

2003-04 and 2004-05 Florida Keys National Marine Sanctuary Commercial Fishing  
Panels' Spatial Fishery Profiles

Manoj Shivlani  
Flavia Tonioli

April 4, 2007

## Table of Contents

Introduction.....	4
Methodology .....	6
Results.....	9
Discussion.....	34
References.....	36

## List of Figures

Figure 1: Reef fishing landings in 2001.....	4
Figure 2: Reef fishing landings in the western FKNMS, 2004-05 .....	5
Figure 3: 2004-05 reef fish landings in the western FKNMS.....	7
Figure 4: 2004-05 reef fish landings in the western FKNMS with benthic areas.....	7
Figure 5: 2004-05 reef fish landings in the western FKNMS with benthic areas and protected areas .....	7
Figure 6: Lobster fishing in 2003-04 .....	9
Figure 7: Lobster fishing in 2003-04, close up .....	10
Figure 8: Lobster fishing in 2004-05 .....	11
Figure 9: Lobster fishing in 2004-05, close up .....	12
Figure 10: Stone crab fishing in 2003-04 .....	14
Figure 11: Stone crab fishing in 2003-04, close up .....	15
Figure 12: Stone crab fishing in 2004-05 .....	16
Figure 13: Stone crab fishing in 2004-05, close up .....	17
Figure 14: Shrimp fishing in 2003-04.....	19
Figure 15: Shrimp fishing in 2003-04, close up .....	20
Figure 16: Shrimp fishing in 2004-05.....	21
Figure 17: Shrimp fishing in 2004-05, close up .....	22
Figure 18: Reef fish fishing in 2003-04.....	24
Figure 19: Reef fish fishing in 2003-04, close up.....	25
Figure 20: Reef fish fishing in 2004-05 .....	26
Figure 21: Reef fish fishing in 2004-05 close up.....	27
Figure 22: Marine life trips in 2003-04.....	29
Figure 23: Marine life trips in 2003-04, close up .....	30
Figure 24: Marine life trips in 2004-05.....	31
Figure 25: Marine life trips in 2004-05, close up .....	32

## Introduction

Since 1997, the Florida Keys National Marine Sanctuary (FKNMS) has implemented a network of no-take zones, consisting of ecological reserves, sanctuary preservation areas, and special-use areas. The socioeconomic effects of these zones have been addressed for the commercial fishing industry (Milon et al., 1997; Suman, Shivlani, and Milon, 1999), dive operators (Shivlani and Suman, 2000; Suman and Shivlani, 1998), and local communities (Suman, Shivlani, and Milon, 1999). More comprehensive efforts have been focused on the Dry Tortugas commercial fishery (Leeworthy and Wiley, 2000; NOAA, 2000). However, most of these studies have represented a “snapshot” of the socioeconomic effects resulting directly from FKNMS management and less directly from the FKNMS no-take zones. By contrast, our research and monitoring program tracks the commercial fishing industry over time and across fisheries and regions. The program, divided into four distinct fishing panels, determines the long-term effects of marine zoning on commercial fishing, including changes in catch, effort, costs, investments, and attitudes and perceptions concerning marine resources (see Thomas J. Murray and Associates, Inc., 2007, for a description of the first eight years of data collection in the program).

Now in its eighth year of research, the program had continued with collection of spatial data. Over the past two years, years 7 and 8, the program has shifted its spatial data collection from simply determining areas of use to actually quantifying fishing intensity by area. Previous spatial analysis within the program (Shivlani and Rudders, 2003) focused on the importance of fishing areas, where the areas provided by panel members were digitized as polygons where landings occurred in the years in which such data were collected. An example of such a fishing area is shown below in the figure depicting total reef fish landings in 2001.

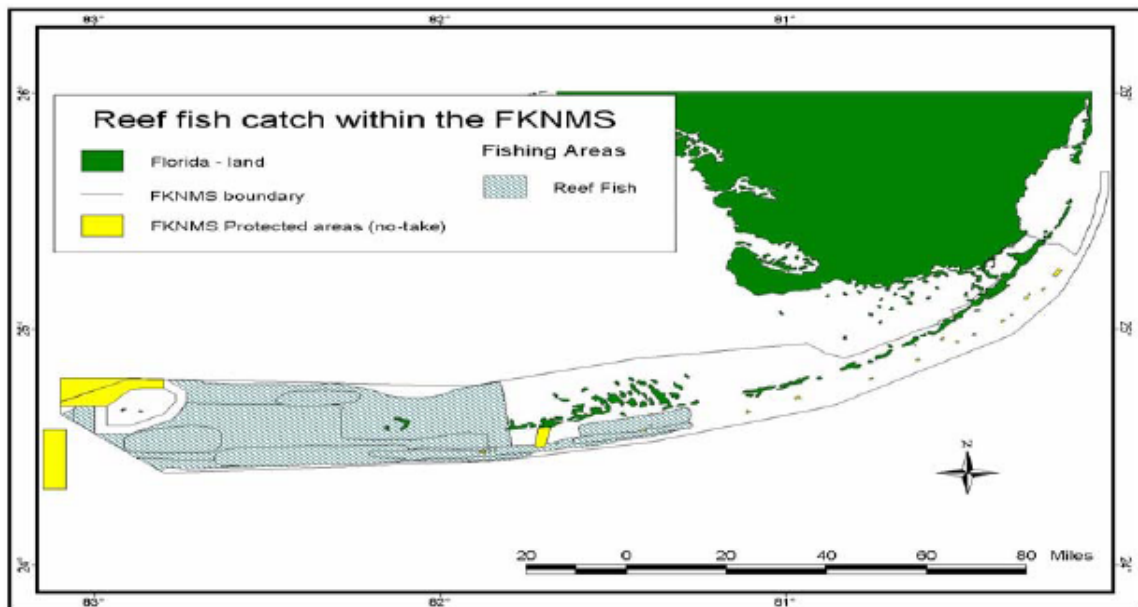
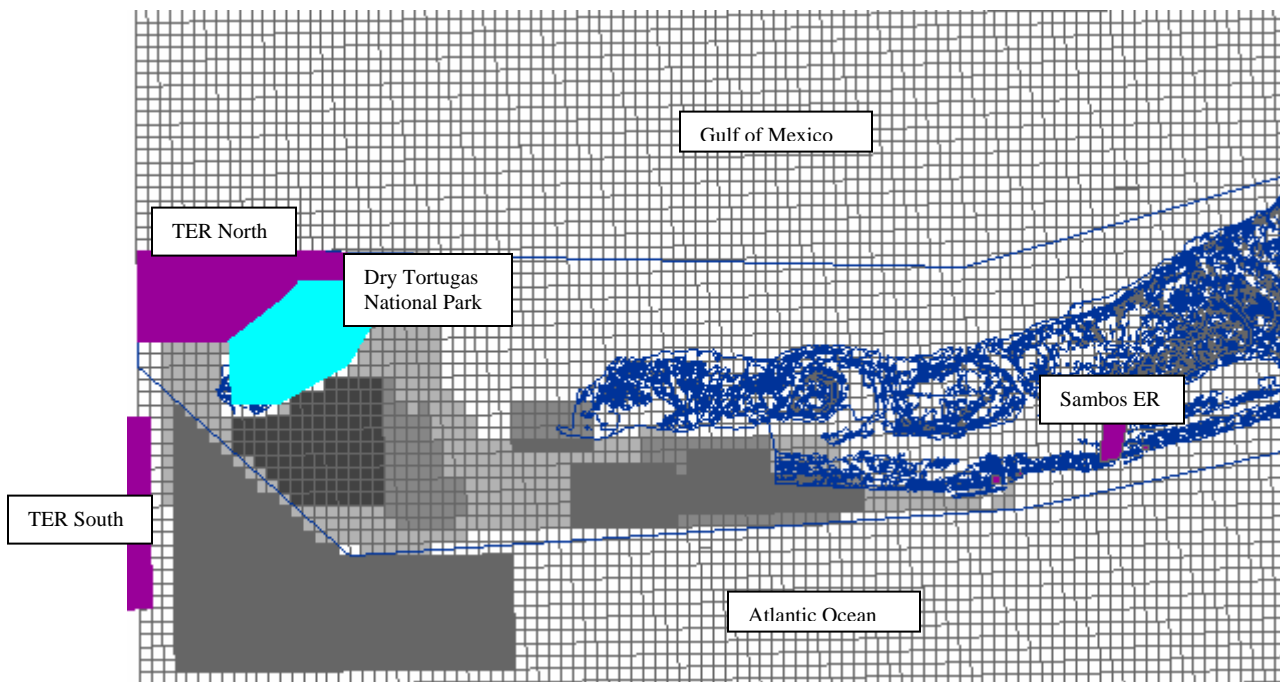


Figure 1: Reef fishing landings in 2001



As shown in the above figure, reef fish landings are depicted using individual fishing areas are provided by the six panel members who reported targeted reef fish that year. Also, the spatial profiles do not provide any information that can be used to determine intensity of use. As stated in the earlier report (Shivlani and Rudders, 2003), the fishing areas were by “themselves useful in descriptive analysis” (p. 2) and did not provide information beyond changes in overall fishing patterns by species. Finally, such earlier mapping did not include effort from outside the FKNMS; while fishers did provide catch information for both inside and outside the FKNMS, maps were cropped to focus on FKNMS landings. The figure below shows reef fish landings in the western FKNMS as determined in the most recent mapping effort.



**Figure 2: Reef fishing landings in the western FKNMS, 2004-05<sup>1</sup>**

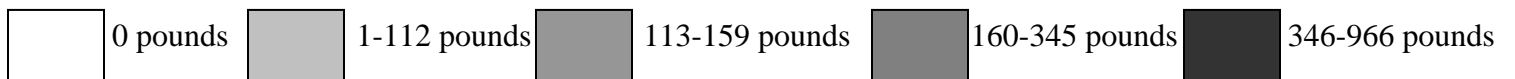


Figure 2 shows the difference in mapping from the earlier, more descriptive efforts (as shown in Figure 1) and the higher resolution, fishing intensity mapping in the present effort. The present effort uses a grid map approach similar to that used in the Tortugas Ecological Reserve Study Area (TERSA) commercial fishing characterization study (Leeworthy and Wiley, 2000; Shivlani, et al., 1999), where grid cells are created by via minute degree lines of latitude and longitude in the study area, and where each grid cell can contain fishery and other related information that can then be depicted in spatial

<sup>1</sup> Please note that the Dry Tortugas National Park, under the jurisdiction of the National Park Service (NPS), is shown in a different color (light blue) than the FKNMS no-take zones (purple) in Figure 2. However, all subsequent maps use a uniform color (purple) to show areas that exclude commercial fishing.

layers. The data shown in Figure 2, for instance, shows fishing intensity in the western FKNMS in 2004-05, from the Lower Keys to the Dry Tortugas, including hotspots (or areas where landings were concentrated) and areas of lesser importance.

The results presented in this report are indicative of all four panels used in the survey effort: Dry Tortugas, Sambos, General, and Marine Life fishery panels. The data depicted in the maps are based on the 2003-04 and 2004-05 seasons and address the main fisheries as reported for those seasons, including spiny lobster, stone crab, shrimp, reef fish, marine life<sup>2</sup>.

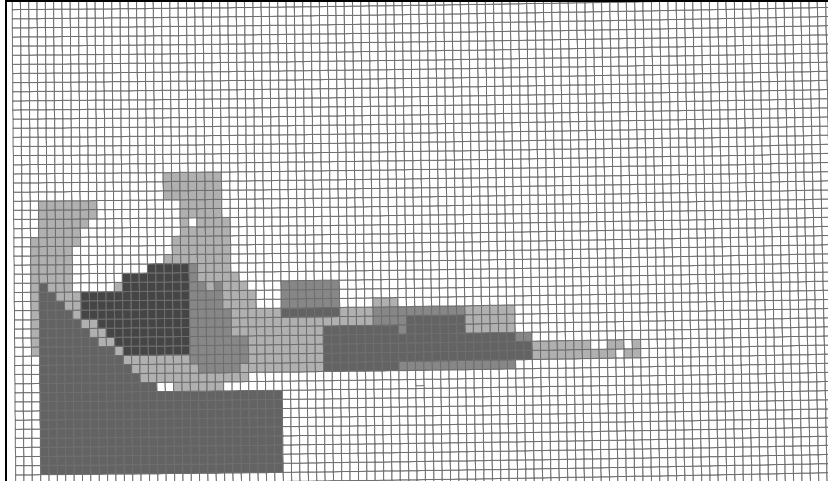
## **Methodology**

As described in the previous section, the current effort for depicting years 7 and 8 of spatial panel data is based on a recently developed grid map. The grid map covers the entire FKNMS and surrounding regions as determined by a series of charts used in data collection. These charts are effectively identical to the areas covered in NOAA nautical charts 11434 and 11451. All panel members provide catch information on the charts as part of their annual panel surveys; the respondents differentiate fishing areas by species targeted, if such difference existed.

