of the exploitation of male crabs by either sector of the fishery. Nonetheless, estimates of the ratio of recreational to commercial harvest at a particular site utilizing this method better accounted for crabs which moved from tributaries zones to the Bay Mainstem, and serve as an upper bound on the estimates provided.

Incorporating movement into estimated ratios of recreational to commercial harvest provided the most robust estimate of recreational and commercial exploitation rates within each harvest reporting area. This method allowed for calculation of exploitation rates and accounted for multiple sources of tag loss from the system (molting, mortality, physical tag loss), an important improvement over the second method. This method provided a good approximation for the crabs caught and available to be caught in each harvest reporting area, after accounting for crab movements, and provided the most reliable estimate of the ratio of recreational to commercial harvest statewide.

Similar methods are rare in mark-recapture studies of fisheries. For example, in a study of snapper in New Zealand, site-by-site density and exploitation estimates were used to standardize the movement patterns of snapper, determined from recapture locations (Parsons et al. 2011). These methods are somewhat similar to the second method used in the present study, as both group recaptures by recapture location, rather than release area. In most other mark-recapture fisheries surveys, exploitation calculations are limited to the release location of individuals, calculating exploitation for each release area, similar to the first method used in the present study (Rudd et al. 2014, Whitlock et al. 2016).

To date, the few studies which have used movement information to improve estimates of harvest and exploitation rates have been focused on harvest of waterfowl. Nichols et al. (1995), stratified marked waterfowl recoveries from several releases into 10 general harvest areas, and calculated reporting rates and exploitation fractions for each. This provided an example of how movement information can be used in harvest recovery systems, but did not work within the framework of pre-defined harvest areas. Munro and Kimball (1982) calculated harvest fractions for pre-defined harvest areas. However, neither of these studies calculated exploitation for multiple sectors, which was required for the present study to estimate recreational harvest based on commercial harvest data. Where possible, future mark-recapture experiments should incorporate movement information where the movement of study organisms among harvest areas is substantial.

Seasonal patterns in recreational harvest were not consistent between all harvest reporting areas, but a general seasonal trend of both higher recreational exploitation and a greater ratio of recreational to commercial exploitation can be observed across Maryland. As predicted, both showed a humped relationship, with a peak in recreational harvest in August and a peak in the ratio of recreational to commercial harvest centering between August and September (Fig. 9). The humped relationship in the ratio of recreational to commercial harvest indicated that while both recreational and commercial harvest show seasonal relationships, the summer increase in recreational harvest, was much steeper, with especially high recreational harvests coinciding with the Labor Day holiday weekend in early September and the surrounding weeks.

There was a clear spatial pattern of recreational harvest. Tributaries near population centers along the Western Shore, and in the Miles and Wye Rivers on the Eastern Shore, had the highest ratios of recreational to commercial exploitation and the highest recreational harvests. In contrast, recreational exploitation made up a smaller proportion of total exploitation, and recreational harvest was smaller at sites along the southern portion of the Eastern Shore. These results confirm a generally accepted assumption that recreational harvest is smaller in coastal areas with smaller population densities.

Results of sensitivity analyses suggested that potential under-reporting of tagged crabs by commercial watermen had little impact on the ratio of recreational to commercial harvest in the present study. Even if it is assumed that only 85% of high value tags caught across the commercial fishery were reported, this results in a 11.2% ratio of recreational to commercial harvest of male hard crabs. This value is equivalent to the average ratio (11.6%) estimated over the four recreational fisher surveys, which were not subject to potential reporting bias by commercial fishers (Table 7). Rather than being widespread across the fishery, it is much more likely that any tag underreporting that may occur would be localized in areas of the bay where commercial fishing dominates, and where commercial fishers are perceived as being less likely to participate in scientific studies. Sensitivity analysis indicated that potential commercial underreporting had a negligible effect on the ratio of recreational to commercial harvest, especially in areas dominated by commercial fishing. While variance in some reporting areas, particularly the Patuxent, Miles, and Magothy Rivers, had the greatest impact on statewide harvest ratio, these changes are not substantial when expanded to statewide harvest. Additionally, the harvest reporting areas with the most commercial harvest had the smallest effect on the statewide estimate of recreational harvest. Thus, potential underreporting by commercial fishers in the Mainstem Bay, Choptank River, and lower Eastern Shore where commercial fishing dominates has negligible impact on estimates of recreational fishing in the present study.

Compared to estimates of recreational harvest using 2015 commercial harvest data, recreational harvest estimates were only slightly lower when average harvests for 2010-2014 were used. There was a 7-8% decrease in estimates of the ratio of recreational to commercial harvest in 2015 compared to the average of the previous five years. Therefore, in 2015 a greater proportion of commercial harvests may have come from tributaries than usual. In prior years, commercial landings may have been more concentrated within harvest reporting areas that were mostly or entirely commercial in nature.

Other commercial harvest factors, such as the breakdown by crab sex or by harvest location, are also not thought to have been much different in 2015 compared to the five year average, and likely did not influence the results. The total reported commercial hard crab harvest in 2015 was roughly 18 million adult crabs (MD DNR 2015a). Although this was about 30% smaller than the average reported harvest from 2010-2014 (MD DNR 2015b), commercial landings have varied widely over the past two decades and this value is consistent with other years of low historical reported harvests (MD DNR 2015b, 2015c). Also, in 2015 a smaller proportion of the crabs harvested were female (about 7% fewer) (MD 2015a, 2015b). However, this can be attributed to a long-term trend in harvests since 1996, in which female crabs have made up a smaller portion of landings over time (MD DNR 2015b, 2015c). A similar pattern can be seen with the proportion of crabs harvested in the tributaries, estimated here based on gear type. In 2015 there was roughly a 5% greater proportion of crabs coming from the tributaries than on average from 2010-2014 (MD DNR 2015a, 2015b). This too is attributed to a long-term increase in the proportion of harvest coming from the tributaries over time (MD DNR 2015b, 2015c). As no harvest factors in 2015 were far outside their range in recent history it can be expected that results are not skewed by conditions specific to 2015 and would be similar in other recent years.

Although sensitivity analyses were able to address three potential limitations of the present study, there are two other sources of uncertainty that could not be addressed using available data. The first of these stems from the study only tagging crabs at fifteen of the twenty-five harvest reporting areas of Maryland due to funding constraints. While there is confidence in the approximations of recreational harvest for sites where tagging did not occur, conducting tagging in those areas would be preferable, especially because of increased information on movement among reporting areas. A second potential limitation of this work is that the movement information used only details the locations where individuals were caught, and therefore must assume the movement patterns of individuals that avoid capture. The patterns of movement used may be influenced by differences in exploitation in many areas. For example, if tagged crabs from one release moved to two other harvest reporting areas in equal proportions, but the exploitation within one of these harvest reporting areas was much greater, then we would have assumed un-equal movement in this study. In order for the movement patterns detailed to be devoid of any exploitation bias, an independent estimate of exploitation for each harvest reporting area would be required, which could be based on fishing effort and crab density. These data are not available at the spatial scale needed for incorporation in the present study.

Although comparable analyses of tag reporting via high-value tags could not be identified for crustacean fisheries, similar methods have been employed in a variety of finfish fisheries, and have shown tag reporting estimates in a similar range as those seen here (Bacheler et al. 2009, Kleiven et al. 2016, Cadigan and Brattey 2006, Kearns et al. 2016, and Meyer et al. 2012) and indicate cases where reporting by either recreational or commercial fishers may be more likely (Bacheler et al. 2009, Kleiven et al. 2016). For example, in North Carolina overall reporting rates for red drum ranged from 0.53 to 0.82 over multiple tagging studies (Bacheler et al. 2009). In one of these studies, which broke down returns by fishing sector, recreational fishers (0.72) were more likely to report captures of red drum than commercial)fishers (0.44). In contrast, commercial fishers in the Norwegian Cod fishery were more likely to report captures of cod (0.73), than recreational fishers who captured cod by line (0.09) or with fixed gear (0.66) (Kleiven et al. 2016). While these examples illustrate that either commercial of recreational fishers may be more or less likely to report recaptures in a given fishery, they do not explain the differences observed in sector-specific reporting between years in this study. One likely explanation for why commercial reporting rates were higher in year 1 is that previous tagging efforts by our lab had occurred in all sites where crabs were tagged in year 1 (Hines unpublished data). In year 2 however, many of the tagging locations were new to our lab, and familiarity of commercial fishers with the tag-reporting program may have been lower. Nevertheless, reporting rates were fairly similar among years.

In summary, the present study indicates that recreational harvests remain consistent with the values estimated using creel surveys, reducing uncertainty about potential biases in prior studies. Recreational crab harvests in 2015 were roughly 8% as large as total commercial harvests in Maryland and 14% as large as male hard crab harvests. The banning of female harvest by recreational fishers in Maryland has likely resulted in a shifting of recreational effort onto male crabs. As a result, recreational harvests are likely to be best illustrated as 8% of the size of total commercial harvest, and 12.8% the size of total male harvest. This study provided the first, statewide data on the spatial distribution of recreational harvest in Maryland's blue crab fishery, as well as the first information on exchange of male crabs among harvest reporting areas.

Tables

Table 1. Harvest reporting areas for which the ratio of recreational to commercial exploitation was assessed. No crabs were tagged within reporting areas listed in bold. For these locations, the ratio of recreational to commercial exploitation was estimated as that of a site where tagging occurred. Sites chosen in these cases were selected based on proximity to the original reporting area, similarities in habitat, and similarities in the density of coastal homes and developments, based on professional judgement. Dashed lines indicate that exploitation was determined directly via tagging in that site.

Original Site	Estimated As
Big Ammenesex (005)	**Nanticoke River**
Mainstem NN (014)	**Mainstem N**
Tribs NN (114)	**Magothy River**
Mainstem N (025)	-----
Tribs N (125)	**Magothy River**
Mainstem S (027)	-----
Tribs S (127)	-----
Mainstem SS (029)	**Mainstem S**
Tribs SS (129)	**Patuxent River**
Chester River (031)	**Eastern Bay**
Choptank River (037)	-----
Eastern Bay (039)	-----
Fishing Bay (043)	-----
Honga River (047)	-----
Little Choptank River (053)	-----
Magothy River (055)	-----
Manokin River (057)	**Nanticoke River**
Miles River (060)	-----
Nanticoke River (062)	-----
Patapsco River (066)	**Magothy River**
Patuxent River (068)	-----
Pocomoke Sound (072)	**Nanticoke River**
Potomac (MD Tribs) (074)	-----
Severn River (082)	-----
South River (088)	-----
Tangier Sound (092)	**Nanticoke River**
Tangier Sound Tribs (192)	**Nanticoke River**
Wicomico River (096)	**Nanticoke River**
Wye River (099)	**Miles River**

Table 2. Tagged crabs released in 2014. Crabs were tagged at four sites in Maryland, with three separate tagging events for each site, throughout the fishing season. For each site, there was a tagging event early in the fishing season (June - July), one in the middle of the season (August) and one late in the fishing season (September).

Tagged Crabs Released in 2014

Site	Release	Date	Males	Females	Total
South River	Early	7/14/2014	102	5	107
South River	Middle	8/11/2014	233	11	244
South River	Late	9/10/2014	108	270	378
Rhode River	Early	6/24/2014	53	4	57
Rhode River	Middle	8/4/2014	333	0	333
Rhode River	Late	9/8/2014	135	68	203
Eastern Bay	Early	6/23/2014	61	19	80
Eastern Bay	Middle	8/13/2014	343	15	358
Eastern Bay	Late	9/16/2014	185	91	276
Little Choptank	Early	7/16/2014	338	30	368
Little Choptank	Middle	8/6/2014	312	93	405
Little Choptank	Late	9/17/2014	58	356	414

Table 3. Tagged crabs released in 2015. Crabs were tagged at fifteen sites in Maryland, with only one tagging event for each site. Tagging events were concentrated during the mid to late summer, when exploitation of male crabs is generally greatest.

Tagged Crabs Released in 2015

Site	Reporting Area	Date	Males	Females	Total
Little Choptank	053	6/18/2015	259	140	399
Honga River	047	6/19/2015	277	123	400
Fishing Bay	043	6/25/2015	220	180	400
Patuxent River	068	7/15/2015	182	218	400
Eastern Bay	039	7/17/2015	381	17	398
Wicomico (Potomac)	074	7/20/2015	305	95	400
West River	027	7/21/2015	387	13	400
South River	088	7/22/2015	341	20	361
Magothy River	055	7/29/2015	350	19	369
Tred Avon River	037	7/30/2015	343	44	387
Bay Mainstem S	027	7/31/2015	357	43	400
Miles River	060	8/4/2015	181	24	205
Bay Mainstem N	025	8/5/2015	385	2	387
Severn River	082	8/10/2015	195	16	211
Nanticoke River	062	8/25/2015	376	19	395

Table 4. Statewide estimates of recreational and commercial harvest (in millions of crabs) using three methods of calculation. Calculations were performed using both 2015 harvest data, and with an average of the five years prior. hR / hMHC indicates level of recreational harvest as a percentage of commercial male hard crab harvests.

