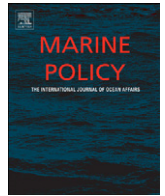


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## Enforcement and compliance trends under IFQ management in the Gulf of Mexico commercial reef fish fishery

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### ABSTRACT

United States fisheries are increasingly relying on catch share programs for fisheries management, but the relationship of these programs with compliance and enforcement behavior is not well understood. This study uses historical enforcement records and surveys of fishery participants to investigate how imposition of catch share management in the Gulf of Mexico commercial reef fish fishery has altered patterns of fisheries violations and fisher perceptions of changes in compliance. This fishery has been partially managed under individual fishing quotas (IFQs) since 2007, allowing for comparison of compliance and enforcement prior to and after introduction of catch share management. The shift to catch shares in this fishery has yielded minor but expected changes in enforcement activity. The overall number of cases declined, and the mix of cases shifted: enforcement incidents related to reporting and recordkeeping became more common and catch limit and permit cases declined. These changes are consistent with expectations about the effects of catch shares. However, confidence in these results is limited by the low number of applicable cases, the effects of enforcement effort on case frequency, and the effects of other management system changes during the study—most notably, new vessel monitoring system (VMS) and observer program requirements. Limitations in the enforcement data and survey data both suggest that noncompliance in the Gulf of Mexico reef fish fishery is higher than suggested by the low number of relevant records in the federal enforcement database, but that compliance has improved in the sector under catch share management. The study concludes that increased enforcement resources may be justified to ensure continued compliance benefits and to ensure the accuracy of landings records.

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### 1. Introduction

Many studies have demonstrated that catch share programs are an economically rational way to manage fisheries (e.g., [1,2]). Research indicates that fishermen who own a secure right to a certain percentage of the resource profit from improved fishery health and have financial incentives to conserve fisheries that do not apply to fishermen operating in open-access or derby systems [3]. Research also suggests that catch shares may improve ecological conditions by slowing and halting the collapse and minimizing bycatch of target species [2,4,5]. Catch shares may lead to social and economic benefits, including reduction of overcapacity, lengthening of fishing seasons, increased safety conditions, reduced gear conflicts, increased ex-vessel price, and increased product quality [6–8]. However, catch shares require careful institutional design to avoid negative social outcomes, such as excessive consolidation of quota ownership in a few

owners [8–10] or in non-fishers, which could undermine the incentive structure for fishers [11,12]; negative environmental impacts, such as continued overfishing due to incorrect stock assessment [13]; and non-target ecosystem impacts including habitat damage and bycatch of non-target species [6,10,14].

Noncompliance with fisheries regulations may compromise sustainability in catch share programs. The rate of noncompliance is a function of economic and normative factors: fishers have economic incentives to violate fishing regulations when the benefits of noncompliance outweigh the costs (including, for example, probability of detection, probability of punishment, and the amount of likely penalties) [15]. However, economic incentives are not the only – or necessarily the most important – driver of compliance decisions. Fishers consistently comply more often than predicted by economic factors alone [16]. These findings can be explained by social and normative factors, such as perceptions of fairness and legitimacy [17,18] and trust among fishery participants [19], and declines in normative and social factors may adversely affect compliance rates [15].

Some research demonstrates that catch shares can encourage compliance [5,20]. Because fishers in catch share systems suffer

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directly when others violate the program due to reduction of potential future catch, catch share programs provide incentives for fishers to accept and support strengthened monitoring, enforcement, and penalization of violations and to report overfishing that they witness [10,21]. For example, catch share participants have demanded increased dockside and at-sea enforcement monitoring to augment rates of detection [6], including observer coverage [22] and taxation [23]. Fishers also have worked with fisheries management authorities to create regulations that make noncompliance easier to detect [24,25]. Such cooperation may lead to increased normative legitimacy of enforcement, especially when combined with enhanced cooperation in the management process [26] and determination of allowable catch [21].

Conversely, changing from open access fishery management to catch share systems may create new enforcement challenges (e.g., [27]). For target species, robust enforcement is needed in catch share systems to protect participants' economic stake in the resource. NOAA summarized this enforcement challenge.

"The success of a [catch share] program rests entirely upon the ability to track the owners of Quota Shares (QS), allocate the appropriate amount of Annual Harvest Privileges (AHP) that flow from the QS, reconcile landings against those AHP, and, ultimately balance the collective figures against the total allowable catch (TAC). If this can not [sic] be accomplished, both illegal landings and unlawful sales will be possible which, more than likely, will eventually destroy the program. These violations not only undermine management goals and objectives, they also erode the security of the privileges holder's interests in a [catch share program] which is the core concept of the program. The... program will fail if the participants lose confidence in the government's ability to manage the program ([20], p.81)".

Little empirical information exists to test the effects of catch shares on compliance. Some studies indicate high rates of compliance [28], but others report substantial noncompliance (e.g., [19,29–32]). These studies led Branch [10] to conclude that while "quota busting" (i.e., non-reported catch) is not a major problem in most catch share fisheries, effective enforcement is an important factor in this success.