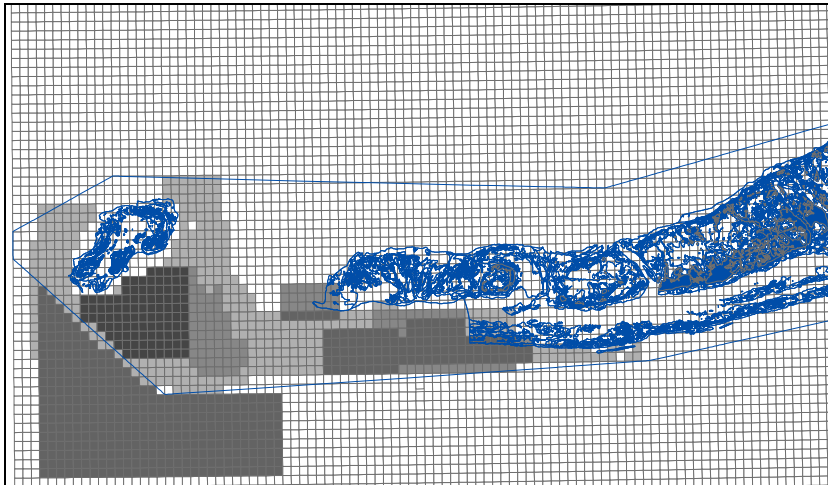
At the end of each data collection period, all fishery information is entered into a database that is linked to the grid map; that is, each database row is linked to one grid cell. The grid cell map used in the present effort consists of 19,763 cells, and each cell corresponds to 1 square nautical mile (the FKNMS area covers approximately 2,900 cells, or 2,900 square miles, of the grid cell map). Once all data have been added, by species, the data are exported as an attribute table that corresponds to the grid cell map, which is geo-referenced as a layer on a regional map. Additional layers that provide further information, such as benthic habitats, FKNMS zones, and other boundaries, are added as needed. The figures below show the process.

---

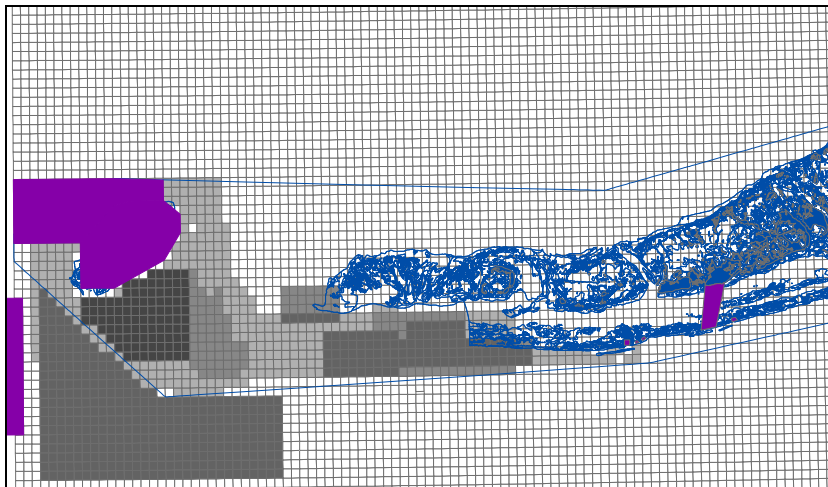
<sup>2</sup> Due to the fact that marine life landings are reported in the number of individuals and because species vary considerably in the numbers harvested, the marine life data collected are represented in terms of total trips rather than landings.



**Figure 3: 2004-05 reef fish landings in the western FKNMS**



**Figure 4: 2004-05 reef fish landings in the western FKNMS with benthic areas**



**Figure 5: 2004-05 reef fish landings in the western FKNMS with benthic areas and protected areas**

As shown in Figures 3, 4, and 5, multiple layers were added to the 2004-05 reef fish catch reported by panel members to provide geographical and protected area context to that data. Thus, while Figure 3 only shows fishing intensity within the western portion of the grid cell map, Figure 4 adds the Lower Keys (from the Content Keys to the northeast to Key West in the southwest) and benthic habitats to the reef fish landings. Also, from Figure 4, it is clear that the panel targeted reef fish mainly west and southwest off Key West. Furthermore, Figure 4 shows that there was fishing along the reef tract and south of the shallow Tortugas reefs. Finally, Figure 5 demonstrates the importance of boundary fishing adjacent to TER North and TER South, as well as south of the Dry Tortugas National Park (please refer to Figure 2 for a depiction of the park). In fact, the area of highest landings coincided with the areas south of Dry Tortugas National Park and east of TER South.

Maps similar to those shown in Figure 5 were created in ArcGIS for the major species landed by panel members, and two views of each species' landings map were exported as picture files, with the first view focusing on the full extent of the landings and the second presenting a detailed, in-depth fishing area extent of the landings (as shown in Figure 5). Each set of landings maps for the 2003-04 and 2004-05 fishing years is presented in the following section.

# Results

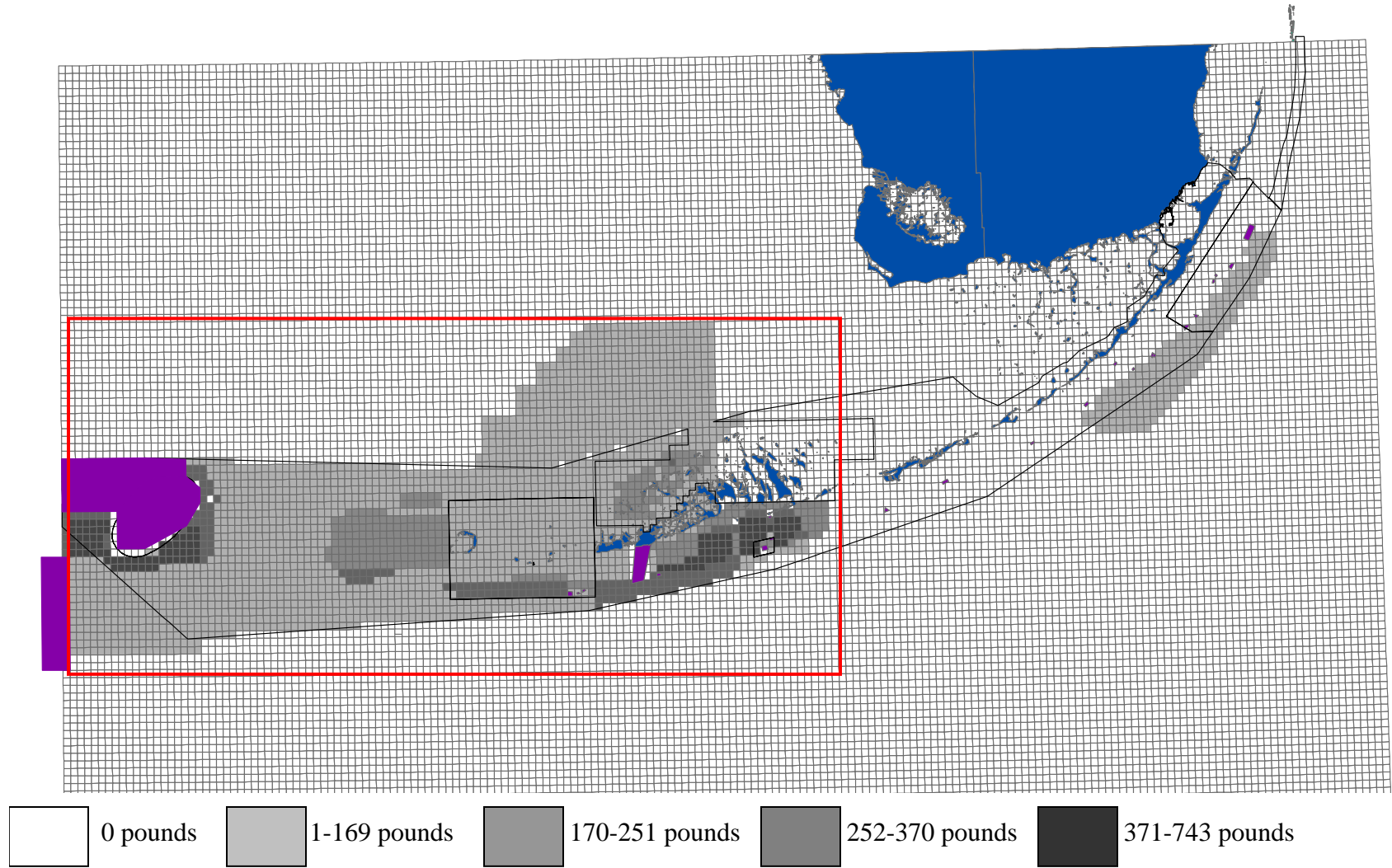
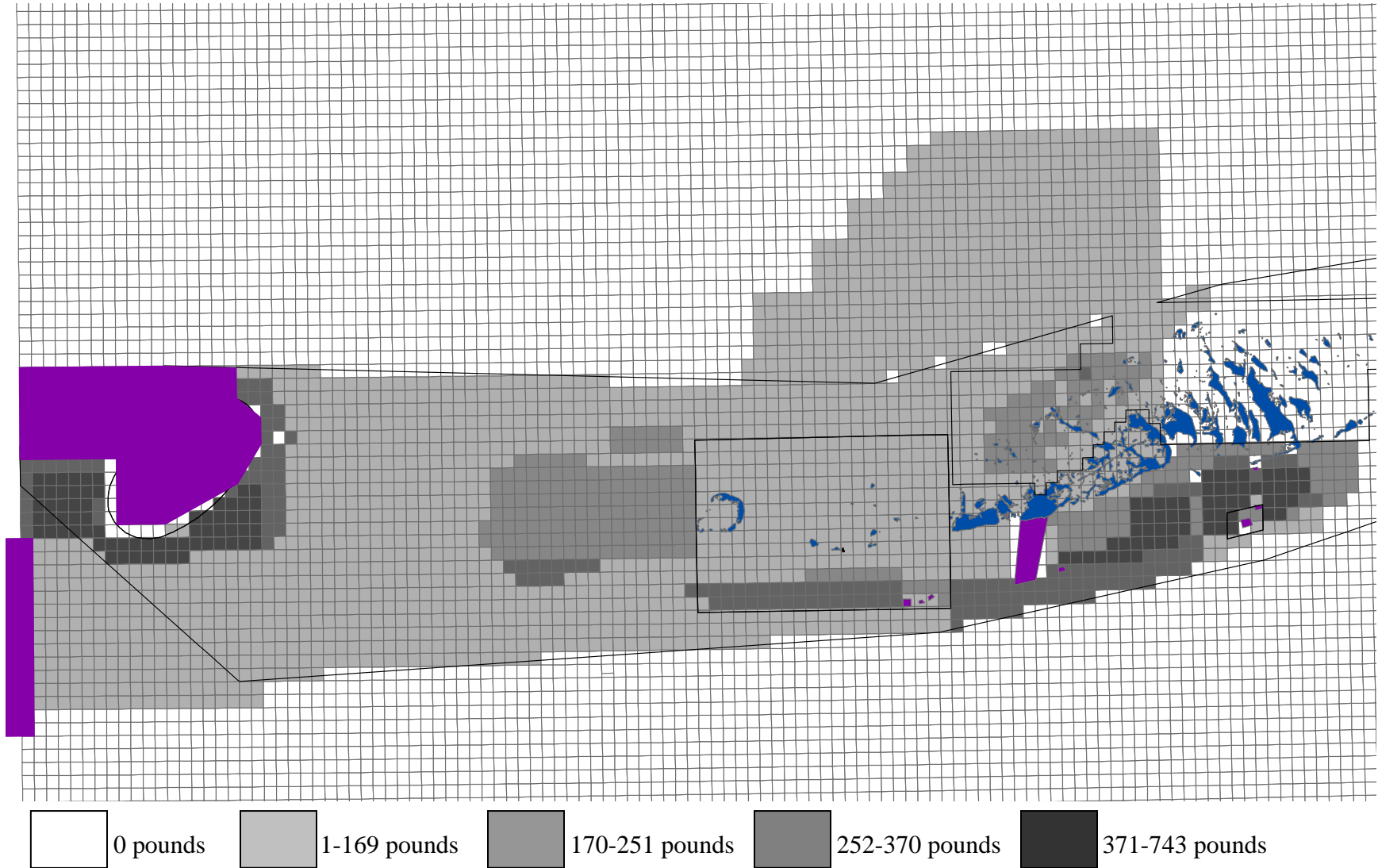
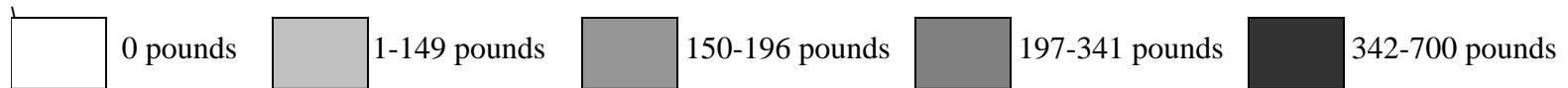
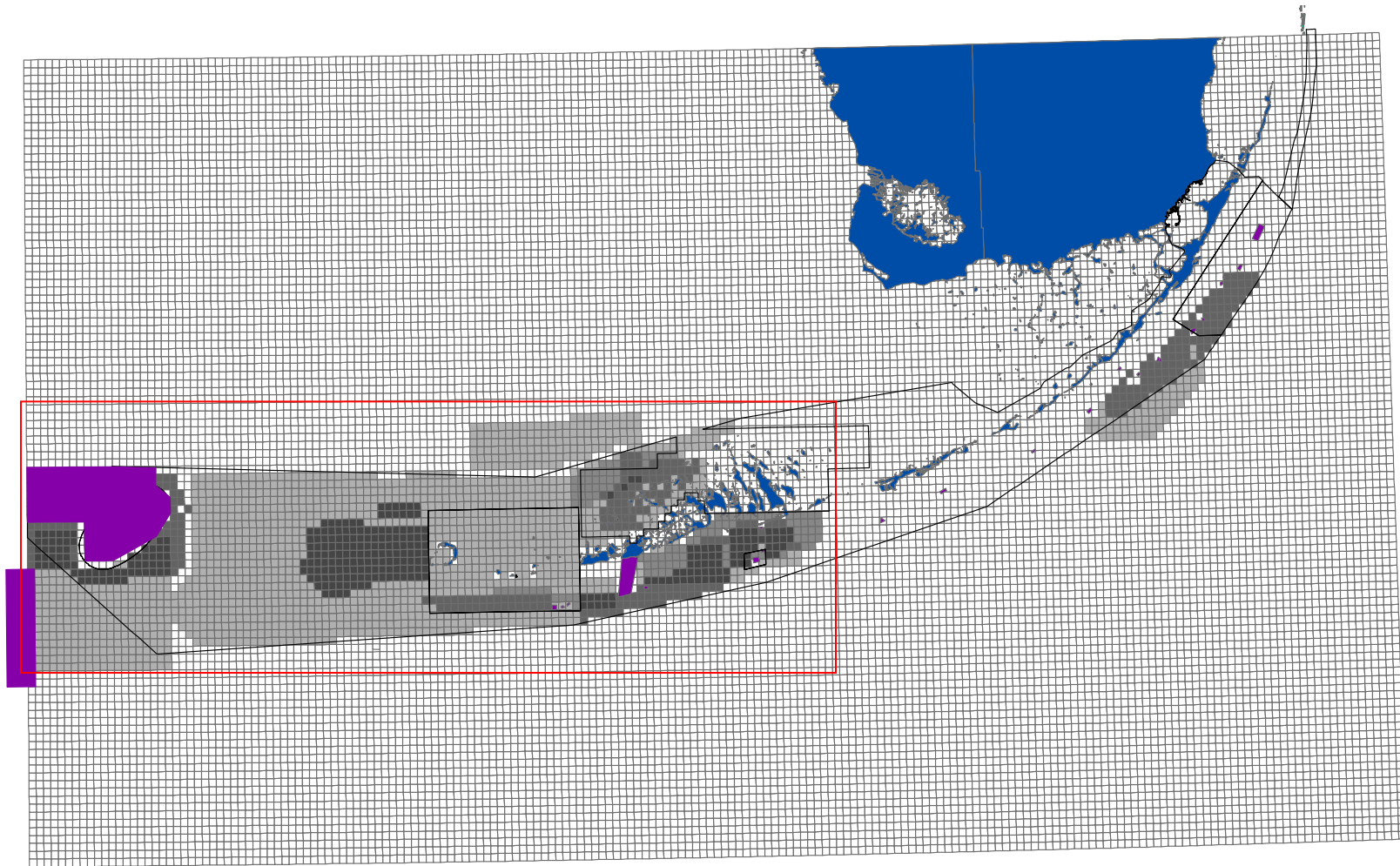