2015	**Method**	**Recreational Harvest (hR)**	**Males Hard Crabs (hMHC)**	**hR / hMHC*100**
	Raw Recaptures	6.864	48.282	14.2%
	Exp Rate	5.390	48.282	11.2%
	Exp Rate + Movement	6.654	48.282	13.8%

2010-2014	**Method**	**Recreational Harvest (hR)**	**Males Hard Crabs (hMHC)**	**hR / hMHC*100**
	Raw Recap	7.480	57.119	13.1%
	Exp Rate	5.914	57.119	10.4%
	Exp Rate + Movement	7.230	57.119	12.7%

Table 5. Estimated ratio of recreational to commercial exploitation across months for each harvest reporting area in Maryland. Exploitation estimates shown are movement-transformed. No recreational harvest was observed in the months of April, May, November, or December.

		uR / uC *100								
Reporting Area	**Site Name**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
005	Big Ammenesex	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
014	Mainstem NN	0.0%	0.0%	0.1%	0.5%	0.7%	0.8%	0.3%	0.0%	0.0%
014	Tribs NN	0.0%	0.0%	16.3%	61.9%	100.0%	103.6%	37.7%	0.0%	0.0%
025	Mainstem N	0.0%	0.0%	0.1%	0.5%	0.7%	0.8%	0.3%	0.0%	0.0%
025	Tribs N	0.0%	0.0%	16.3%	61.9%	100.0%	103.6%	37.7%	0.0%	0.0%
027	Mainstem S	0.0%	0.0%	0.3%	1.2%	1.9%	2.0%	0.7%	0.0%	0.0%
027	Tribs S	0.0%	0.0%	3.6%	13.8%	22.3%	23.1%	8.4%	0.0%	0.0%
029	Mainstem SS	0.0%	0.0%	0.3%	1.2%	1.9%	2.0%	0.7%	0.0%	0.0%
029	Tribs SS	0.0%	0.0%	25.2%	95.7%	154.7%	160.3%	58.3%	0.0%	0.0%
031	Chester River	0.0%	0.0%	3.8%	14.3%	23.1%	23.9%	8.7%	0.0%	0.0%
037	Choptank River	0.0%	0.0%	0.4%	1.4%	2.3%	2.4%	0.9%	0.0%	0.0%
039	Eastern Bay	0.0%	0.0%	3.8%	14.3%	23.1%	23.9%	8.7%	0.0%	0.0%
043	Fishing Bay	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
047	Honga River	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
053	Little Choptank	0.0%	0.0%	3.4%	12.8%	20.7%	21.5%	7.8%	0.0%	0.0%
055	Magothy River	0.0%	0.0%	16.3%	61.9%	100.0%	103.6%	37.7%	0.0%	0.0%
057	Manokin River	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
060	Miles River	0.0%	0.0%	14.7%	55.7%	90.0%	93.3%	33.9%	0.0%	0.0%
062	Nanticoke River	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
066	Patapsco River	0.0%	0.0%	16.3%	61.9%	100.0%	103.6%	37.7%	0.0%	0.0%
068	Patuxent River	0.0%	0.0%	25.2%	95.7%	154.7%	160.3%	58.3%	0.0%	0.0%
072	Pocomoke Sound	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
074	Potomac (MD Tribs)	0.0%	0.0%	7.7%	29.2%	47.2%	48.9%	17.8%	0.0%	0.0%
082	Severn River	0.0%	0.0%	34.7%	131.5%	212.5%	220.2%	80.1%	0.0%	0.0%
088	South River	0.0%	0.0%	22.9%	87.0%	140.6%	145.7%	53.0%	0.0%	0.0%
092	Tangier Sound	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
092	T. Sound Tribs	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
096	Wicomico River	0.0%	0.0%	0.7%	2.7%	4.3%	4.5%	1.6%	0.0%	0.0%
099	Wye River	0.0%	0.0%	14.7%	55.7%	90.0%	93.3%	33.9%	0.0%	0.0%

Table 6. Mean exploitation rates per month, on crabs entering the two Mainstem harvest reporting areas where crabs were tagged, and on crabs released in these areas.

	Mean Commercial Exploitation Rate	
Site	**Crabs Coming In**	**Crabs Released**
Bay Mainstem N (025)	0.308	0.105
Bay Mainstem S (027)	0.197	0.050

Table 7. Statewide harvest values of male hard crabs under varying assumption of commercial reporting. Compared to the traditional assumption that all caught high-value tags are reported, C95% indicates the assumption that 95% of all high value tags caught by commercial fishers are reported. Resulting harvest of male crabs (in millions of individuals) by both sectors are listed, as well as recreational harvest as well as recreational harvest shown as a percentage of commercial harvest (hR / hMHC*100).

Method	**Recreational Harvest (hR)**	**Male Hard Crabs (hMHC)**	**hR / hMHC*100**
Exp Rate + Movement (C100%)	6.654	48.282	13.8%
Exp Rate + Movement (C95%)	6.321	48.282	13.1%
Exp Rate + Movement (C90%)	5.989	48.282	12.4%
Exp Rate + Movement (C85%)	5.656	48.282	11.7%

Table 8. Comparison of statewide harvest ratios between our study (2015) and prior recreational surveys by Ashford and Jones (2001, 2002, 2005, 2011). All harvest values are given in millions of crabs. Recreational harvests are shown as a percentage of total commercial harves (hC), commercial male harvest (hCM) and commercial harvest of male hard crabs (hMHC). Total commercial and commercial male harvest values are estimates from CBSAC. Male hard crab harvest values are reported harvests monitored by MD DNR.

Year	**Recreational Harvest (hR)**	**Commercial Harvest (hC)**	**hR / hC*100**	**Commercial Males (hCM)**	**hR / hCM*100**	**Male Hard Crabs (hMHC)**	**hR / hMHC*100**
2001	5.019	71.990	7.0%	36.871	13.6%	31.312	16.0%
2002	3.195	67.065	4.8%	33.303	9.6%	32.392	9.9%
2005	5.570	85.443	6.5%	44.097	12.6%	42.187	13.2%
2011	5.086	99.432	5.1%	60.380	8.4%	71.576	7.1%
Average	4.718		5.8%		11.1%		11.6%
2015	6.654	82.680	8.0%	51.902	12.8%	48.282	13.8%

Figures

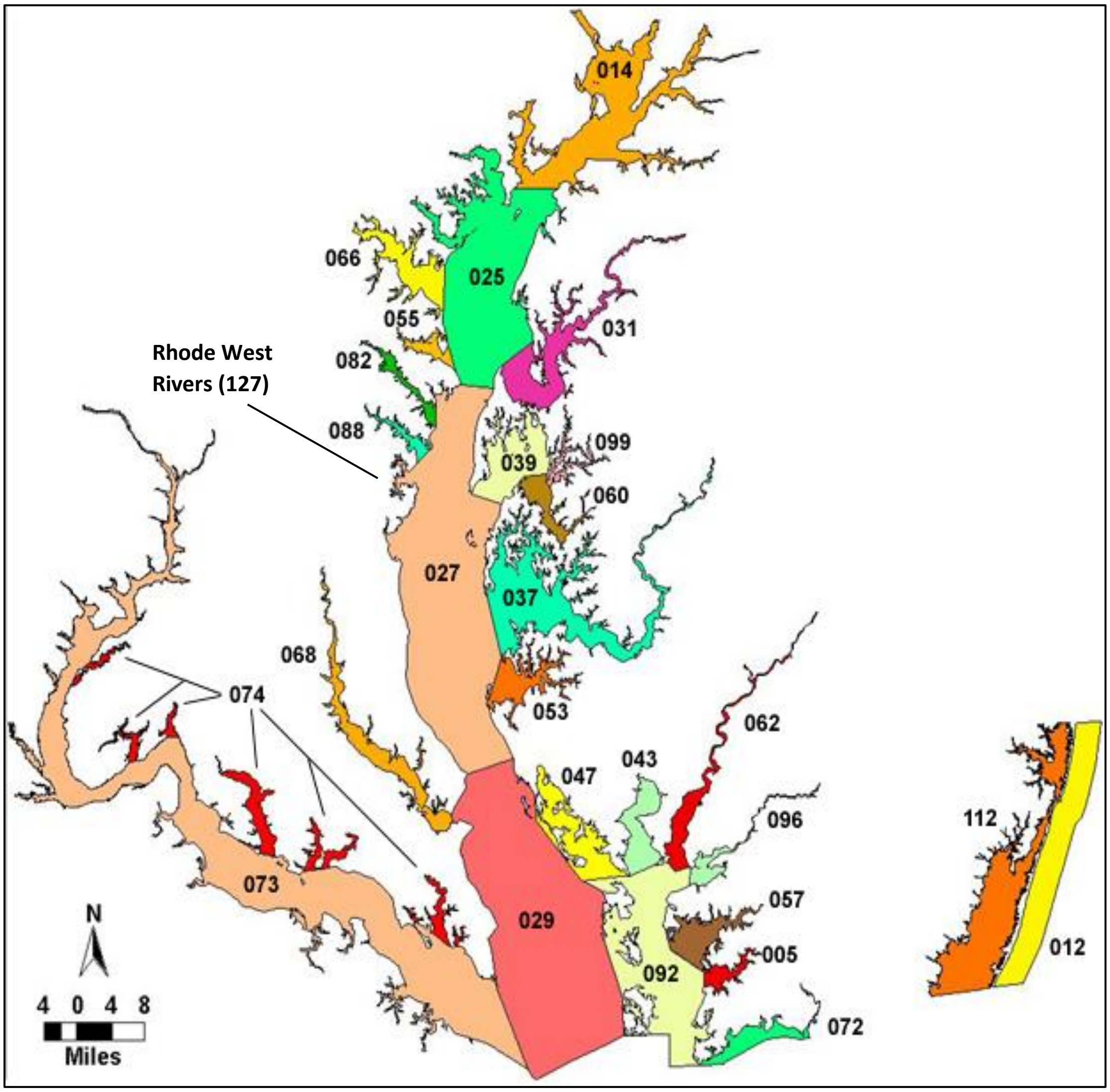

Figure 1. Map detailing the 25 harvest reporting areas of Maryland. Within the first year, crabs were tagged three times over the course of the summer within four separate harvest reporting areas of Maryland. In the second year, crabs were tagged once within fifteen sites. Two of the sites, the West River and “Bay Mainstem S”, were within the same reporting area (027), to illustrate the differences in harvest between mainstem and tributary locations within the same reporting area.

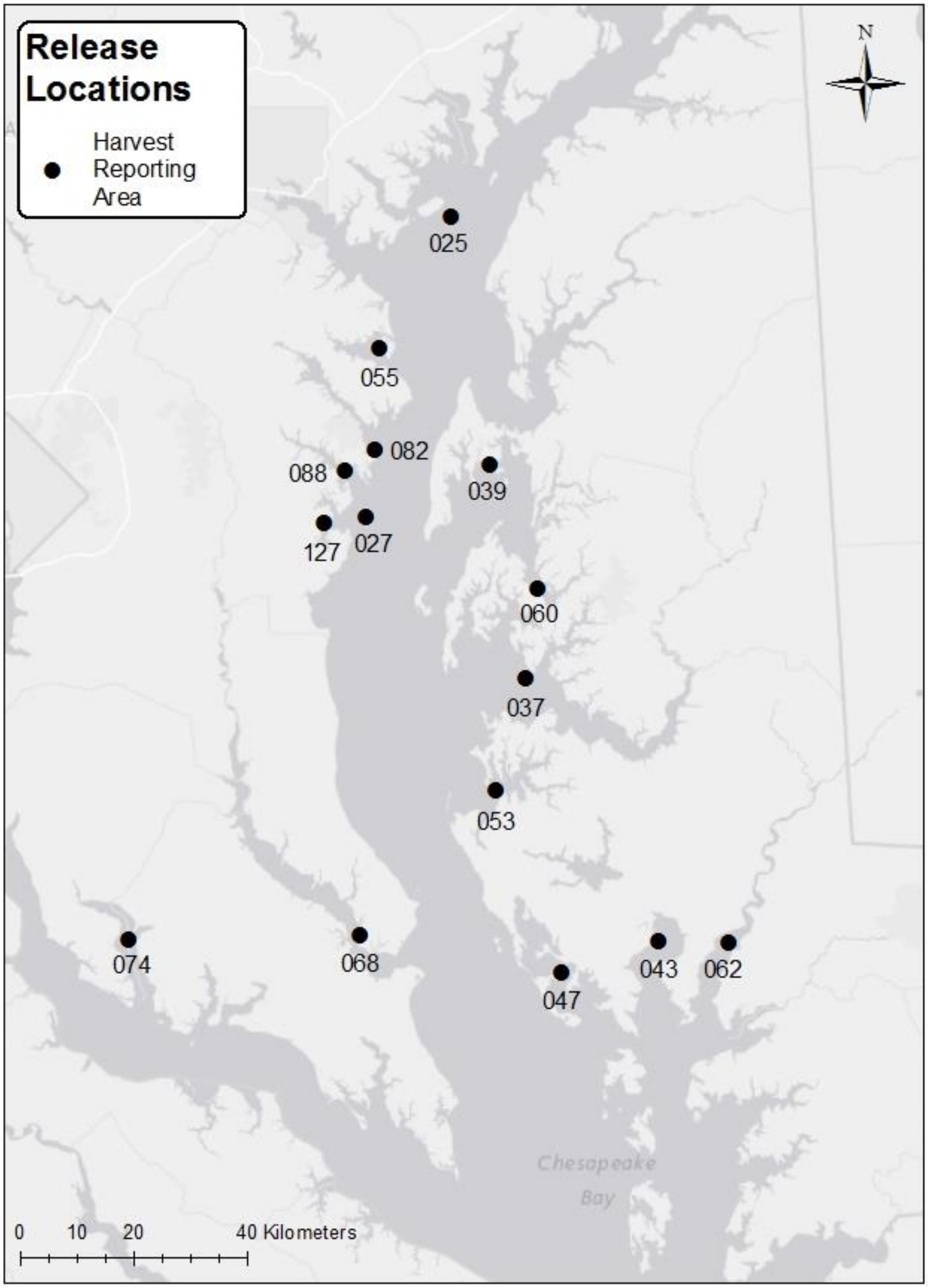

Figure 2. Map detailing the fifteen locations where crabs were tagged for this study. Tagged crabs were released once at each location in 2015. For four of these zones (the Rhode/West River complex, South River, Eastern Bay and the Little Choptank River) an additional three releases were performed in 2014. Numbers indicate harvest reporting area IDs.

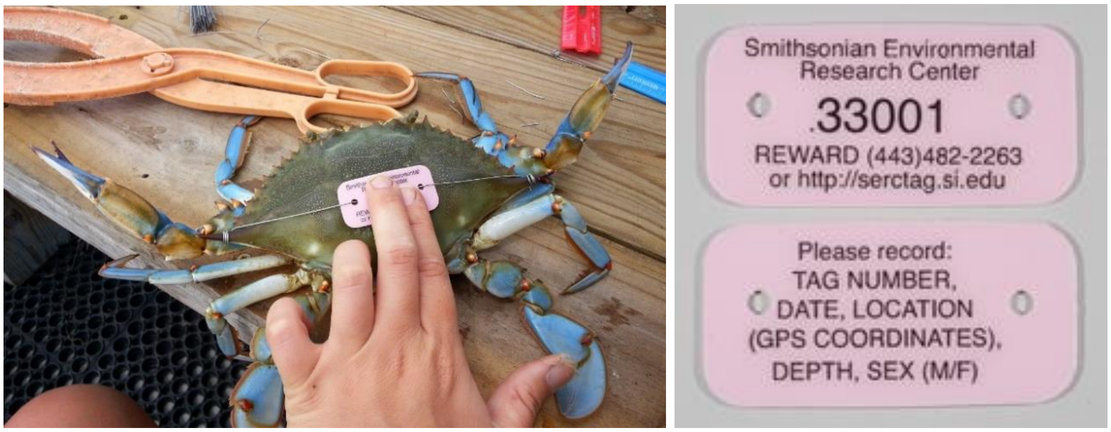

Figure 3. Adult male blue crab tagged with an over-the-back pink vinyl tag. Tags were secured with wire tied around the crab's spines. The exposed side of the tag was inscribed with a unique identification number, contact information for SERC, and reward information. The reverse listed information for the captor to keep track of and report.

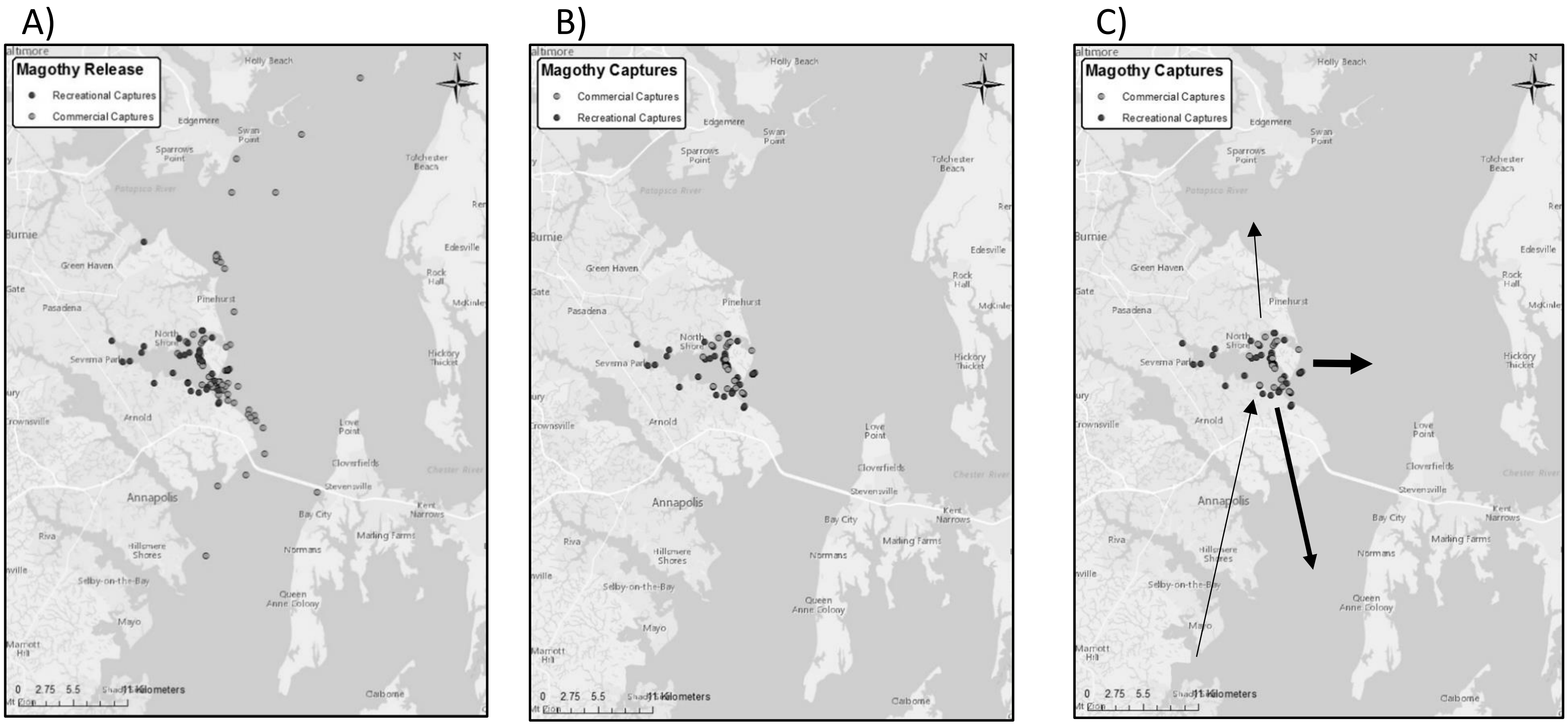

Figure 4. Methods of estimating uR / uC for each harvest reporting area, an example for the Magothy River. A) Calculation of recreational and commercial exploitation rates based on crabs released at the given site, regardless of where they were recaptured. Map indicates all recaptures for a release in the Magothy River. B) Comparison of all recreational and commercial recaptures which occurred at the given site, regardless of their initial release area. Map indicates all recaptures which occurred in the Magothy River. C) Novel adjustment of exploitation rates for each release based on the movement of crabs into and out of the release area. Map indicates all recaptures which occurred in the Magothy River, with an adjustment made to the crabs available to be caught in the system by the strengths of different exchange patterns that were observed.

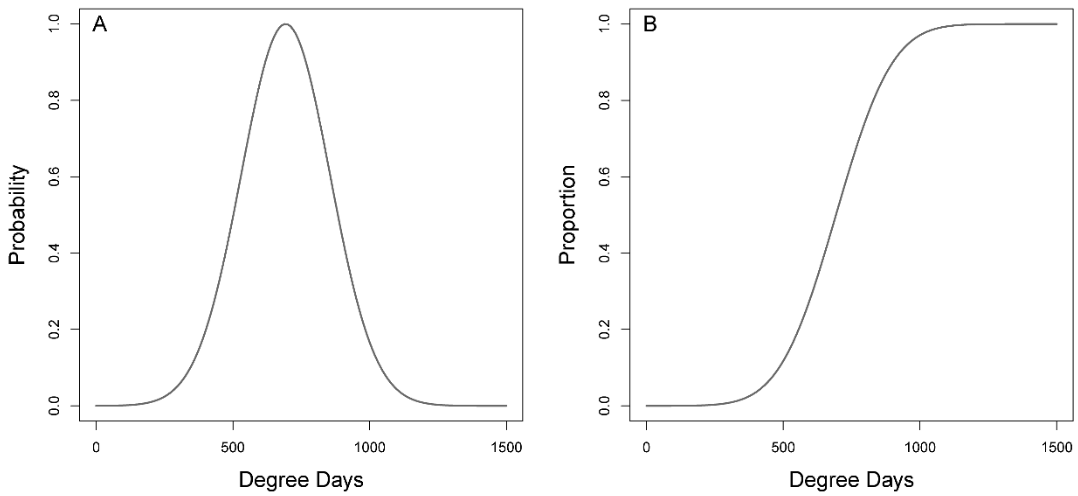

Figure 5. Molting relationship applied to crab recapture data to determine the proportion that had molted since release. (A) The probability of an individual crab molting after a number of degree days, fit to a normal distribution function, using a mean intermolt period and standard deviation determined from published values (Tagatz 1968b). (B) The proportion of crabs that had molted following a given number of degree days, generated from taking the integral of the relationship in (A).