Figure 6: Lobster fishing in 2003-04

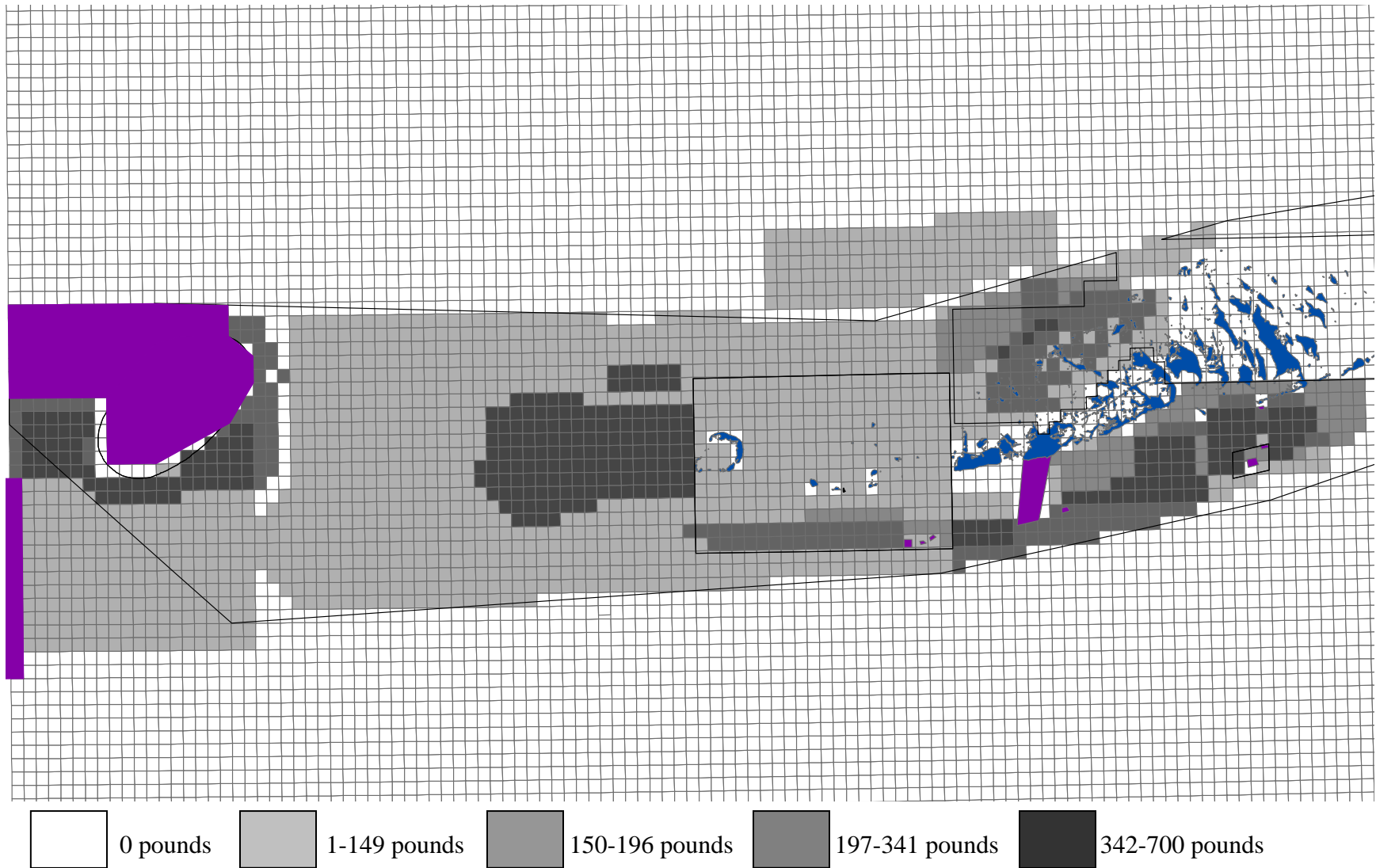


**Figure 7: Lobster fishing in 2003-04, close up**





**Figure 8: Lobster fishing in 2004-05**



**Figure 9: Lobster fishing in 2004-05, close up**



Lobster fishing within the FKNMS panels remained the most prominent fishing sector in both 2003-04 and 2004-05. In 2003-04, 14 fishers (from all panels) reported landing spiny lobster that season. Fishers reported landing lobster all over the FKNMS, but landings were highest in the western portions of the Florida Keys and especially between Big Pine Key and the Dry Tortugas. This is to be expected due to the participants who were interviewed, but it was interesting to note that most landings were reported from within the FKNMS. Within the nearshore fishery, landings were focused mainly on the Atlantic Ocean side of the FKNMS, with General and Sambos Panel fishers reporting fishing areas ranging from Newfound Harbor Key to the east to around the Rock Key-Sand Key-Eastern Dry Rocks SPA complex to the west. From there, lobster landings increased again to the west, through the Marquesas Keys. While in previous years, panel members reported significant landings to the north and northwest of the Content Keys and Key West; however, that pattern was not observed in the 2003-04 sample. Fishers, primarily those from the TER panel, continued to use the TER region after the 2001 closure of TER North and TER South. But, as observed by a 2002-03 study by Thomas J. Murray and Associates (2007), the landings were shifted mainly to the east. That is, compared to previous years (Shivlani and Rudders, 2003; Leeworthy and Wiley, 2000), the fishery appears to have re-configured to the south and to the east of the ecological reserve. Specifically, it appears that the Rebecca Shoal area has become more important than in the past.

In the 2004-05 sample, 15 fishers (from all panels) reported landing spiny lobster that season. As in the previous season, landings occurred all over the FKNMS (and predominantly on the Atlantic Ocean side along the length of the Florida Keys), but the hotspots remained largely unchanged from the 2003-04 season. Thus, panel fishers generally targeted areas like the region south of the Content Keys through the Marquesas; but unlike in the previous season, there were more landings reported for areas closer to the Lower Keys. Specifically, there were more landings north of the Content Keys and in the Marquesas Keys than in 2003-04. While it is not certain that this may have been a reaction to the increase in fuel prices pushing effort further inshore, cost data from that year do suggest that average trip costs increased for each of the panels, and the main item that increased for trip was fuel cost. While these data still do not include the post Hurricane Katrina (September 2005 and later) fuel costs (as the 2004-05 season ended in April 2005), the results suggest that fuel costs, as well as with the TER closure, may have readjusted landings closer to ports.