A) B)

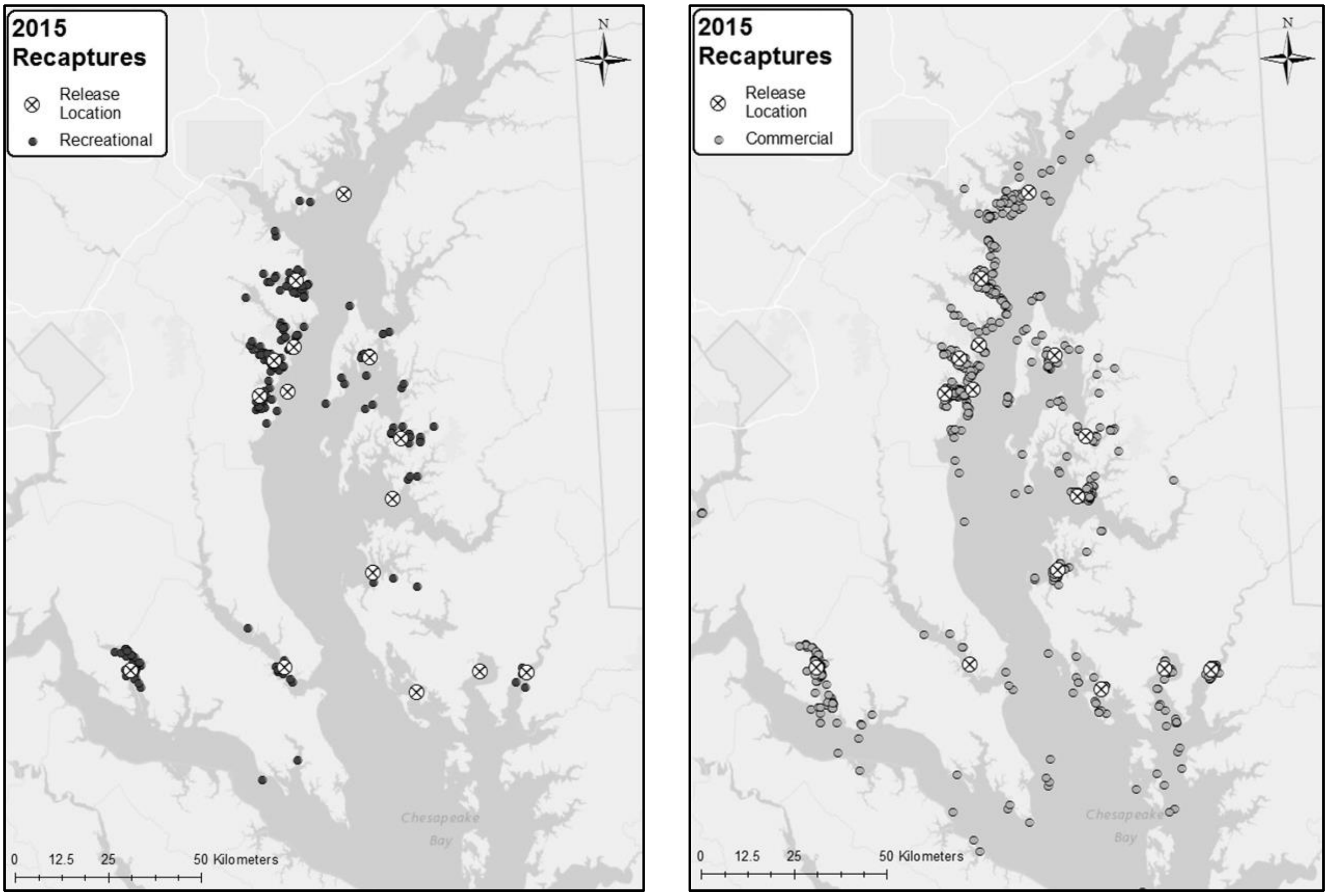

Figure 6. Physical locations where crabs were caught in 2015. Dark grey dots are recreational captures, light gray dots are commercial captures. White dots with Xs represent the 15 release areas for 2015.

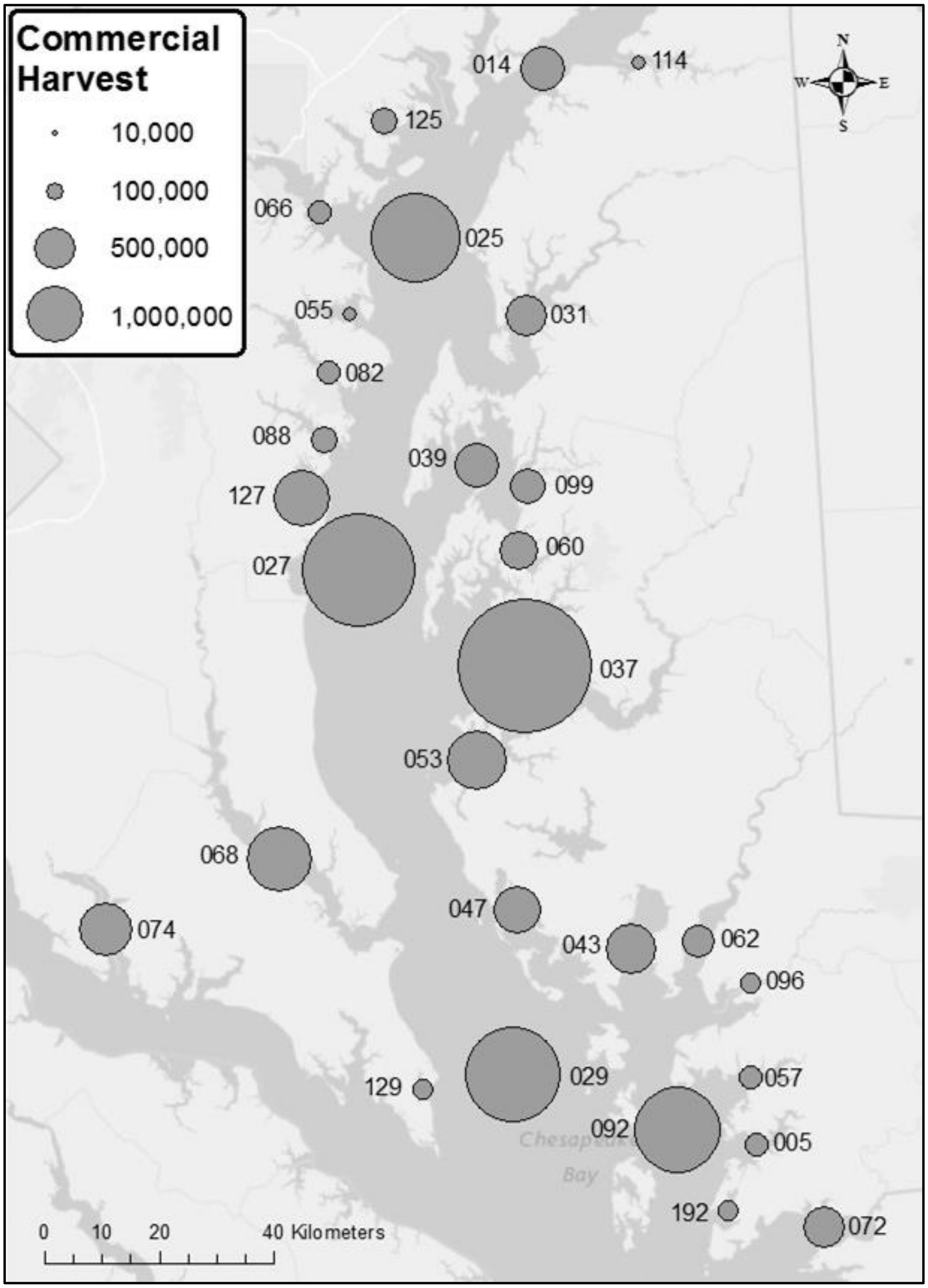

Figure 7. Reported commercial harvest of male hard crabs in each harvest reporting area of Maryland in 2015. Numbers indicate harvest reporting area IDs.

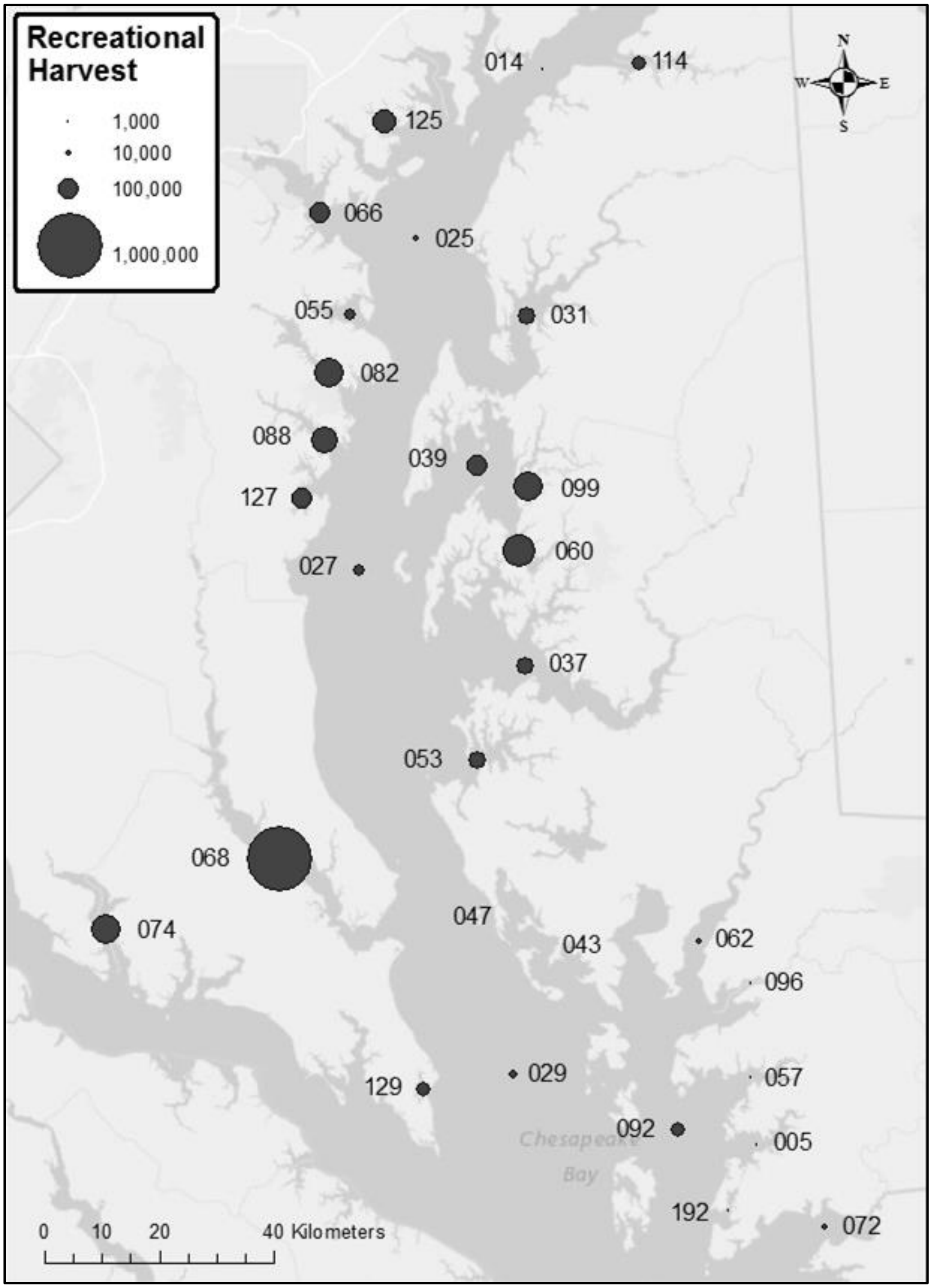

Figure 8. Estimated recreational harvest of male hard crabs in each harvest reporting area of Maryland in 2015. Numbers indicate harvest reporting area IDs. Recreational harvests were calculated with movement transformed estimates of exploitation.

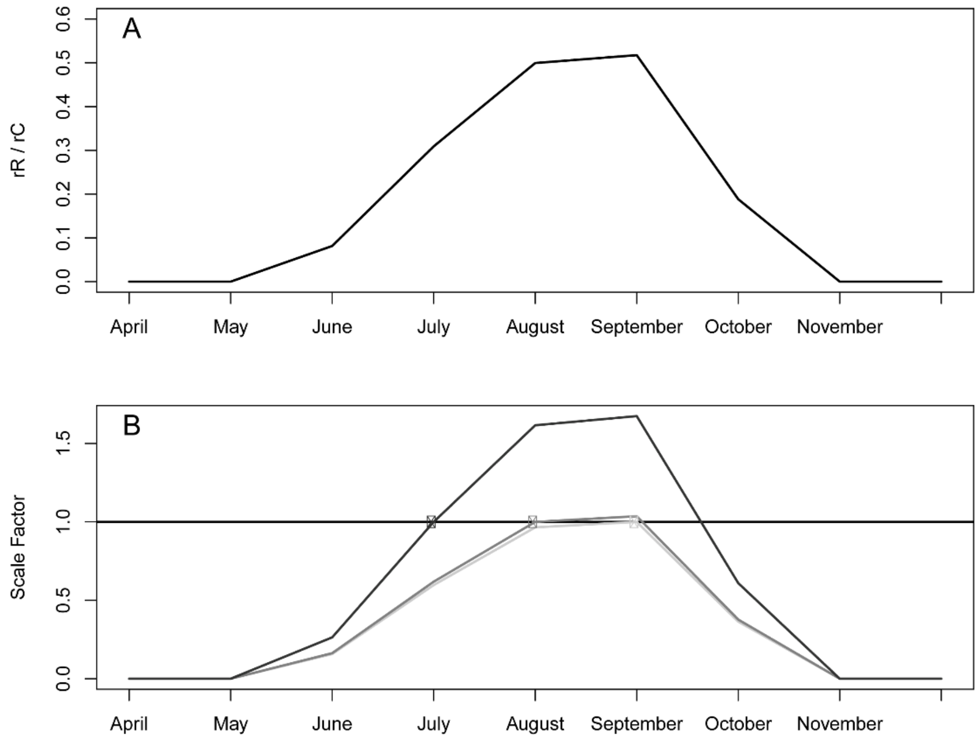

Figure 9. Ratio of recreational to commercial recaptures (rR / rC) by month across sites for releases in 2014 and 2015 releases at sites where crabs were also tagged in 2014. (A) Ratios of recreational to commercial recaptures calculated for each month. (B) The trend in (A), scaled in three different ways to place each of the months where crabs were released (ie. July, August, or September) to 1, so that other months may be scaled to the ratio of recreational to commercial exploitation observed in these months. The black line is scaled to place rR / rC at one in July, the medium gray line scales to one for August, and the light gray line scales to one for September.