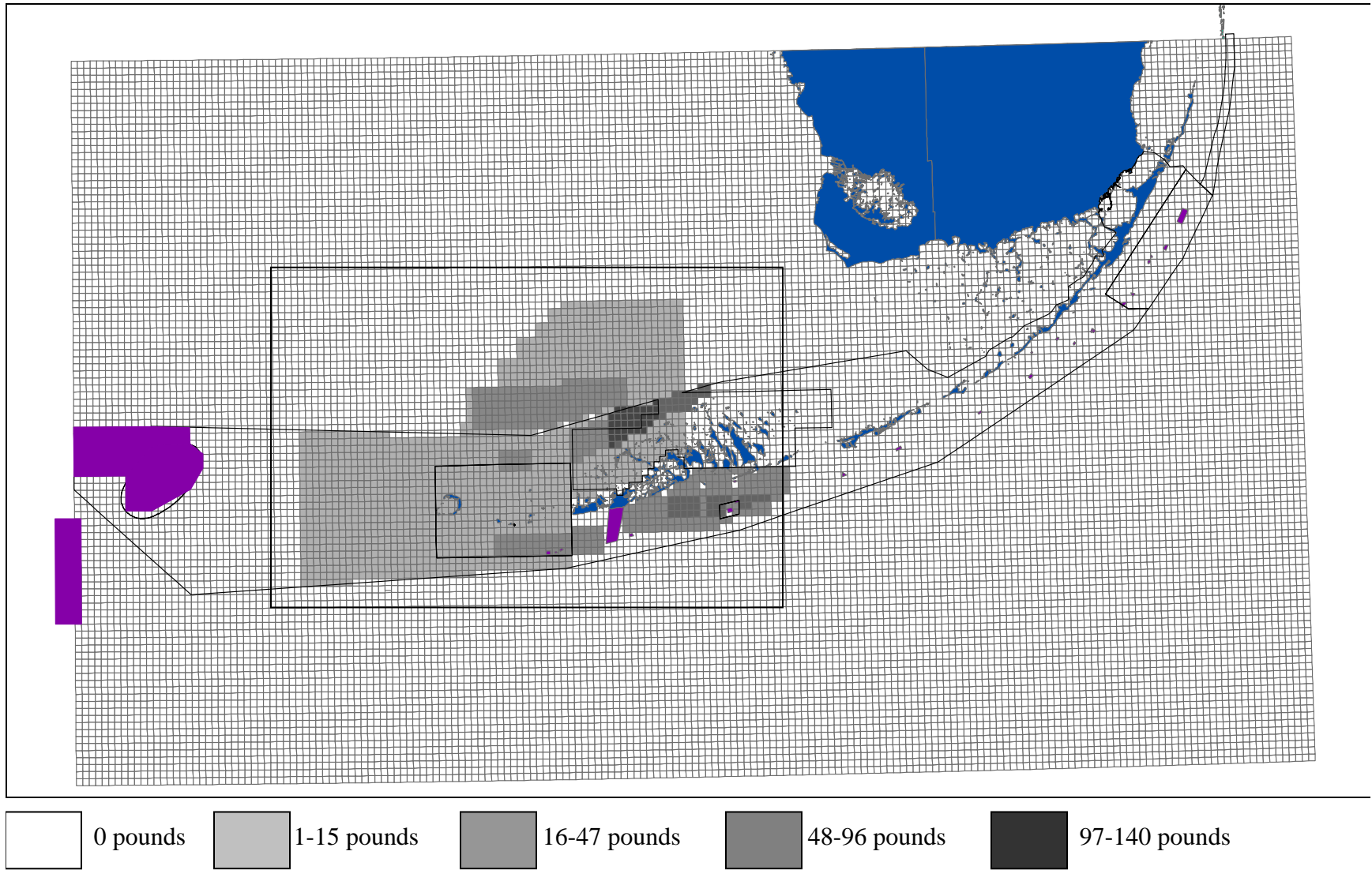


Figure 10: Stone crab fishing in 2003-04

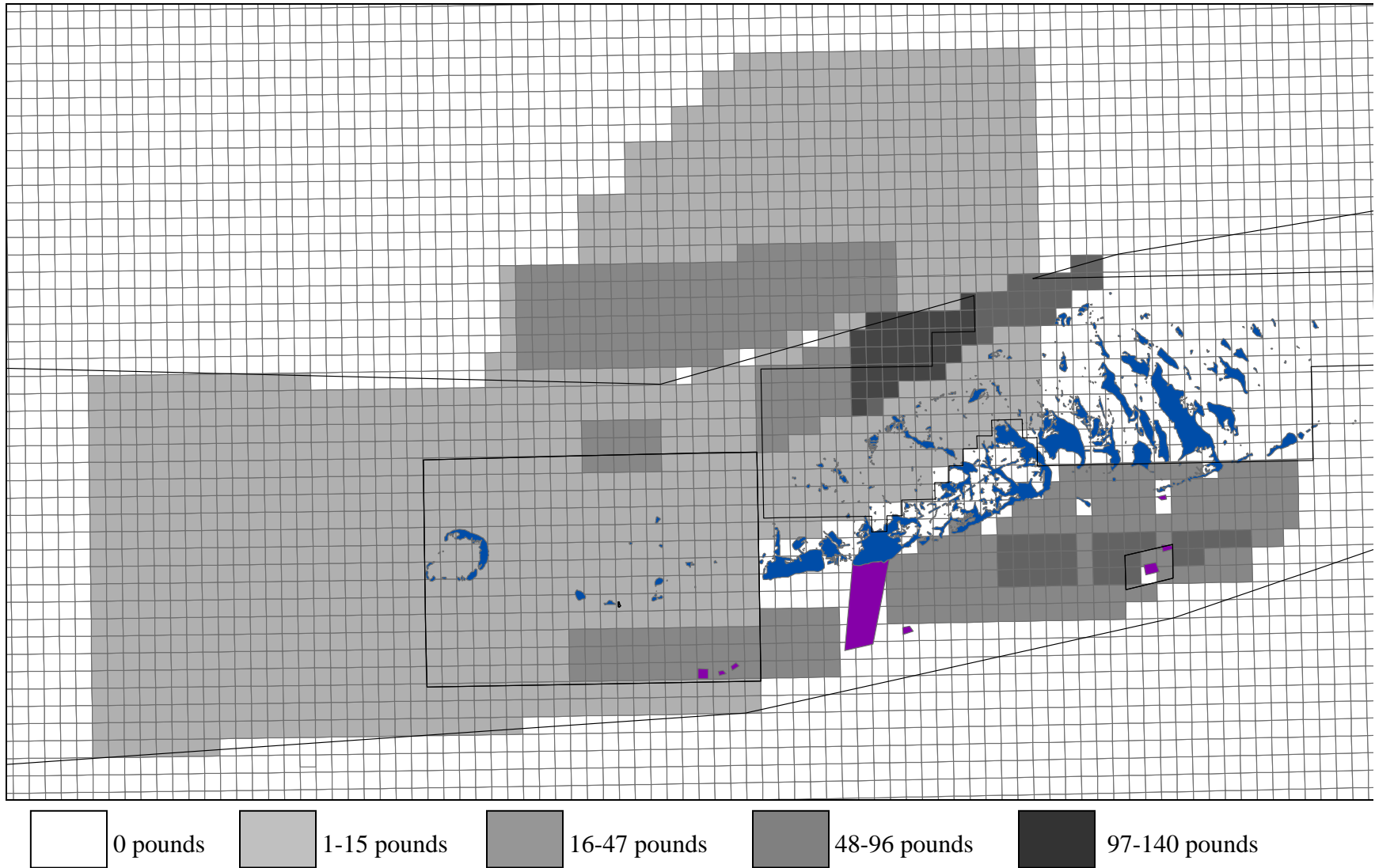
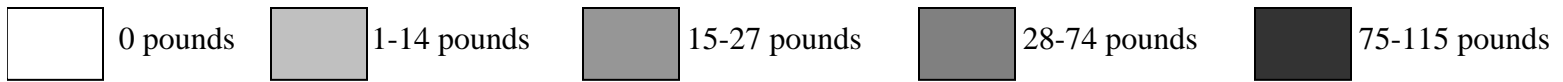
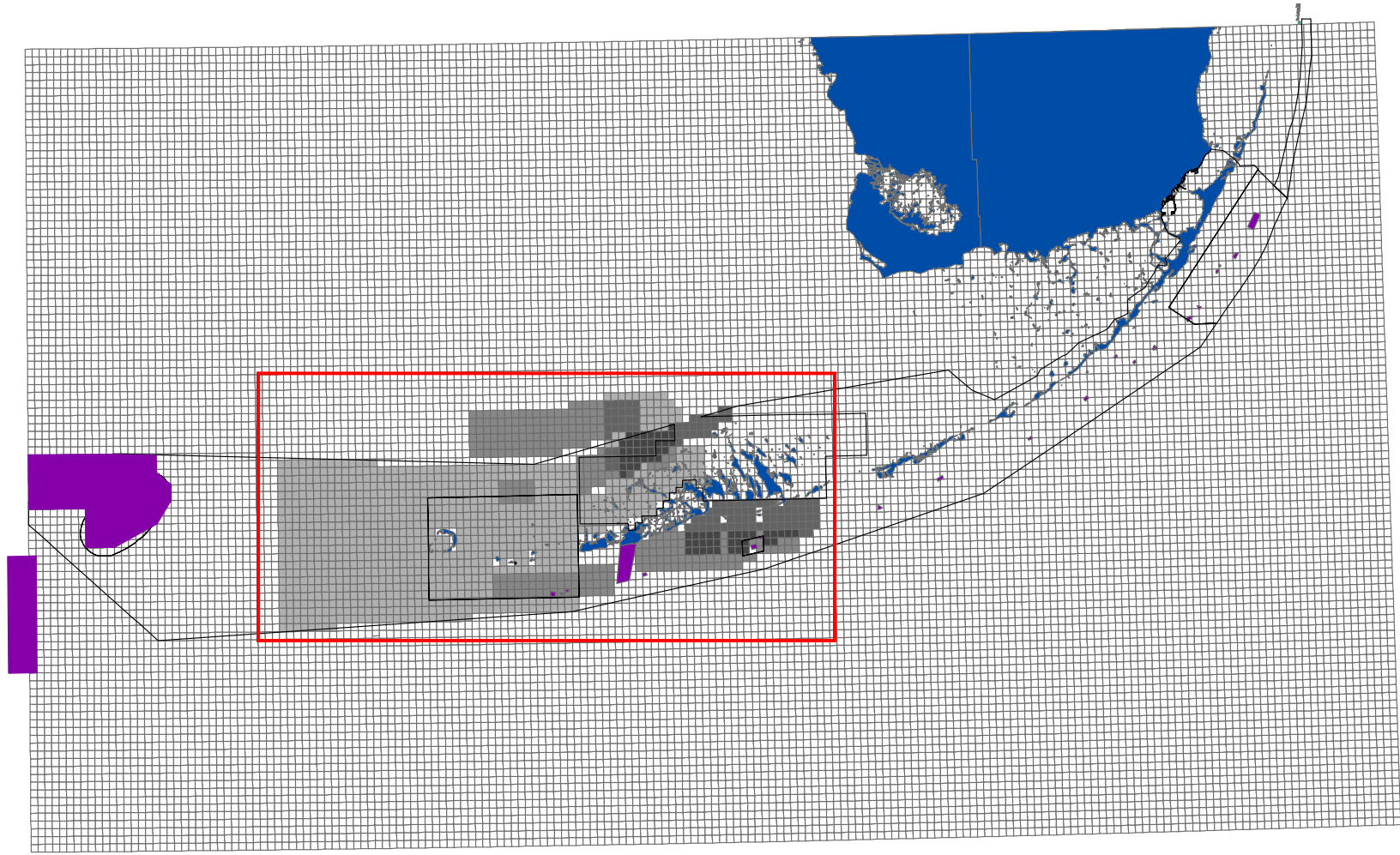


Figure 11: Stone crab fishing in 2003-04, close up



**Figure 12: Stone crab fishing in 2004-05**

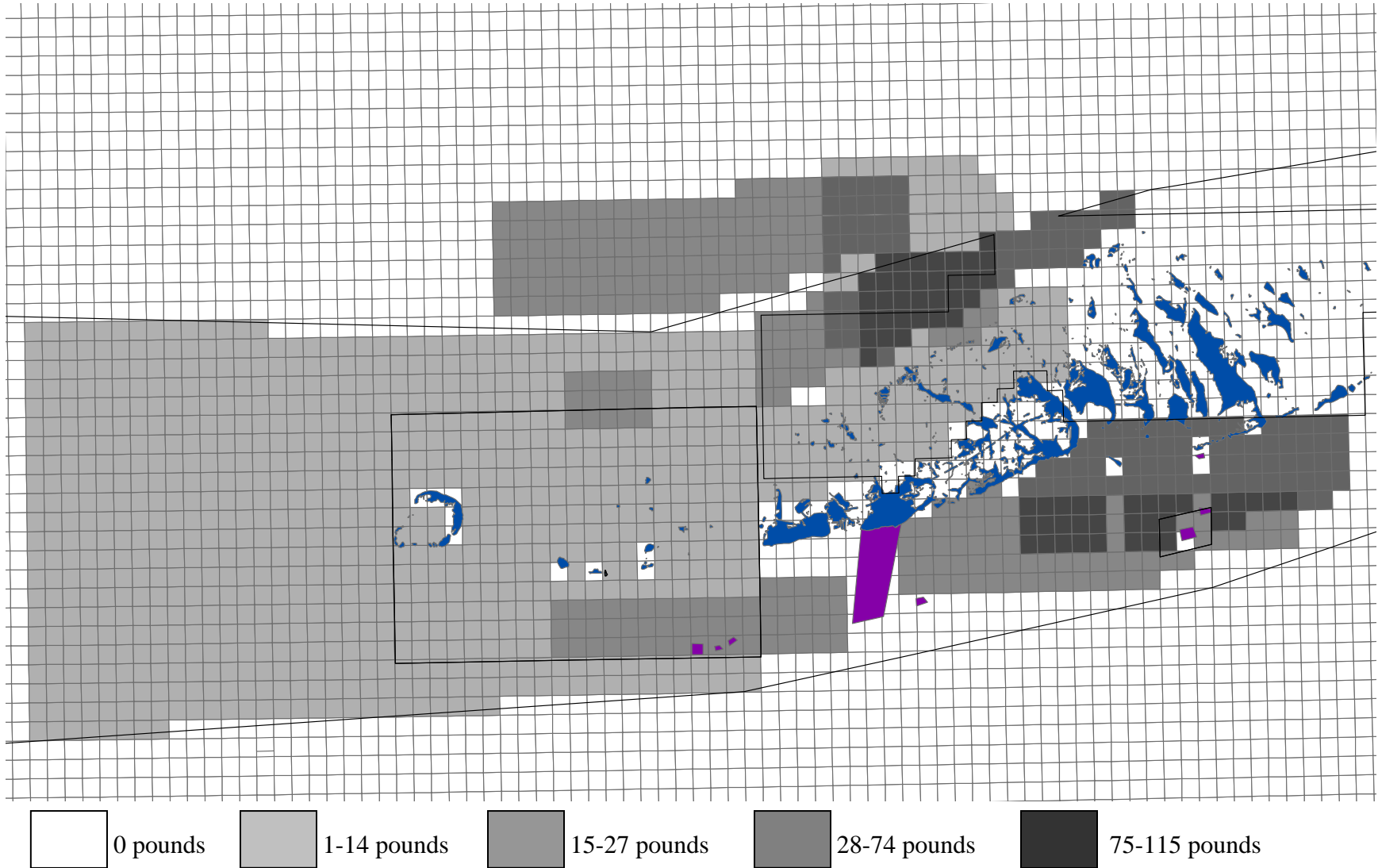
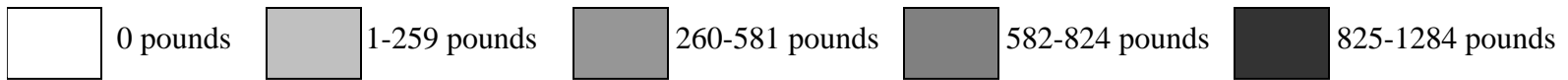
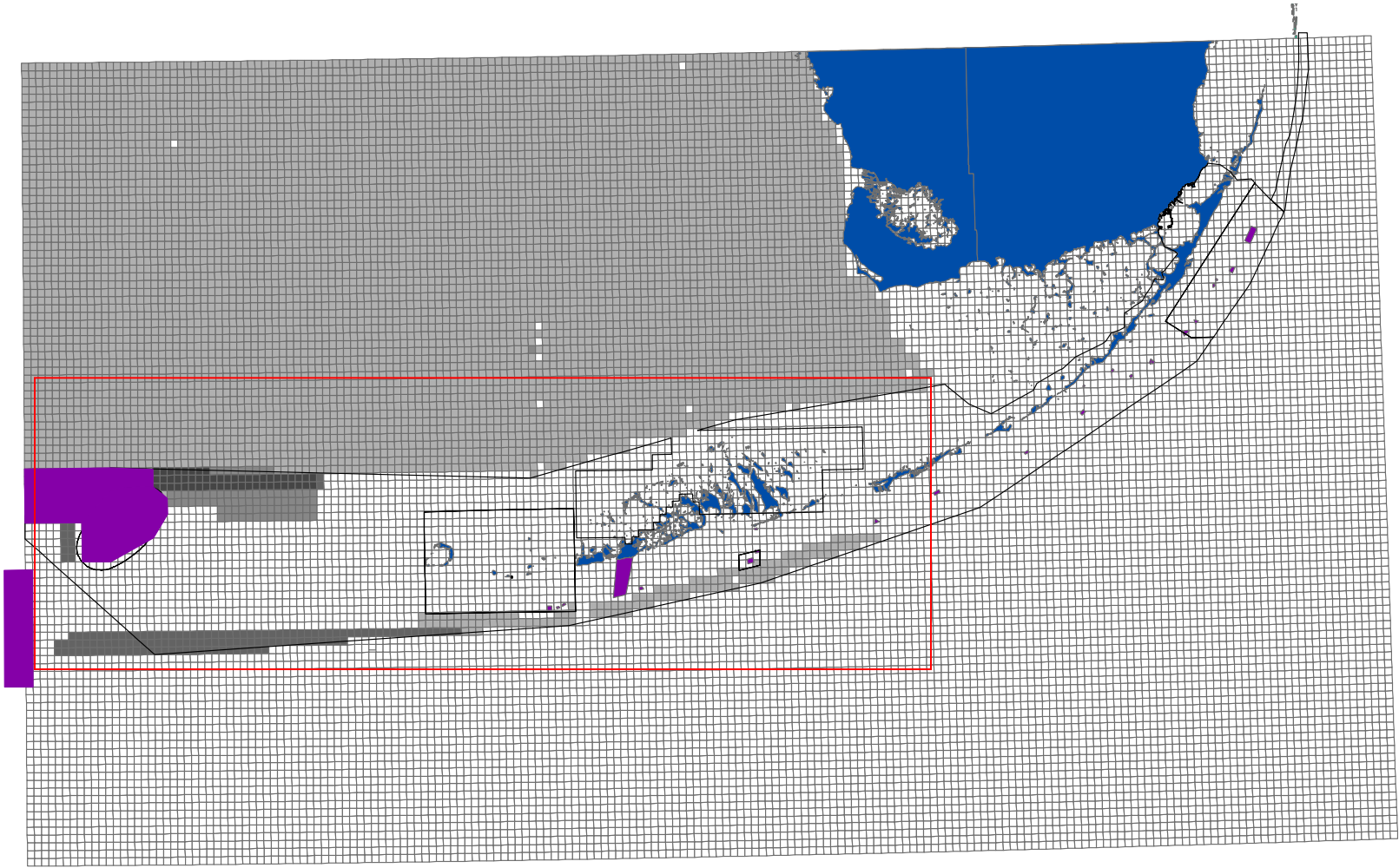


Figure 13: Stone crab fishing in 2004-05, close up

Figures 10 and 11 present stone crab landings in 2003-04, as reported by the six fishers in the TER, SER, and General panels. While some fishers in those panels reported landing stone crab on the Atlantic Ocean side, and this was largely as a result of these fishers claiming the same areas for stone crab and spiny lobster, most of the stone crab landings were reported from the Content Keys to the northern parts of the western FKNMS (and areas north of the FKNMS). As shown in the previous research (Leeworthy and Wiley, 2000, for example), stone crab are not landed west of the Marquesas Keys. The most important hotspot identified among panel members in the 2003-04 sample was that of the area north of the Content Keys.