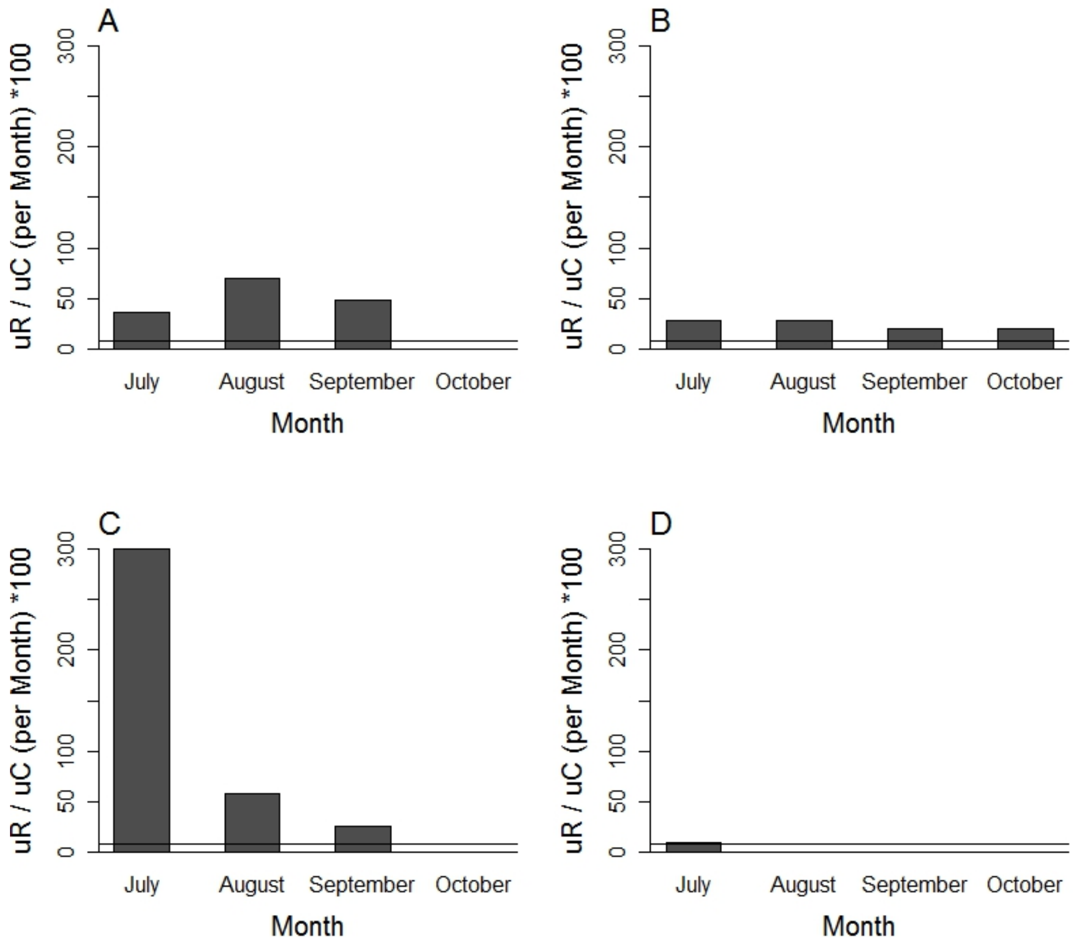

Figure 10. Mean ratio of recreational to commercial exploitation (uR / uC) per month times 100, across months for the four sites where crabs were tagged in 2014. Ratios of recreational and commercial exploitation (uR / uC) were calculated in South River (A), Eastern Bay (B), Rhode River (C), and the Little Choptank River (D). The horizontal line indicates the statewide ratio of recreational to commercial to harvest for Maryland used in the current stock assessment (8%).

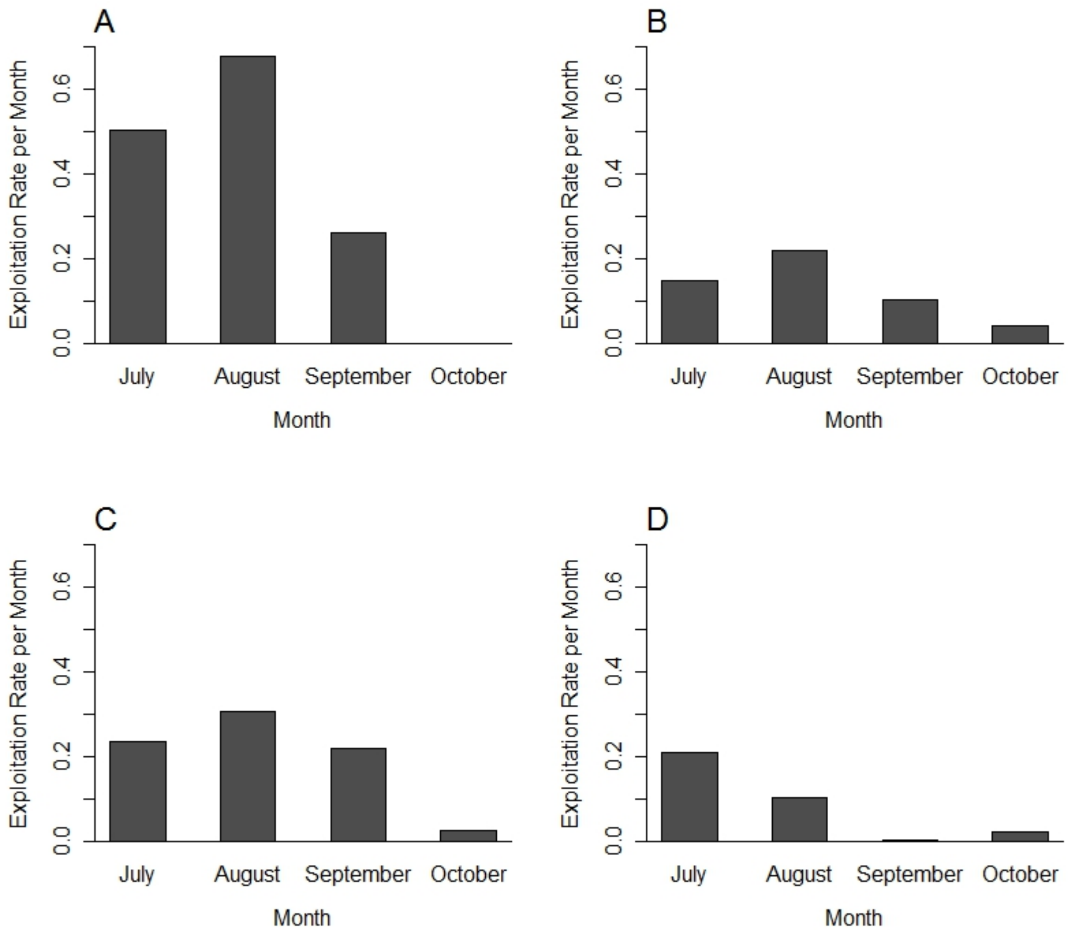

Figure 11. Mean total exploitation rate per month across months at the four sites where crabs were tagged in 2014. Rates were calculated for total exploitation in South River (A), Eastern Bay (B), Rhode River (C), and the Little Choptank River (D).

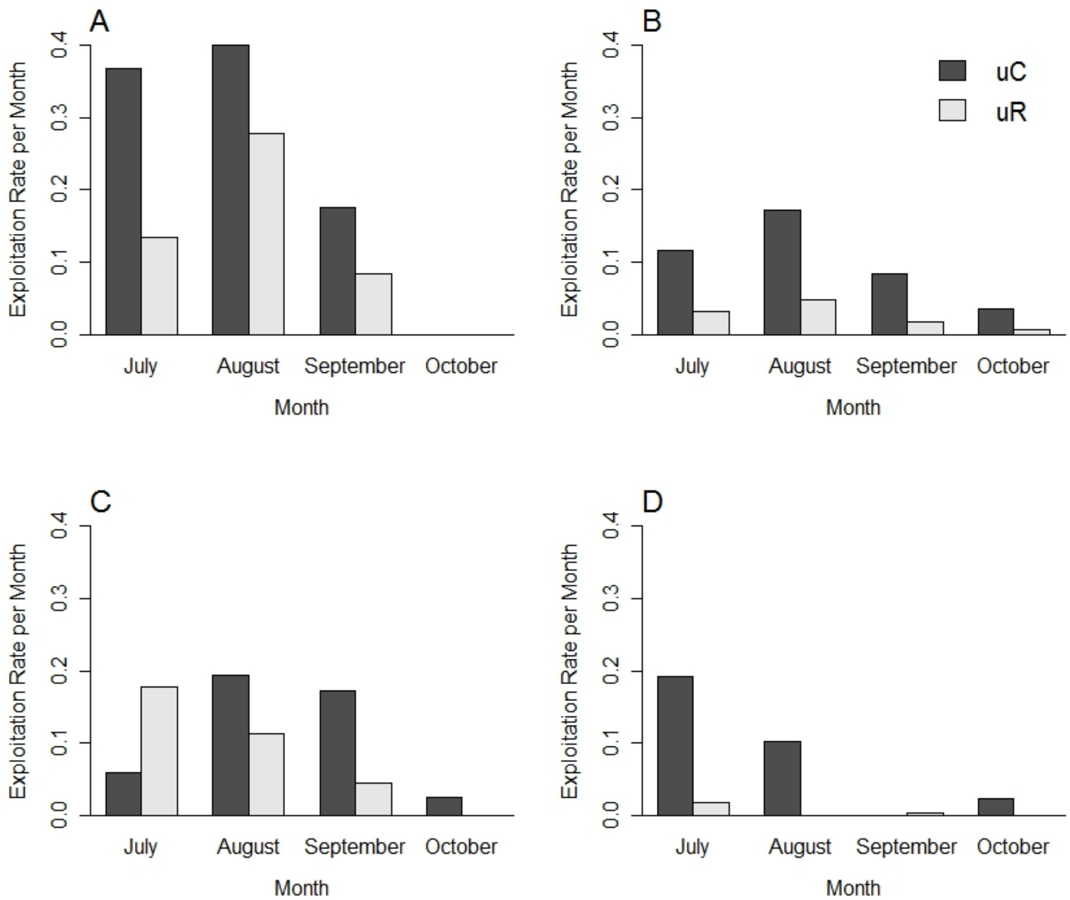

Figure 12. Mean commercial and recreational exploitation rates per month across months for the four sites where crabs were tagged in 2014. Rates were calculated for commercial (uC) and recreational exploitation (uR) in South River (A), Eastern Bay (B), Rhode River (C), and the Little Choptank River (D).