Figures 11 and 12, which show stone crab landings in 2004-05, are similar to the landings shown in 2003-04. However, more panel members (8) participated in the stone crab fishery in 2004-05 than did in the previous season. Landings again were similar in terms of areas where stone crab was landed between both years. There is some indication that the northern region of the western FKNMS may have been more important in 2004-05 than in 2003-04, due to the slightly higher catch totals in some cells in that area. Also, it should be noted that while Hurricane Charley passed over the Lower Florida Keys (especially around the Looe Key SPA area) in the summer of 2004, it did not prevent slightly increased landings there in 2004-05. Further research (i.e. multiple-year data collection) will be required to determine whether the 2005 hurricane season, where Hurricanes Katrina, Rita, and Wilma affected parts of the Florida Keys, have led to any profound shifts in areas fished.



**Figure 14: Shrimp fishing in 2003-04**



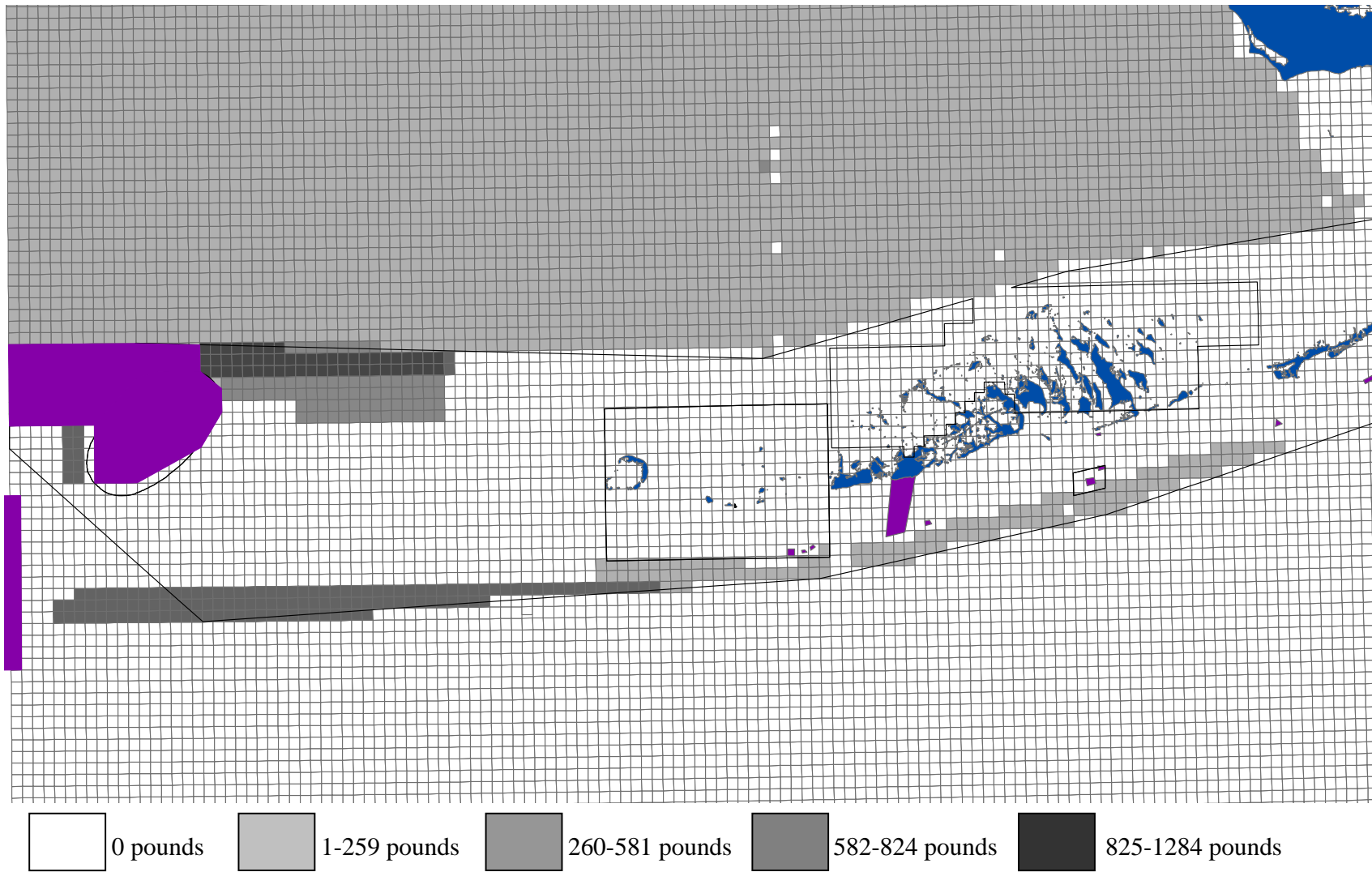
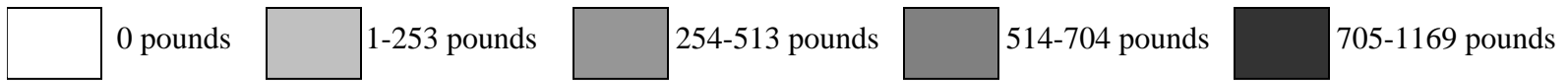
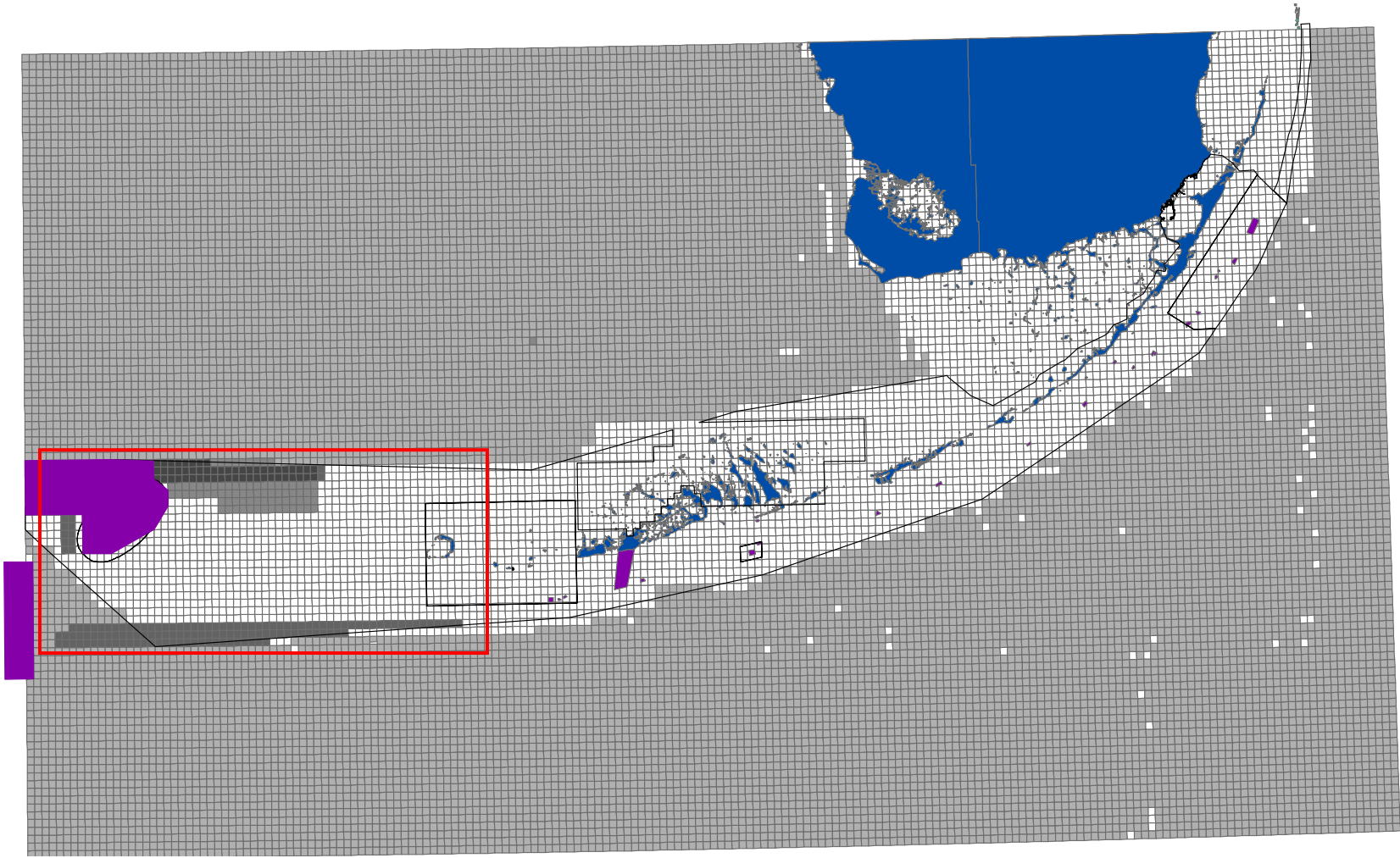