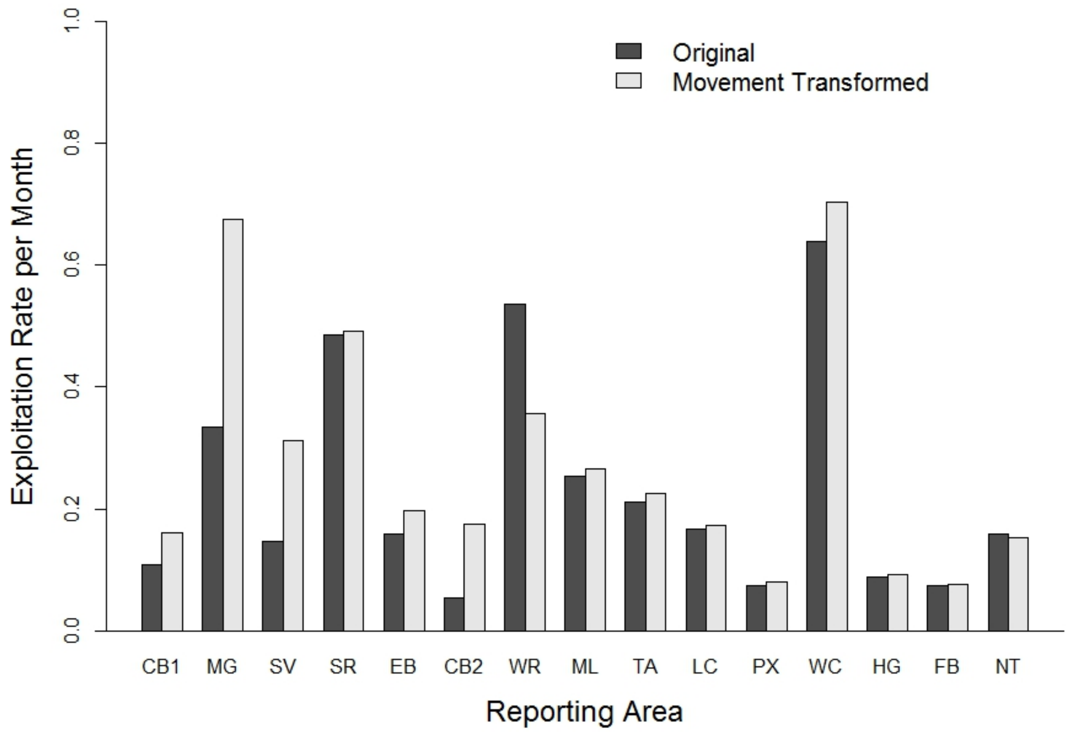

Figure 13. Mean total exploitation per month within each harvest reporting area before and after movement transformation for all sites tagged in 2015. Black bars represent total exploitation calculated normally, gray bars represent total exploitation calculated under the movement transformation method. Labels indicate the following sites, respectively: Bay Mainstem North (Hart-Miller Island) (CB1), Magothy River (MG), Severn River (SV), South River (SR), Eastern Bay (EB), Bay Mainstem South (Off West River) (CB2), West River (WR), Miles River (ML), Tred Avon River (TA), Little Choptank (LC), Patuxent River (PX), Wicomico River (Potomac) (WC), Honga River (HG), Fishing Bay (FB), and Nanticoke River (NT).

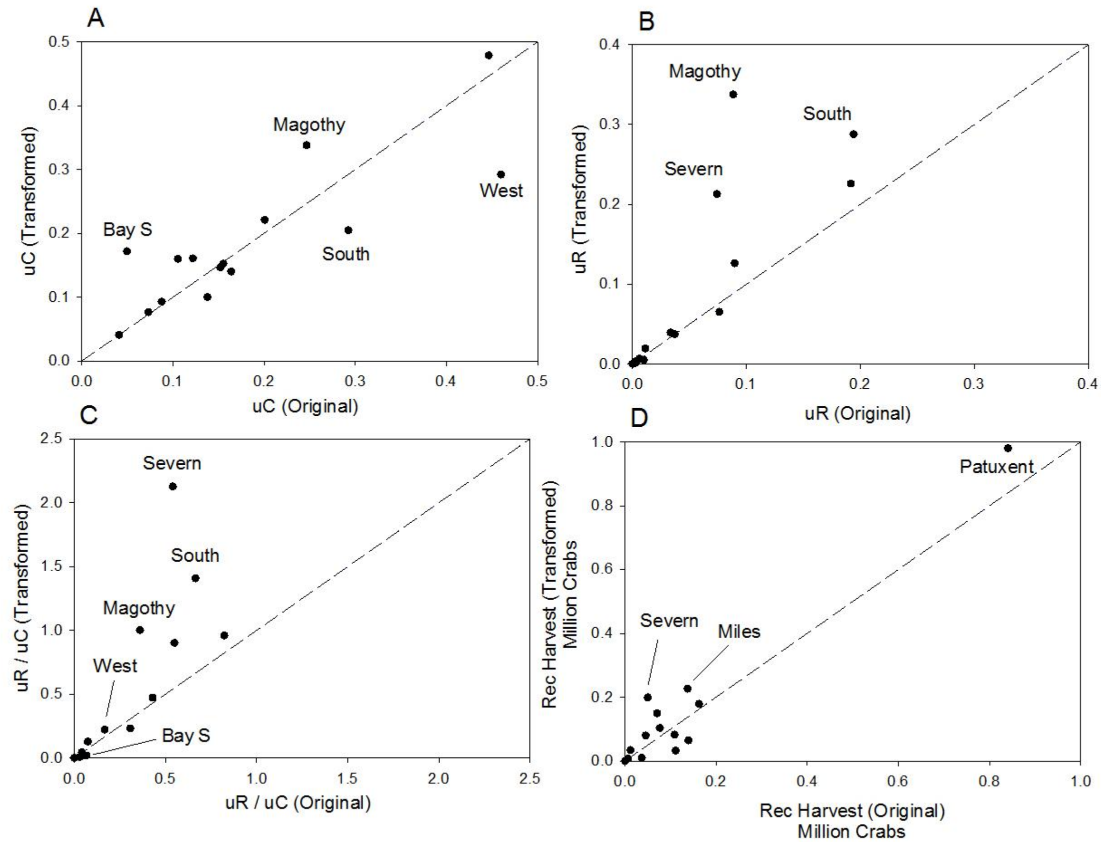

Figure 14. Changes in exploitation and recreational harvest under the movement transformation method for each harvest reporting area where tagging occurred in 2015. (A) Change in commercial exploitation (uC), (B) change in recreational exploitation (uR), (C) change in the ratio of recreational to commercial exploitation (uR/uC), (D) change in the level of recreational harvest.

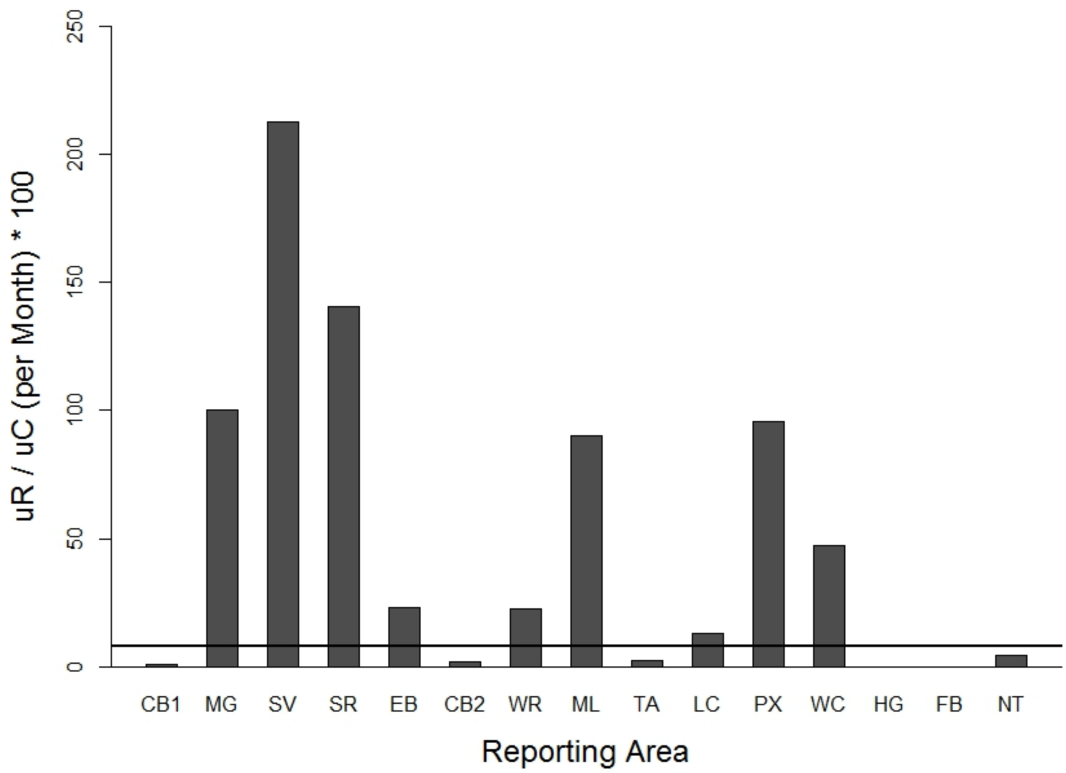

Figure 15 Mean ratio of recreational to commercial exploitation (uR / uC) per month times 100, over the first two months post-release at all sites tagged in 2015. Labels indicate the following sites, respectively: Bay Mainstem North (Hart-Miller Island) (CB1), Magothy River (MG), Severn River (SV), South River (SR), Eastern Bay (EB), Bay Mainstem South (Off West River) (CB2), West River (WR), Miles River (ML), Tred Avon River (TA), Little Choptank (LC), Patuxent River (PX), Wicomico River (Potomac) (WC), Honga River (HG), Fishing Bay (FB), and Nanticoke River (NT). The horizontal line indicates the overall ratio of recreational to commercial to harvest for Maryland used in the current stock assessment (8%).

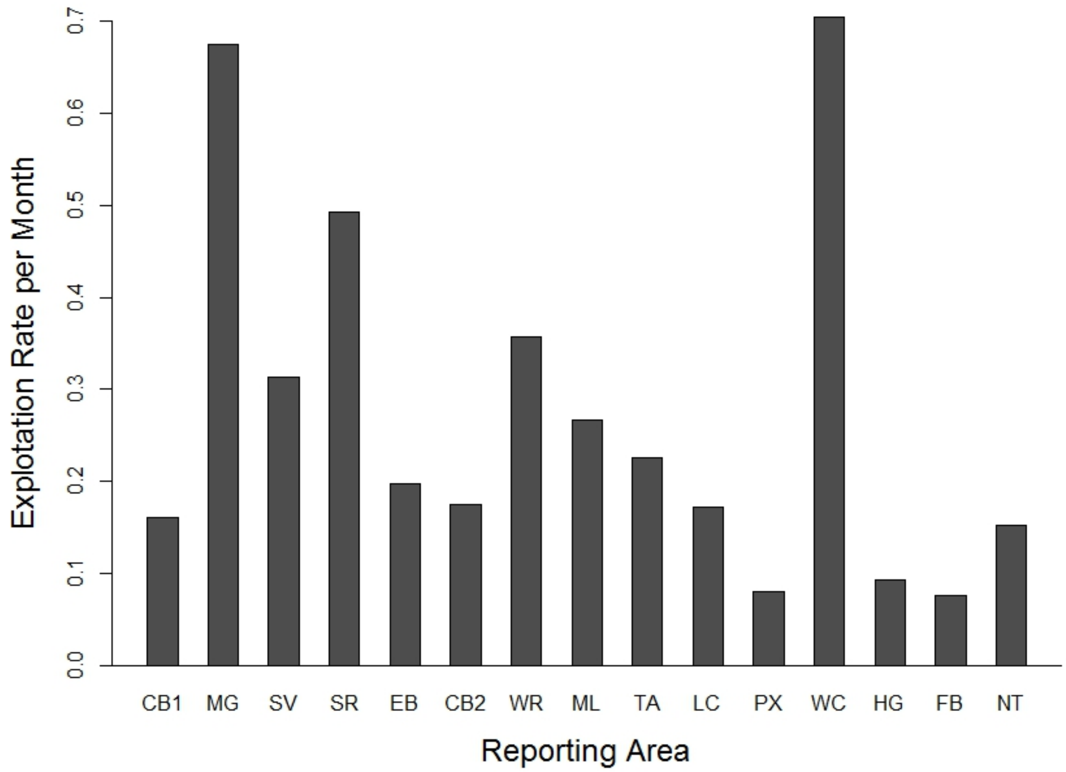

Figure 16. Average total exploitation over the first two months post-release at all sites tagged in 2015. Labels indicate the following sites, respectively: Bay Mainstem North (Hart-Miller Island) (CB1), Magothy River (MG), Severn River (SV), South River (SR), Eastern Bay (EB), Bay Mainstem South (Off West River) (CB2), West River (WR), Miles River (ML), Tred Avon River (TA), Little Choptank (LC), Patuxent River (PX), Wicomico River (Potomac) (WC), Honga River (HG), Fishing Bay (FB), and Nanticoke River (NT).