Figure 15: Shrimp fishing in 2003-04, close up





**Figure 16: Shrimp fishing in 2004-05**

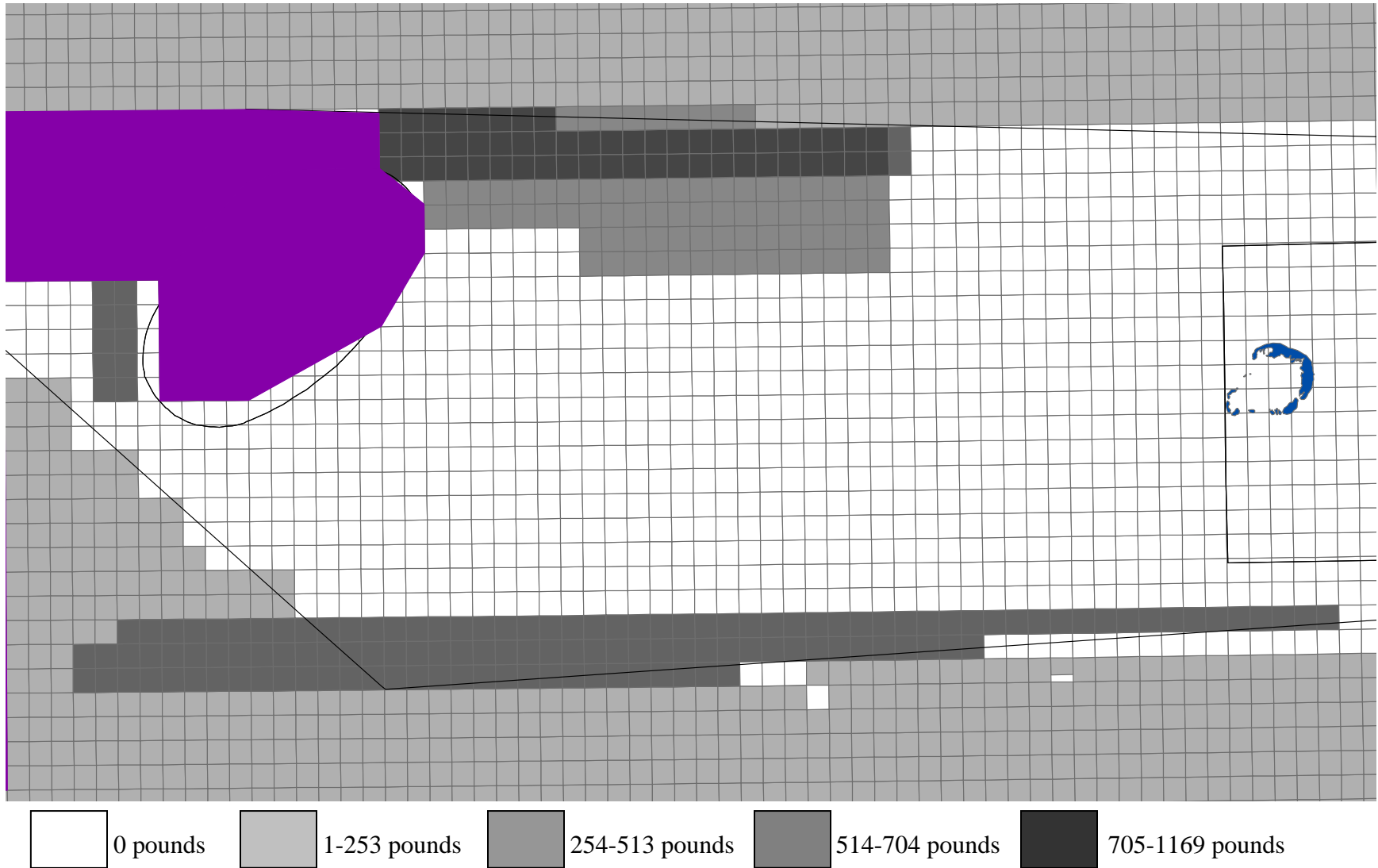
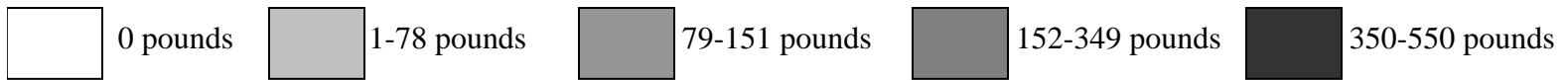
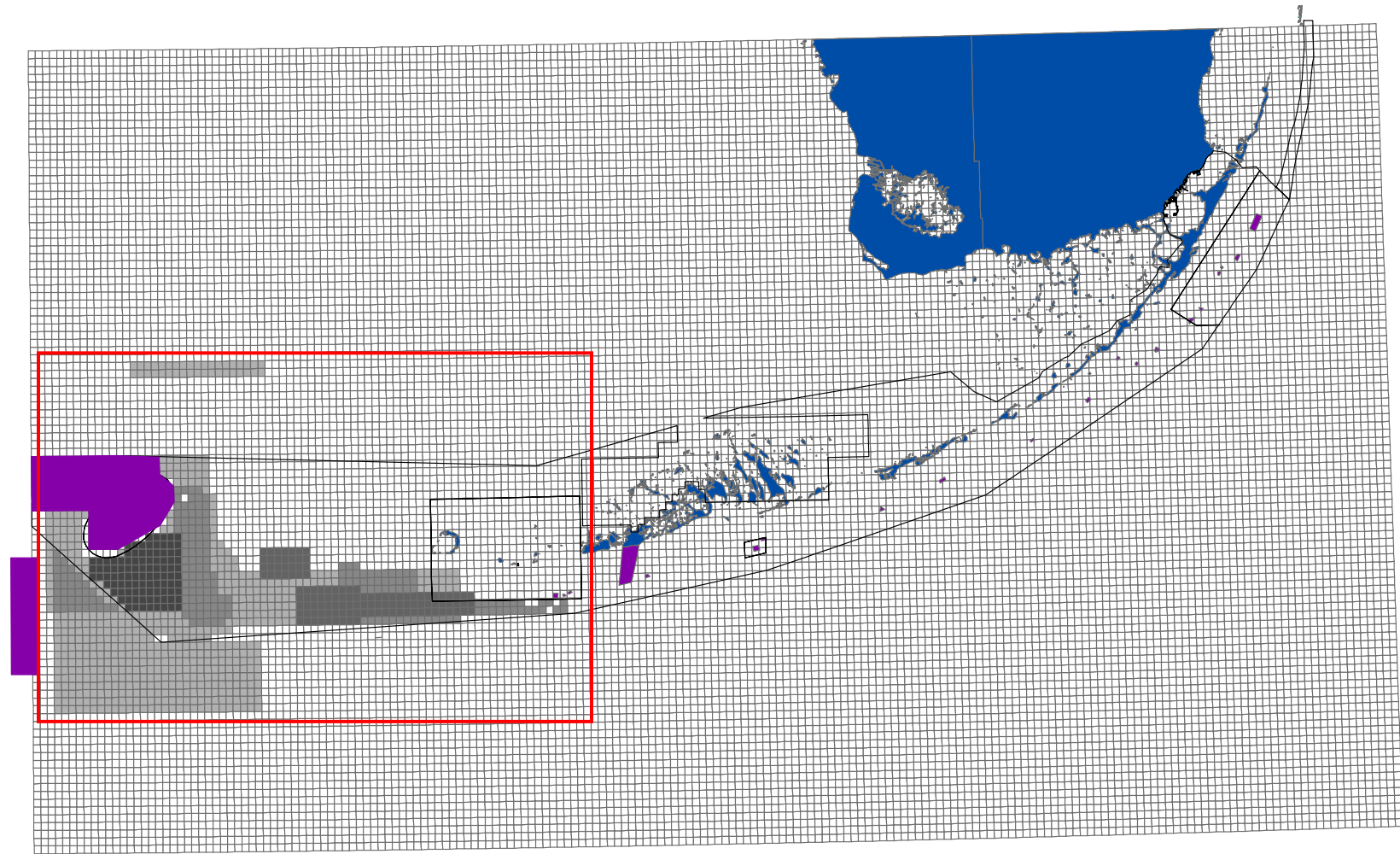


Figure 17: Shrimp fishing in 2004-05, close up

Shrimp landings in 2003-04 were concentrated mainly in the western FKNMS and in the Gulf of Mexico north and west of the FKNMS. As during other years, the fishers interviewed stated that the only major region that they utilized on an inter-annual basis in the Florida Keys is the Tortugas area. Use among those shrimpers who fish the entire Gulf of Mexico averages to less than 5% per year in the Tortugas, but local (i.e. Key West) shrimp fleets use the area more frequently. Use in 2003-04, while focused in the Tortugas, did shift to as far east as Marathon in the Middle Keys. With the Tortugas, the areas where the most landings were recorded was the eastern K buoy to Polaski Shoal area (along the northeast quadrant of the DTNP) and the region south of TER North adjacent to the western boundary of the DTNP. Otherwise, landings were spread along the entire northern section of the map, in the Gulf of Mexico.

In 2004-05, shrimpers in the TER panel reported use all around the FKNMS. It was among the best years for shrimping in several years, according to those interviewed, and this may be most likely due to the physical impacts of the hurricanes (flushing out shrimp, for instance) and the reduced competition (ex. the virtual elimination of parts of the Louisiana shrimp fleet following Hurricane Katrina). Landings within and around the FKNMS did not change much, however, from the previous year. The Tortugas, as in previous years, was the most important shrimping region in the FKNMS for the TER panel, and the catch within the Tortugas remained largely unchanged from 2003-04 with the northwestern portion of the TER being the most prominent hotspot for shrimp landings in the region.



**Figure 18: Reef fish fishing in 2003-04**

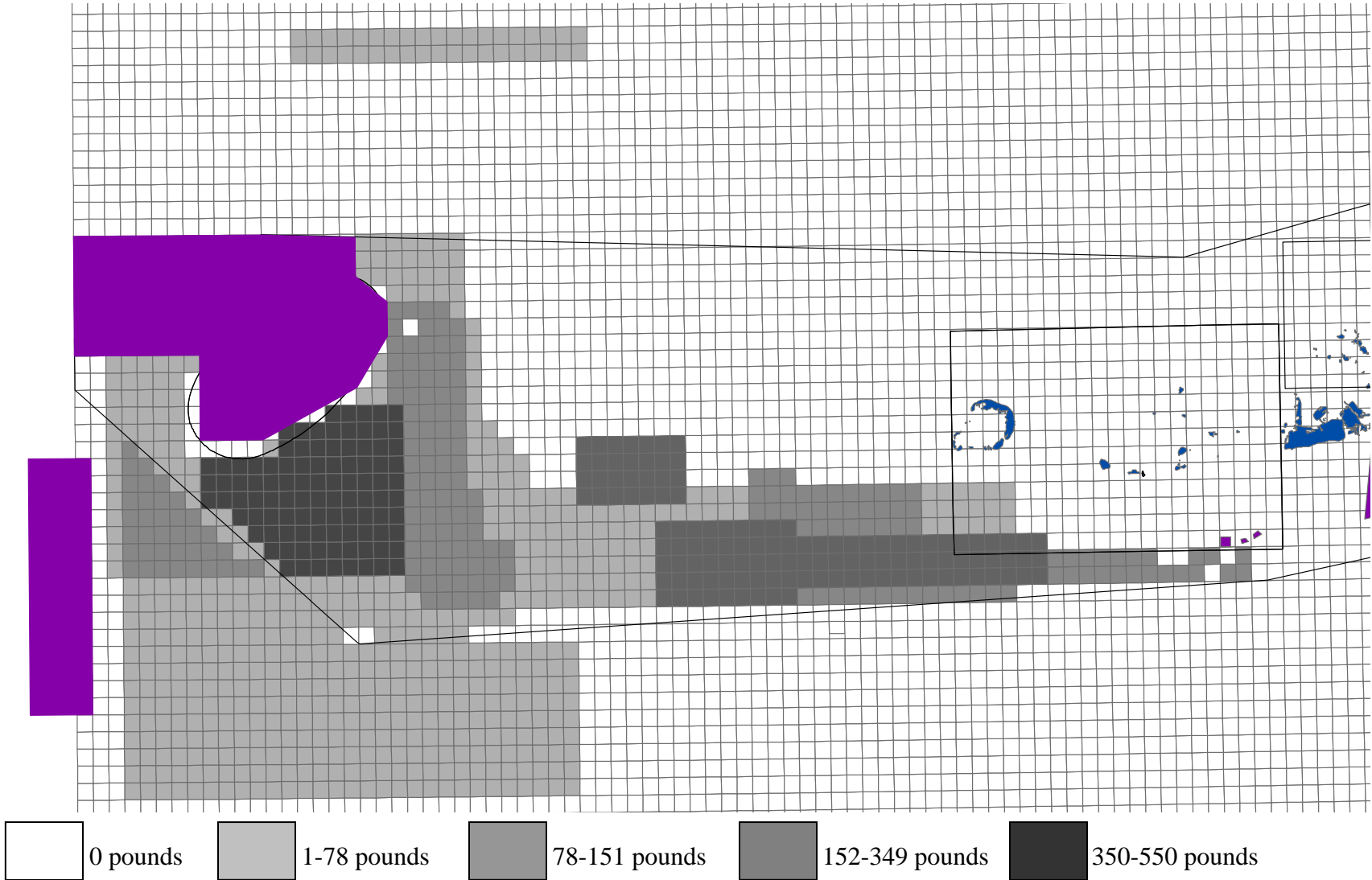
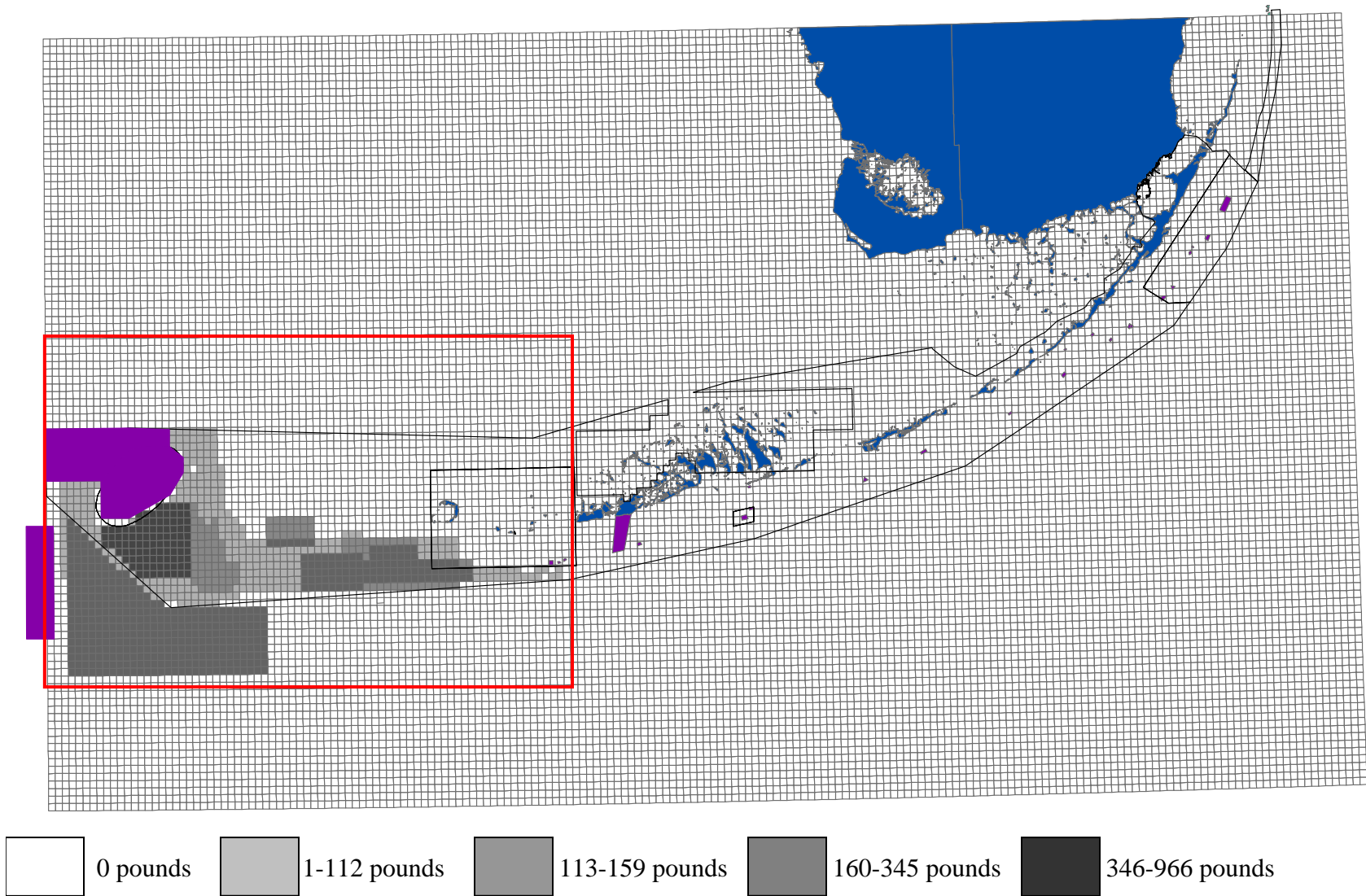