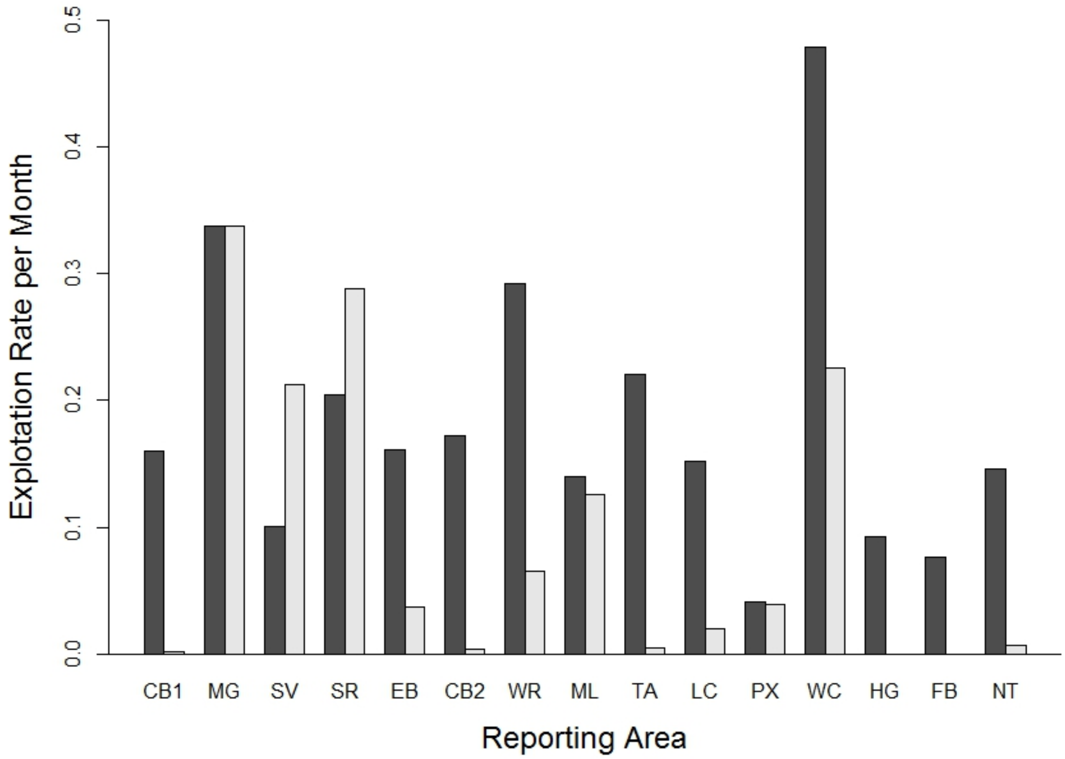

Figure 17. Average commercial and recreational exploitation over the first two months post-release at all sites tagged in 2015. Black bars reperesent total exploitation calculated normally, gray bars represent total exploitation caluclated under the movement trasnformation method. Labels indicate the following sites, respectively: Bay Mainstem North (Hart-Miller Island) (CB1), Magothy River (MG), Severn River (SV), South River (SR), Eastern Bay (EB), Bay Mainstem South (Off West River) (CB2), West River (WR), Miles River (ML), Tred Avon River (TA), Little Choptank (LC), Patuxent River (PX), Wicomico River (Potomac) (WC), Honga River (HG), Fishing Bay (FB), and Nanticoke River (NT).

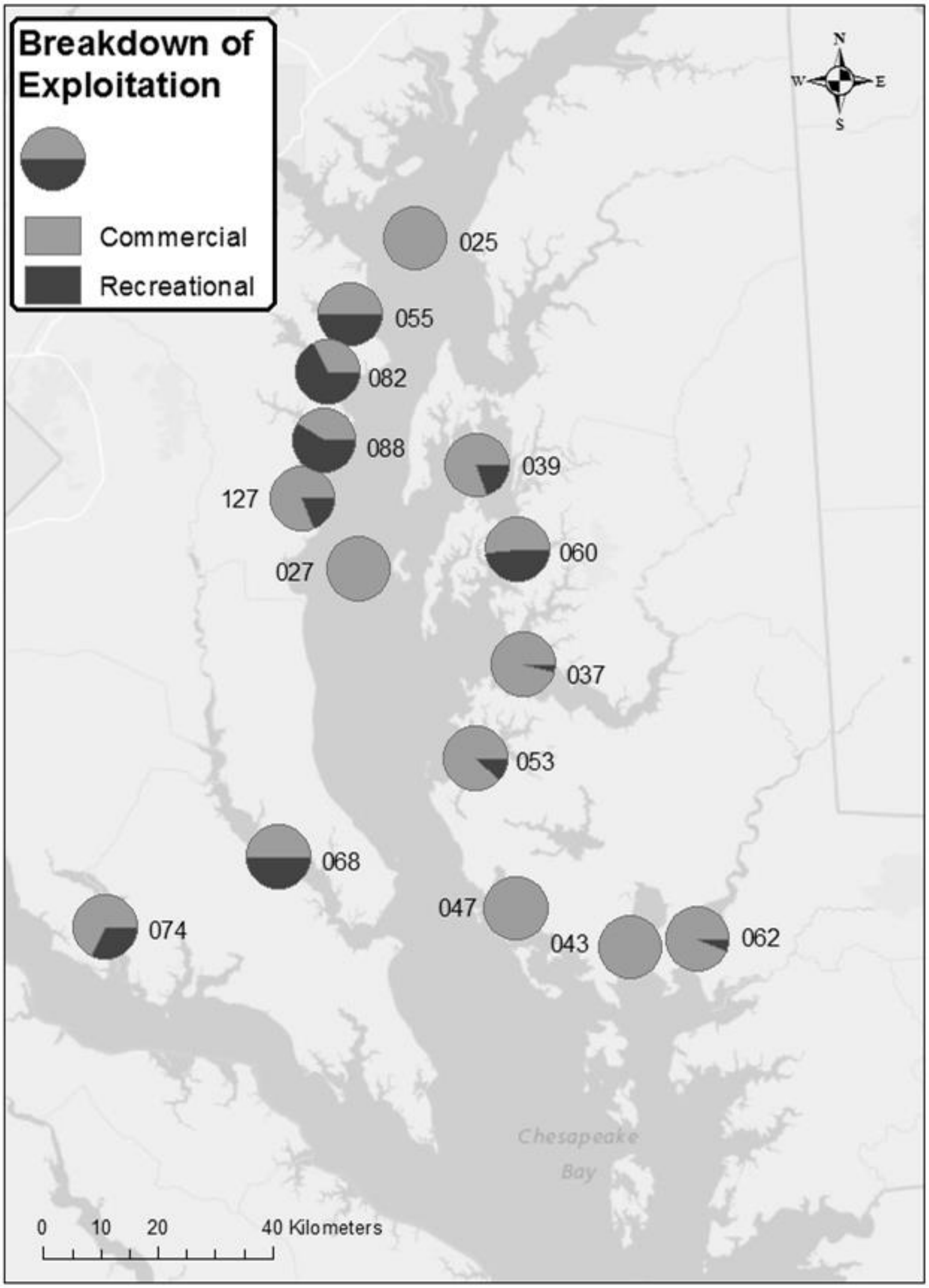

Figure 18. Proportion of exploitation by the recreational and commercial sectors in each harvest reporting area where crabs were tagged in 2015. uC refers to commercial exploitation (light gray) and uR refers to recreational exploitation (dark gray). Numbers indicate harvest reporting area IDs.

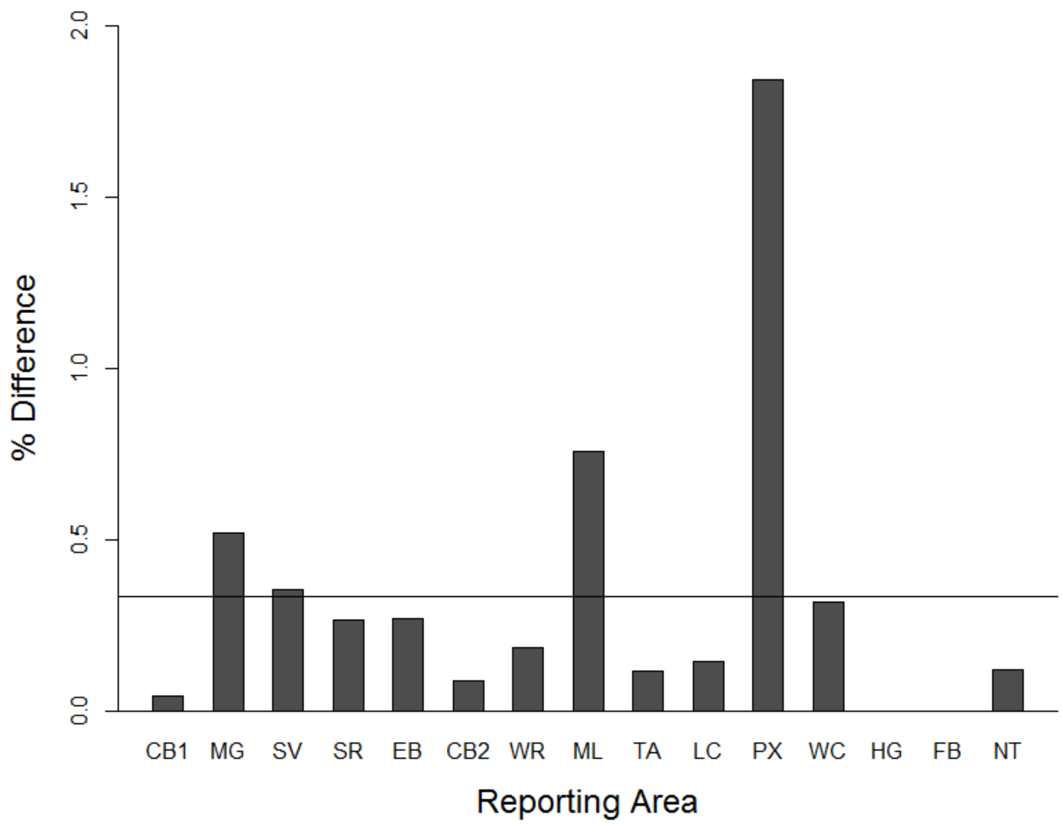

Figure 19. Percent decrease in the statewide ratio of recreational to commercial harvest under the assumption of 5% commercial underreporting in each harvest reporting area. Labels indicate the following sites, respectively: Bay Mainstem North (Hart-Miller Island) (CB1), Magothy River (MG), Severn River (SV), South River (SR), Eastern Bay (EB), Bay Mainstem South (Off West River) (CB2), West River (WR), Miles River (ML), Tred Avon River (TA), Little Choptank (LC), Patuxent River (PX), Wicomico River (Potomac) (WC), Honga River (HG), Fishing Bay (FB), and Nanticoke River (NT). The horizontal line represents the expected percent decrease in each harvest reporting if each contributed to recreational harvests equally (0.33%).

Appendix A: Movements of Adult Male Crabs between Reporting Areas

Introduction:

Blue Crab Movements

Subpopulations of crabs may be subject to some degree of mixing through the continual migration and exchange of adults. These exchanges are expected to be seen both over the course of a crab's active period during the warm months, and from year to year as crabs return to the tributaries following overwintering in basin habitats of the bay mainstem. In particular, the exchange of adults over the course of a crab's active months will be assessed here. Year to year exchanges between reporting areas (i.e., cases where a crab is released in one reporting area in the first summer and is recaptured in another reporting area the following summer), will not be addressed through this study. These year to year exchanges may also simply be cases where the migration between reporting areas occurred during its active period, but were not observed until it was recaptured the following year.

From a fisheries perspective the movements of adult crabs between reporting areas during a crab's active period may be of particular concern at a local scale. If highly exploited habitats are seen to receive a large amount of adult crabs from other habitat zones, then it would be in the best interest of continued sustainable exploitation that the contributing habitat zones are understood and maintained. In this way, harvest reporting areas will need to be categorized as an important destination, receiving large subsidies of crabs, as an important origin location, providing subsidies of crabs to other areas, or as neither.

This study had three specific objectives. First, to quantify the movement patterns of male and female crabs through connectivity matrices of release and recapture location. Second, to identify specific harvest areas in the Maryland waters of the Chesapeake Bay which many adult crabs leave, and subsequently contribute a large proportion of their adult crabs to other harvest areas. And third, to identify subsequent harvest areas within the Bay which many adult crabs will move to, thereby obtaining a large proportion of their adult crabs from outside sources.

Methods:

Data and Organization

Information for this study came from the mark-recapture experiment explained in Chapter 1. Specifically, the connectivity information detailed here came from the second year of the tagging study, in which crabs were tagged at fifteen different harvest reporting areas in Maryland, with one tagging event in each harvest reporting area. As well as describing spatial patterns of harvest in different areas of the Chesapeake Bay, recapture information from these fifteen sites also illustrates the dispersal and movement patterns of crabs and how these may differ by harvest reporting areas. Descriptions of the recapture locations provided by anglers that reported crabs in this study were used determine the reporting area where each tagged crab was recaptured. These could then be compared against the reporting area in which each crab was released, to infer movement of adult crabs between reporting areas.