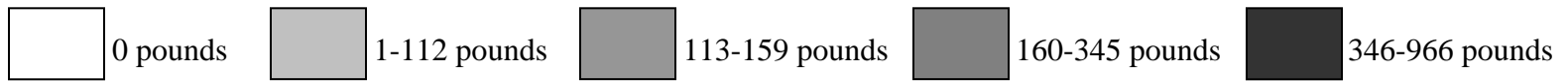
Figure 19: Reef fish fishing in 2003-04, close up



**Figure 20: Reef fish fishing in 2004-05**



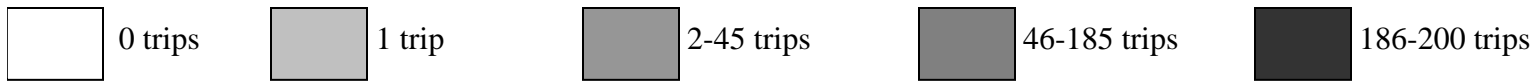
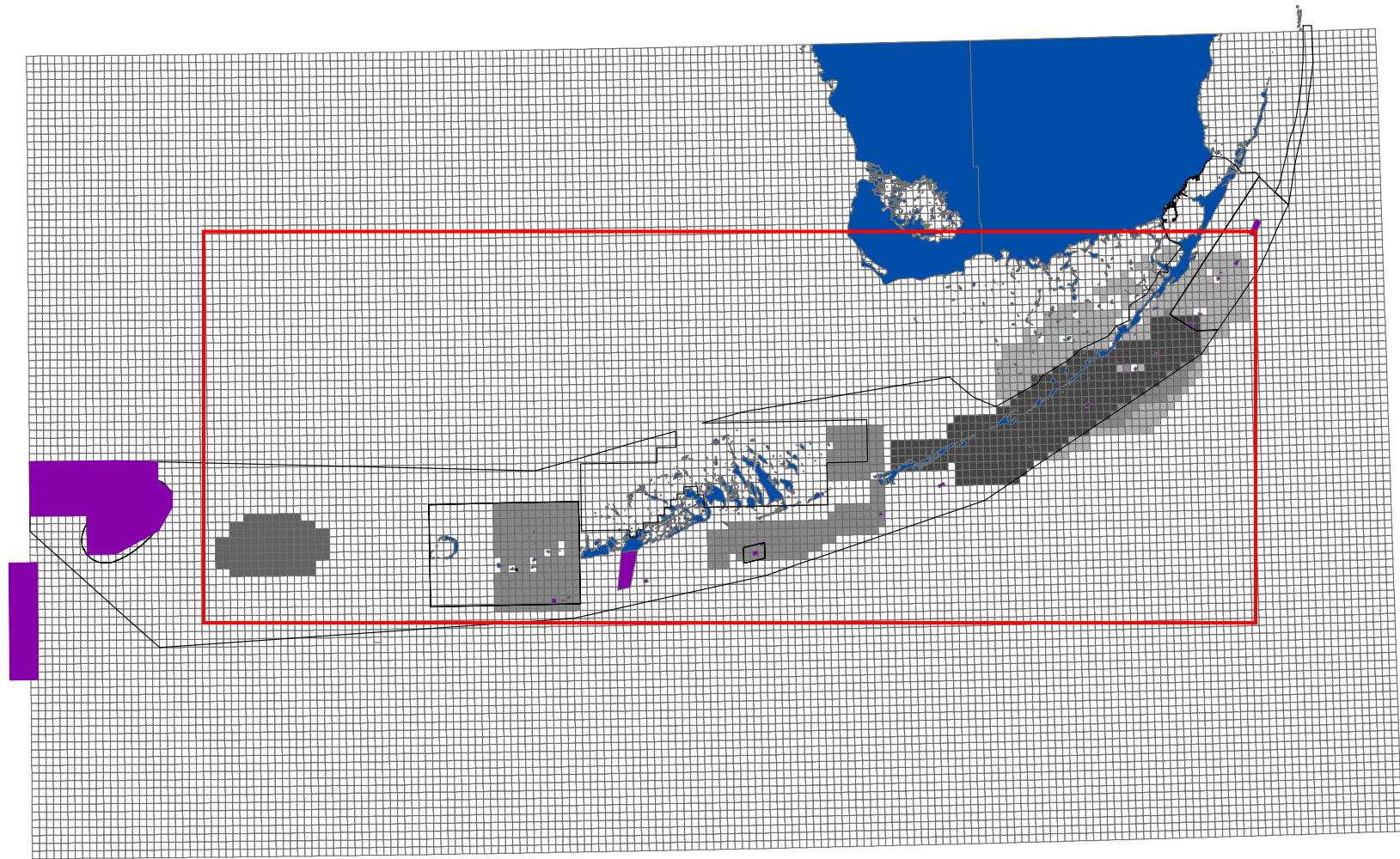
Figure 21: Reef fish fishing in 2004-05 close up



As shown in figures 19 and 20, reef fish fishing in and around the FKNMS in 2003-04 among panel members occurred mainly southwest from Key West to the Tortugas. Altogether, five panel members from the Tortugas and Marine Life panels participated in the reef fish fishery in 2003-04. The most important areas were located along the southwestern reef tract, extending west from the Marquesas to Riley's Hump (part of the TER South). By contrast, the northern sections of the FKNMS were less important for reef fishing. The close up view of the landings suggests that there is considerable boundary fishing along the southern sections of the Tortugas, especially south of DTNP. However, there was less effort reported on the western side of the Tortugas, due most likely to the closure of the TER (see, for instance, use profiles in the NOAA baseline study of the TER Study Area prior to the closure of the TER (Leeworthy and Wiley, 2000)).

Reef fishing landings from the 2004-05 panel study showed a similar spatial profile to landings from the previous season. Overall, use was concentrated again in the western section of the FKNMS from the Marquesas Keys to the Tortugas. A total of six panel members from the Tortugas and Marine Life panels participated in the reef fish fishery in 2004-05, but average catch totals remained similar across reporting years. The only, minor spatial difference in landings from the two years was that in 2004-05, panel members slightly increased their fishing totals from the Tortugas, suggesting greater effort in this region even though fuel prices increased overall trip costs in 2004-05. Otherwise, as in 2003-04, the spatial profile suggests that the boundaries along the no-take zones did show landings; however, it is not clear that this is a result of increased CPUE along such boundaries (and actually anecdotal information from the fishers denies that this is occurring).





**Figure 22: Marine life trips in 2003-04**

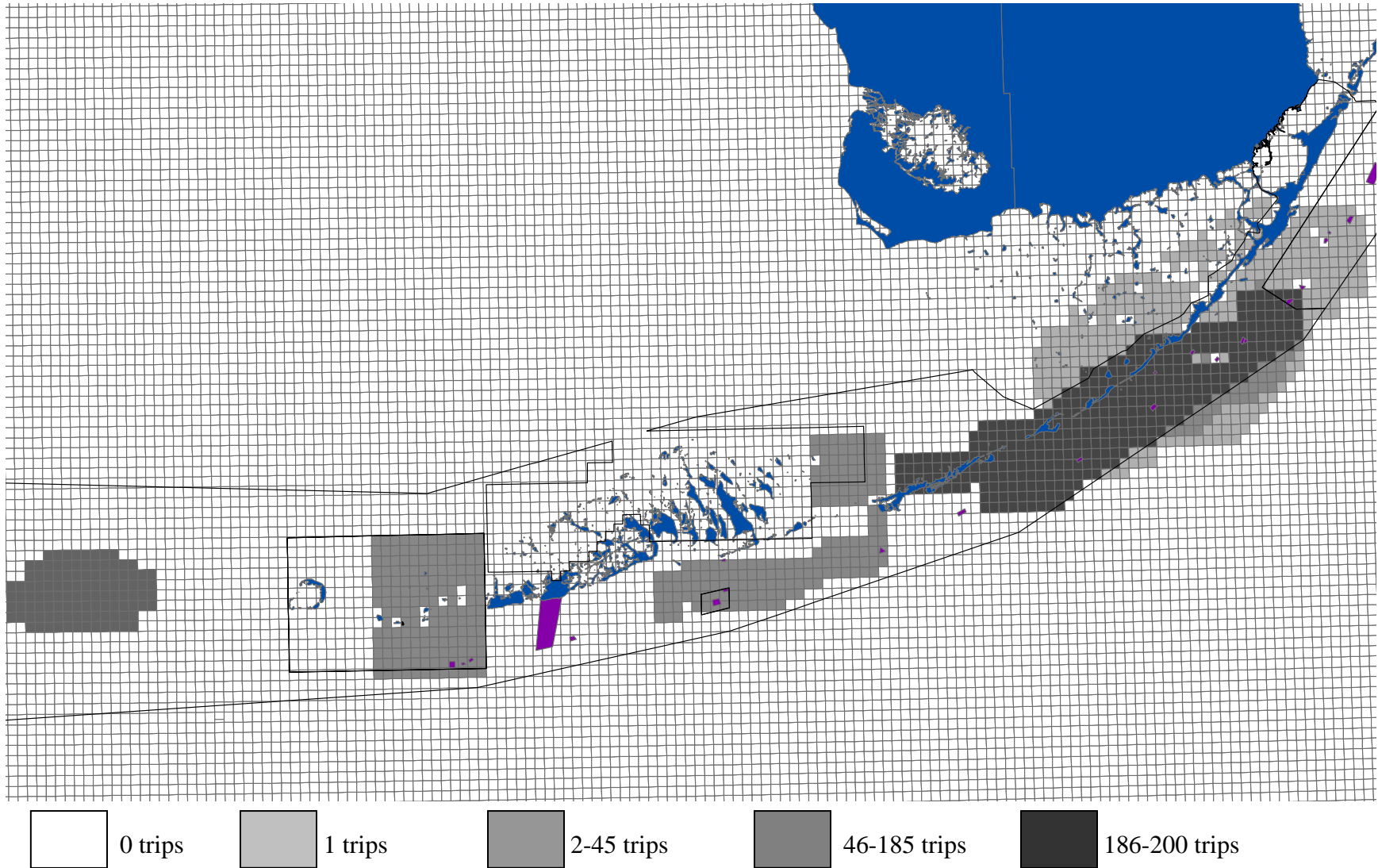
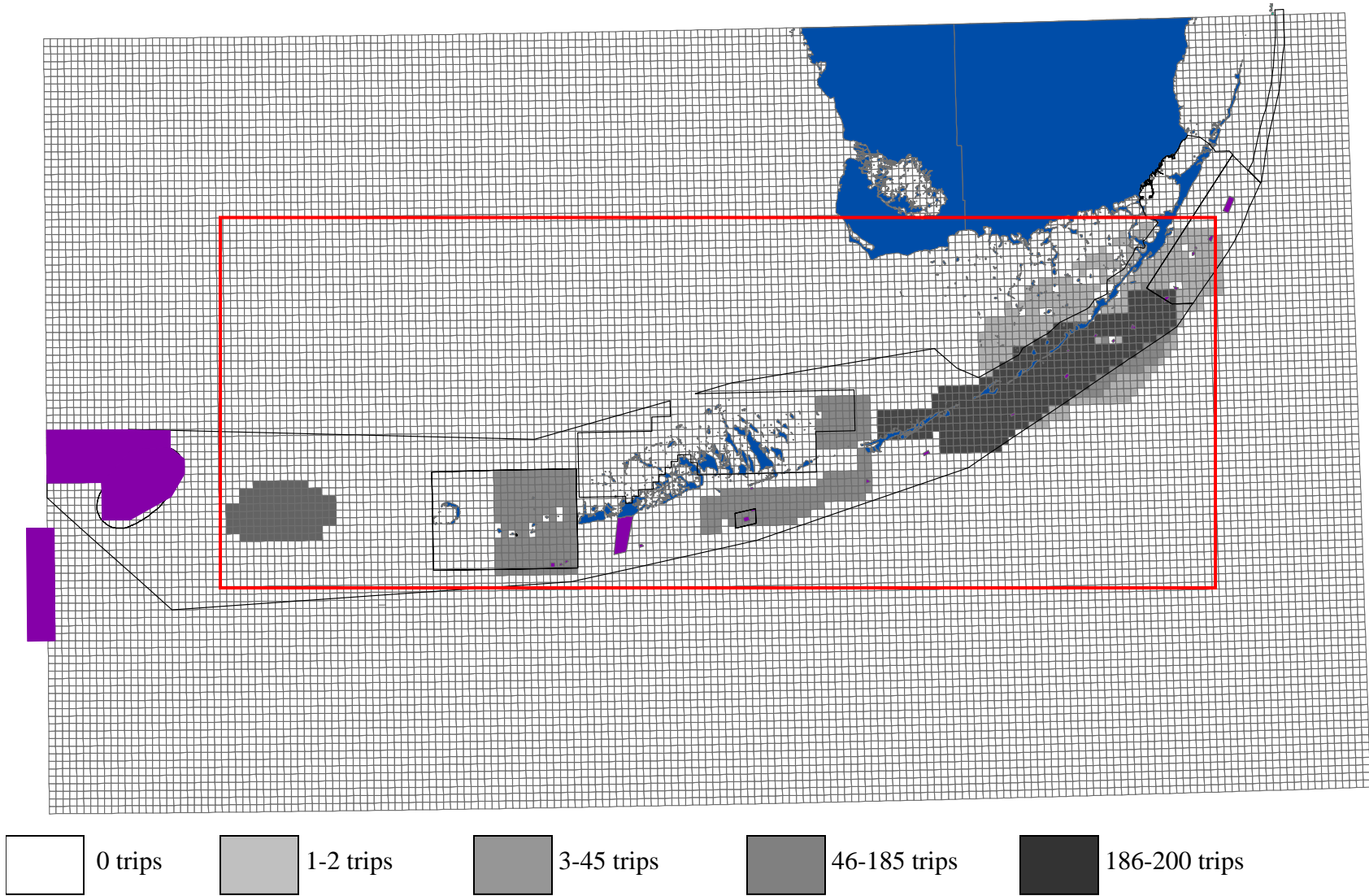


Figure 23: Marine life trips in 2003-04, close up



**Figure 24: Marine life trips in 2004-05**

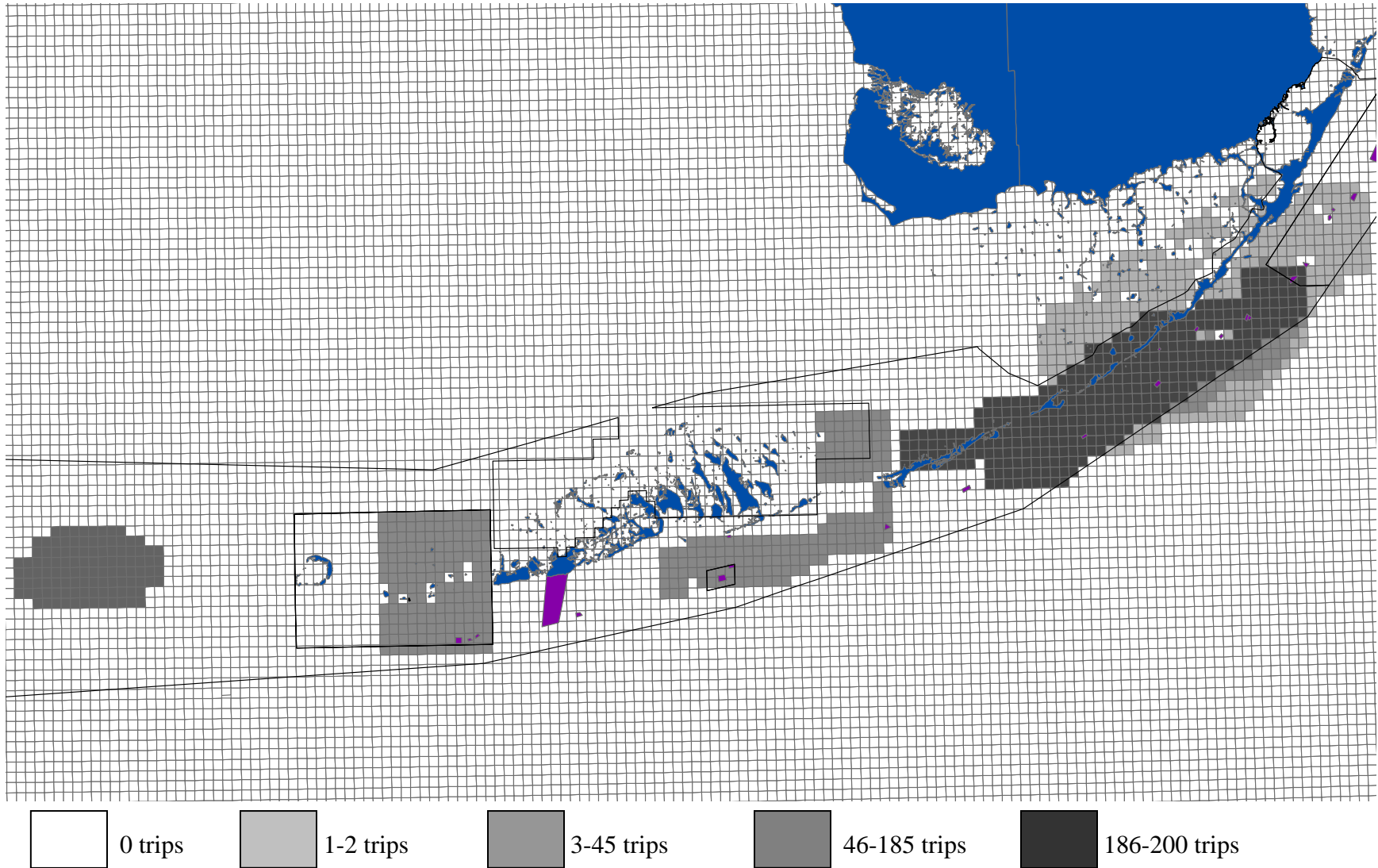


Figure 25: Marine life trips in 2004-05, close up

Marine life collectors' data for both seasons (2003-04 and 2004-05) is spatially expressed as trips and not landings, due to the reasons discussed in an earlier section. In 2003-04, the trips reported by the respondents were mostly concentrated in the Upper Keys. This is partly because of the fact that most of the marine life collectors on the panel reside in that region, but it is also a result of the greater availability of suitable habitat (and hence target species). Thus, trips in the Upper Keys focused on the Atlantic Ocean side and included the areas around all of the Sanctuary Preservation Areas (SPAs). Similarly, collectors reported taking several trips in the Looe Key SPA and SUA area and the Sand Key-Rock Key-Eastern Dry Rocks SPA complex in the Lower Keys. Use did not extend beyond the Marquesas Keys, as it did for the other fisheries, and the Marquesas Keys represented the western boundary of collector trips.

In 2004-05, marine life collectors fished the identical areas that they fished in 2003-04, and overall effort – in terms of trips – remained the same. This was interesting as it did not appear that the 2004 hurricane season affected their use patterns even though several of the collectors stated that post-hurricane conditions had greatly impacted collection areas (i.e. increased turbidity, high rates of target species mortality, and overall mechanical damage to the substrate). Further monitoring may show changes in use patterns, however, as the 2005 hurricane season had significant impacts on the Florida Keys with three storms affecting at least parts of the region (Hurricane Katrina in August, Hurricane Rita in September, and Hurricane Wilma in October).

## Discussion

The spatial profiles obtained from the 2003-04 and 2004-05 fishery panels have provided a useful way by which to understand commercial fisheries in the FKNMS, in terms of their geographical context and extent, the identification of hotspots, and the evaluation of changes in the location and magnitude of landings (as well as effort and costs) over time. It should be noted, however, that fishery panel spatial data representation is biased; that is, it focuses on members of panels that are either pre-disposed to a geographical area and/or target species. Moreover, the fishers on each panel represent the high liners in their fisheries (Thomas J. Murray and Associates, 2007) and therefore their use profiles are not representative for their respective fisheries. Finally, these spatial data and maps do not address the medium-term, spatial conditions; rather, the two years provide a snapshot each on the changes from year 1 (2003-04) to year 2 (2004-05).

The spatial profiles generated from the two fishery panel surveys show that fisher ports largely dictate effort, but that landings are largely shifted to the west in the FKNMS. This is partly explained by the nature of the panels (ex. the TER panel is selected due to its participation in the western, TER fisheries), but it is clear from participants in the other panels (especially the SER panel) that landings for key species such as spiny lobster and reef fish (and even king mackerel, which was not shown due to low participation in the fishery in the two study years) are concentrated in the regions west of Key West. Within some fisheries, especially stone crab, landings still do occur south of the Lower Keys, but in comparison with landings in other areas north and west of the Lower Keys in particular (and the Florida Keys in general), most landings occur along the western corridor of the FKNMS.

The other important finding from this study has been the identification of landing hotspots by fishery. This has shown that fishers who participate in the panel study do provide accurate information, at least in terms of not simply stating that they fish the entire region, and that there are discrete areas (by species) that may serve as important aggregation sites. Within the stone crab fishery, such sites tend to be located in the northern sections of the Lower Keys. For spiny lobster, the hotspots are located in the southern sections of the Lower Keys through to the Tortugas, with the Marquesas Keys' area serving as both a transit route and as a fishing ground. The Marquesas Keys are also important for reef fish, which is landed in hotspots around the Tortugas (and especially south of the DTNP) and then along the length of the southern reef tract from Rebecca Shoal east to the SPA complex southwest of Key West. The highest shrimp landings in both years have been along the northeastern section of the Tortugas, an area that shrimpers had identified in an earlier study (Leeworthy and Wiley, 2000). It appears, however, that shrimp landings have otherwise largely been from outside the FKNMS and mainly in the Gulf of Mexico (to the north and west) and the Atlantic Ocean (to the south). Finally, marine life hotspots have been those that offer considerable habitat (ex. coral reefs, hardbottom areas, etc.). Thus, use has been most often reported for the John Pennekamp/Key Largo National Marine Sanctuary area in the Upper Keys extending towards the Middle Keys. Other regions, populated by sea grass and sandy habitats, are of less importance, at least as shown by the marine life collector maps.

The third main finding, although preliminary, suggests that geographical use (at least through the two study years) may be mainly consistent across years. Thus, apart from those fishers who switch landing sites as a result of relocation, it appears that panel members generally fish within the same area on an inter-annual basis. This is further confirmed by comparing maps from this and the previous spatial use characterization study (Shivlani and Rudders, 2003), which suggests a certain amount of territoriality and the importance of home ports.

Finally, it is noteworthy that there is considerable fishing that occurs along the boundaries of established MPAs. For example, although most use in the Tortugas region shifted to the east in a 2003-04 study (which evaluated the TER fishery for the 2002-03 season), it appears that at least among TER panel members, most recent use (in 2003-04 and 2004-05 seasons) may be shifted further to the west.

These findings reinforce the need to have a continuous, socioeconomic monitoring program for each of the ecological reserves and the FKNMS in general. While many of the results from these spatial profiles could be used to evaluate more regional, fishery-wide conditions, it is suggested that a larger, more regionalized sample may provide greater coverage and representative spatial use profiles. Thus, a future panel effort should consider the dissolution of zone-specific (ex. ecological reserve) panels and instead develop regional panels covering the main fishing areas and/or island groupings. One such approach may be the creation of four panels based on their fishing locations: Tortugas panel; Lower Keys panel; Middle Keys panel; and Upper Keys panel. Each of the panels can then be populated with a group of fishers who cover the main fisheries in the area. For example, the Tortugas panel would be comprised of spiny lobster, shrimp, king mackerel, and reef fish fishers. Moreover, panel sizes should be increased; currently, the largest panel – the TER panel – consists of nine members. Smaller panels, such as the SER panel, have four members. Larger, regional panels should consider including as many as 15 members. This increased study effort may result in more effort and costs, but it will also provide more economic, fishery, and use information, all of which can be used to develop a better understanding of the performance of commercial fisheries in the FKNMS.



## References

Leeworthy, V. R., and P. C. Wiley. 2000. Proposed Tortugas 2000 Ecological Reserve, Final Socioeconomic Impact Analysis of Alternatives. Silver Spring, MD: National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects Office.

National Oceanic and Atmospheric Administration (NOAA). 2000. Final Supplemental Environmental Impact Statement/Final Supplemental Management Plan for the Tortugas Ecological Reserve. SRD/OCRM/NOS/NOAA, Silver Spring, MD.

National Oceanic and Atmospheric Administration (NOAA). 1996. Florida Keys National Marine Sanctuary Final Management Plan/Environmental Impact Statement: Volume 1. SRD/OCRM/NOS/NOAA, Silver Spring, MD.

National Oceanic and Atmospheric Administration (NOAA). 1995. Florida Keys National Marine Sanctuary Draft Management Plan/Environmental Impact Statement: Volume 1. SRD/OCRM/NOS/NOAA, Silver Spring, MD.

Milon, J. W., D. O. Suman, M. Shivlani, and K. A. Cochran. 1997. Commercial fishers' perceptions of marine reserves for the Florida Keys National Marine Sanctuary. Florida Sea Grant Technical Paper-89.

Shivlani, M. P., D. Letson, and C. R. Sawzcyn. 1998. Socioeconomic Effects of the Florida Net Ban in Monroe County. Florida Geographer 29: 12-29.

Shivlani, M., and D. Rudders. 2003. November 2003 - Year Three GIS Report: Commercial Fishing Panels GIS Spatial Patterns of Catch. World Wide Web document. URL: <http://www.marineconomics.noaa.gov/SocmonFK/Year%203.pdf>.

Shivlani, M. P. and D. O. Suman. 2000. Dive Operator Use Patterns in the Designated No-take Zones within the Florida Keys National Marine Sanctuary. Environmental Management 25 (6): 647-659.

Suman, D. O., and M. P. Shivlani. 1998. Characterization of the Commercial Dive Operator Industry in the Florida Keys National Marine Sanctuary. Florida Sea Grant Technical Paper-103.

Suman, D. O., M. P. Shivlani, and J. W. Milon. 1999. Perceptions and Attitudes Regarding Marine Reserves: A Comparison of Stakeholder Groups in the Florida Keys National Marine Sanctuary. Ocean and Coastal Management 42: 1019-1040.

Thomas J. Murray and Associates, Inc. 2007. Socio-economic baseline development in the Florida Keys National Marine Sanctuary: Fishing years 1998-2006. Draft version, March 2007.