Each recapture was also plotted as a GPS location. Recapture locations were plotted from information provided by anglers. Points were plotted with varying levels of accuracy and were subset as follows. The first group included all recaptures for which GPS locations were explicitly provided by anglers and are expected to be plotted with high accuracy to the actual capture location. The second group includes all recaptures for which anglers physically marked on maps where capture occurred. These were then replot as GPS coordinates and are also expected to be highly accurate to actual recapture locations. The third group includes all recaptures for which descriptions of the capture location were sufficiently detailed and specific as to ensure points would be plotted within a close proximity. Examples of sufficiently detailed locations descriptions include “Wicomico Shores pier pot”, “Off of Ft. Howard Park”, and “Miles River, Hunting Creek”. The final group includes all recaptures for which descriptions of capture locations were not sufficiently detailed. Examples of such descriptions include “West River Mouth”, “Choptank River, Broad Creek”, and “South River”.

Detailing Crab Movement Patterns

Movements and exchanges of crabs between reporting areas were calculated and illustrated through connectivity matrices. The connectivity matrices used assessed two separate factors related to adult crab exchange. First, they assessed the number of crabs originally released within each reporting area, and the proportion of those released that were captured at each different reporting area. Second, they assessed the number of crabs that were captured within each reporting area, and the proportion of those captured that were originally released within each reporting area. More simply, these two methods assessed both where the crabs released at each site went (from here on referred to as "Destinations matrices") and where the crabs recaptured at each site originally came from ("Origins matrices" from here on). Both of these assessments were run for both males and females, as well as for specific factors (ie. sectors and months) pertaining to exploitation rate transformations used to refine recreational harvest estimates in Chapter 1. For females, matrices will be calculated based on releases in both years, to ensure a large number of crabs to draw relationships from. However, for males only the 2015 releases were uses as multiple releases for particular harvest reporting areas could skew proportions significantly.

Identifying Important Origin and Destination Zones

If a large proportion of the crabs initially released from a particular harvest reporting area and were eventually caught were caught elsewhere, then that site could be seen as an important origin location for crab movements. Important origin zones will be identified by the size of their factor of exit (F_{EX}), or the proportion of crabs originally released there which were caught elsewhere. The calculation of F_{EN} is described by the equation:

$$F_{EX} = 1 - P_{(RS)S,S}$$

Where $P_{(CS)S,S}$ represent the proportion of crabs released at the given site and eventually caught which were initially released there. Important origin areas are designated as harvest reporting areas with a $F_{EX} > 0.25$. These were only designated if there were greater than 20 crabs initially released from a reporting area were caught, otherwise there were not enough crabs to provide accurate proportions.

If a large proportion of the crabs caught in a particular harvest reporting area were initially released elsewhere, then that site could be seen as an important destination for crab movements. Important destinations will be identified by the size of their factor of entry (F_{EN}), or the proportion of crabs caught there which originated from other zones. The calculation of F_{EN} is described by the equation:

$$F_{EN} = 1 - P_{(CS)S,S}$$

Where $P_{(CS)S,S}$ represent the proportion of crabs caught at the given site which were initially released there. Important destination areas are designated as harvest reporting areas with a $F_{EN} > 0.25$. As with F_{EX}, these were only designated in cases where the number of crabs caught within the given site was greater than 20, in order to provide reliable proportions.

Results:

Detailing Crab Movement Patterns

Crab movement patterns appear to be markedly different between sexes. For females, movements from tributaries into the Bay Mainstem were substantial (Table A2). For example, of the 26 female crabs which were released in the Little Choptank River (053) and were caught, 38% were caught in the Mainstem S (027 North of Cove Pt and South of Bay Bridge), 8% were caught in the Mainstem SS (029 South of Cove Pt), and 15% were caught in Virginia (101). In all, that is 61% of crabs caught in Mainstem waters. Compare this to males released in the Little Choptank in 2015 (Table A4). For this release 55 crabs were captured and only 6% of crab captures occurred in Mainstem waters (4% in Mainstem SS, and 2% in Virginia).

Additionally, females can be observed to primarily move to harvest reporting areas at the same latitude as or south of their release area. For example, the only northward subsidy of female crabs observed occurred from releases in the Rhode / West Complex (127). Of the 25 crabs caught from these releases, 4% were caught in the Mainstem N (025 North of Bay Bridge and South of Worton Pt). In contrast, for male crabs released in 2015, there were many northward subsidies for 9 of the releases.

Identifying Important Origin and Destination Zones

Though there were not a sufficient number of crabs to assess origin and destination zones for females, all four of the harvest reporting areas assessed had F_{EX} values greater than 0.25, and were designated as important origin zones. These were the Wicomico River (Potomac) (0.71), the Little Choptank River (0.62), Rhode River (0.48), and South River (0.34). For male crabs, five of the fifteen harvest reporting areas assessed had an F_{EX} value greater than 0.25, and were designated as important origin zones. These were the Magothy River (0.45), Severn River (0.45), Eastern Bay (0.30), Rhode River (0.26), and Bay Mainstem S (0.26). Of the five important origin zones identified for male crabs, four were tributaries in the upper Bay. The Bay Mainstem S was also designated as an important origin zone, due to reciprocal exchanges of crabs between the Rhode / West River complex and mainstem areas at the mouth of the complex. For male crabs, two of the fourteen harvest reporting areas assessed had an F_{EN} value greater than 0.25, and were designated as important destination zones. These were the Bay Mainstem N (0.55) and the Bay Mainstem S (0.85). Both of the zones identified were mainstem areas of the bay, and both exhibited F_{EN} values far above the cutoff, indicating large subsidies of crabs entering these zones.

Discussion

Results from this study confirm expected patterns of movement and harvest that, until now, had not been quantified. Within the Chesapeake Bay, a general pattern exists where crabs, especially mature females, will move from tributaries out into areas of the Bay Mainstem, supplying these Mainstem areas with harvestable crabs. There is some evidence that these patterns, while not quantified, have been understood by fishers, and are already being utilized by fishers. As highlighted above, when exploitation calculations for Mainstem zones were limited to either crabs entering Mainstem areas, or those already residing there, crabs entering Mainstem zones faced 3 to 4 times as high exploitation pressure as those crabs residing with them (Table 8). This is likely due to the setting of commercial crab pots near the mouths of tributaries, to target crabs exiting the tributaries for Mainstem zones. For these reasons, the maintenance of crab habitats in tributaries is important in ensuring plentiful continued harvests in Mainstem zones where commercial fishing dominates.

Table A1) Numeric code designations for harvest reporting areas. For reporting areas in Maryland, designations were taken directly from harvest reporting sheets used by commercial crabbers. Other designations were added to include harvest in Virginia (101), the Potomac River (102), and North Carolina (103). Additionally, harvest in the Rhode and West Rivers (127) was separated from that in the Bay Mainstem south of the Bay Bridge (027). Harvest reporting areas are listed from north to south.

Harvest Reporting Area	**Code**
Bay Mainstem NN	014
Patapsco River	066
Chester River	031
Magothy River	055
Bay Mainstem N	025
Severn River	082
South River	088
Rhode / West Rivers	127
Wye River	099
Miles River	060
Eastern Bay	039
Choptank River	037
Little Choptank River	053
Patuxent River	068
Bay Mainstem S	027
Honga River	047
Fishing Bay	043
Nanticoke River	062
Wicomico River	096
Potomac (MD Tribs)	074
Potomac River	102
Bay Mainstem SS	029
Manokin River	057
Pocomoke Sound	072
Big Annemessex	005
Tangier Sound	092
Virginia	101
Atlantic Ocean	012
North Carolina	103

Table A2) Destinations matrix for all female crabs released in both years. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rl
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.00	0.00	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
082	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
088	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.14	0.00	0.02	59
127	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.08	0.00	0.04	25
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	2
039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.29	0.00	0.00	17
037	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.15	0.00	0.00	26
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	10
027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	4
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.17	0.00	0.00	6
062	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.38	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	24
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A3) Origins matrix for all female crabs released in both years. Proportions indicate proportion of crabs recaptured in the reporting area indicated on the left that were initially release in the area indicated at the top. Reporting area codes are listed in Table A1. Rc indicates the total number of crabs recaptured in the area indicated at the left.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
025	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
082	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
088	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39
127	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
037	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
053	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
027	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.19	0.00	0.00	0.22	0.00	0.31	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
062	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
102	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.14	0.07	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
029	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.13	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.06	0.00	0.03	0.14	0.00	0.11	0.17	0.00	0.03	0.03	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2

Table A4) Destinations matrix for all male crabs released in 2015. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.06	0.00	0.55	0.32	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	121
025	0.04	0.04	0.02	0.00	0.78	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.02	0.00	0.00	0.00	51
082	0.00	0.00	0.00	0.00	0.05	0.55	0.00	0.03	0.00	0.00	0.00	0.05	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40
088	0.00	0.00	0.00	0.00	0.01	0.00	0.87	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	155
127	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.74	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	187
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.09	0.78	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46
039	0.00	0.00	0.05	0.00	0.04	0.00	0.00	0.00	0.03	0.04	0.70	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	55
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21
027	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	32
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06	0.00	0.00	0.00	80
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	149
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A5) Origins matrix for all male crabs released in 2015. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rc indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
066	0.00	0.00	0.00	0.78	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
031	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.17	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
055	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68
025	0.00	0.00	0.00	0.44	0.45	0.02	0.01	0.01	0.00	0.01	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	89
082	0.00	0.00	0.00	0.00	0.04	0.92	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24
088	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	136
127	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	143
099	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39
039	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52
037	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
027	0.00	0.00	0.00	0.06	0.01	0.11	0.16	0.39	0.00	0.04	0.06	0.00	0.02	0.00	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	114
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	138
102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
029	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.10	0.00	0.00	0.40	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A6) Destinations matrix for male crabs released in 2015 which were caught in the first month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.06	0.00	0.55	0.34	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	101
025	0.04	0.02	0.02	0.00	0.80	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00	45
082	0.00	0.00	0.00	0.00	0.03	0.60	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30
088	0.00	0.00	0.00	0.00	0.01	0.00	0.89	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	140
127	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.01	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	177
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.03	0.83	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29
039	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00	0.04	0.72	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	52
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
027	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	74
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	110
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A7) Destinations matrix for male crabs released in 2015 which were caught commercially in the first month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.08	0.00	0.40	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72
025	0.05	0.00	0.02	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.02	0.00	0.00	0.00	43
082	0.00	0.00	0.00	0.00	0.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16
088	0.00	0.00	0.00	0.00	0.01	0.00	0.84	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97
127	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.01	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	138
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.79	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
039	0.00	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	81
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
027	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	67
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	88
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A8) Destinations matrix for male crabs released in 2015 which were caught recreationally in the first month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27
025	0.00	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
082	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
088	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41
127	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
039	0.00	0.00	0.07	0.00	0.07	0.00	0.00	0.00	0.00	0.14	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
047	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
043	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A9) Destinations matrix for male crabs released in 2015 which were caught in the second month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.05	0.00	0.55	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20
025	0.00	0.17	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
082	0.00	0.00	0.00	0.00	0.10	0.40	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
088	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15
127	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.71	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17
039	0.00	0.00	0.08	0.00	0.04	0.00	0.00	0.00	0.08	0.04	0.67	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	4
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.33	0.00	0.00	0.00	6
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A10) Destinations matrix for male crabs released in 2015 which were caught commercially in the second month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.00	0.00	0.38	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13
025	0.00	0.17	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
082	0.00	0.00	0.00	0.00	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6
088	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
127	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.56	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
039	0.00	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.06	0.00	0.71	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
027	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	3
043	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
062	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.33	0.00	0.00	0.00	6
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

Table A11) Destinations matrix for male crabs released in 2015 which were caught recreationally in the second month after their release. Values indicate proportion of crabs released in the reporting area in the column on the left that were recaptured in the area indicated at the top. Reporting area codes listed in Table A1. Rl indicates the total number of crabs released in the area indicated at the left which were captured.

	014	066	031	055	025	082	088	127	099	060	039	037	053	068	027	047	043	062	096	074	102	029	057	072	005	092	101	012	103	Rs
014	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
066	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
055	0.00	0.14	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
025	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
082	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4
088	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9
127	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
099	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
039	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
037	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
053	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
068	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2
027	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
047	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1
043	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
062	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
096	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
074	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17
102	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
029	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
057	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
072	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
092	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
101	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
103	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0

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