Adequate enforcement also is necessary to ensure that participants comply with regulations that are related to non-target species and habitats. In contrast to target species, catch shares do not explicitly affect incentives to comply with area closures, gear restrictions, or other requirements that primarily protect non-target species or habitats. Less information is available on compliance with these regulations, although the few studies that have considered the issue indicate that catch shares yield compliance benefits for such regulations [10,33].

This study assesses the effects of catch share management on compliance and enforcement in the Gulf of Mexico reef fish fishery in order to improve understanding of how IFQ management affects compliance in this fishery and to identify lessons that can be applied in fishery management in other fisheries and regions.

### 1.1. Gulf of Mexico reef fish management

The Gulf of Mexico Fishery Management Council (Gulf Council) manages commercial and recreational<sup>1</sup> fishing for 42 species of reef fish across a 5-state region under a single fishery management plan (FMP). Soon after the FMP was first issued in 1984, stock assessments revealed that economically-important species

were overfished and/or subject to continued overfishing, resulting in increased restrictions on fishing effort, as described in more detail elsewhere [36,37]. Red snapper (*Lutjanus campechanus*) has been considered depleted and overfished since a 1988 stock assessment [37], while the two primary grouper species – red grouper (*Epinephelus morio*) and gag grouper (*Mycteroperca microlepis*) – were found to be overfished and/or undergoing overfishing in 1999 and 1997, respectively [38].

Initial revisions to the reef fish FMP intended to end overfishing and rebuild depleted stocks did not reverse declines, leading to additional and ongoing reforms. In the past decade, the Gulf Council has adopted rebuilding plans and restricted effort for red snapper, deep- and shallow-water grouper, tilefish (Mala-canthidae), and other species; implemented a mandatory observer program for commercial and recreational reef fish fishing vessels (effective 2006) [39]; imposed a vessel monitoring system requirement for commercial reef fish vessels (effective 2007) [40,41] and created marine reserves to restrict fishing effort in particular areas [42–44].

The Gulf Council also implemented new measures allowing for catch shares. First, in 2006, the Council acted to allow transfers of fishing permits by creating a renewable limited access permit system to replace its moratorium on the issuance of new commercial reef fish permits [45]. Like the previous system, permits are renewable and the number of permits remains constant. The amendment differed from the prior regime by allowing participants to purchase and sell their permits, allowing them to exit or enter the fishery as desired. Second, having created a mechanism for transferring permits, the Council implemented Individual Fishing Quota (IFQ) systems for commercial red snapper in 2007 and for commercial grouper and tilefish in 2010 [35,46]. Under both IFQ systems, fishing entities possess shares in the fishery. Each year, shareholders receive an annual allocation of catch that corresponds to the percentage of the total shares that they own. The annual allocation that corresponds to a share fluctuates along with the total allowable catch for the fishery. Both shares and annual allocations can be bought, sold, and traded, subject to some limitations on consolidation of ownership. The Gulf Council may bring the remainder of the reef fish complex into an IFQ system in the future.

Fishery sustainability and overall profitability have improved in recent years. While NOAA continues to officially list red snapper as both overfished and undergoing overfishing [47], the results of a 2009 stock assessment update indicated that overfishing has ceased [48]. Fish length and weight also have increased, despite an increase in allowable catch [49]. According to landings records, fishing in excess of allowable catch has ceased under the IFQ system. Commercial red snapper landing volume was higher in 2010 than in 2007 despite closures associated with the *Deepwater Horizon* oil spill, and the ex-vessel price per pound has improved [50]. The cause of stock rebuilding is uncertain, however, as factors other than management changes, such as the decade-long decline in shrimping effort ([48], pp. 51–56), are likely contributors to red snapper stock abundance ([51], p. 13).

While initial signs are positive, confounding factors, including the effect of noncompliance with fishing regulations on fishery sustainability, obscure the linkage between the apparent stock recovery and fishery management. Catch share programs provide incentives for participants to under-report landings, which may undermine the reliability of landings information and lead to underestimates of fishing effort and mortality. Consideration of the relationship between catch shares and compliance is required to understand the benefits, limitations, and avenues for improvement of catch share programs in the Gulf of Mexico and elsewhere.

<sup>1</sup> Recreational catch for these species is substantial, ranging from approximately one-quarter to more than half of the total catch on a species by species basis [34]. Shrimp vessels are also a source of red snapper mortality external to the directed commercial fishery [35].

## 2. Methods

The data presented in this study come from two major sources of information: (1) NOAA enforcement records between January 2001 and October 2011 included in NOAA Office of Law Enforcement's (OLE) databases; and (2) written surveys of the Gulf of Mexico commercial IFQ allocation owners. The information and analysis is bolstered by unstructured interviews with enforcement personnel. For some sources, additional information is provided in King et al. [52].

### 2.1. Enforcement history

Enforcement record data are drawn from two OLE enforcement record databases, the Enforcement Management Information System (EMIS), described in King et al. [52], and the Law Enforcement Accessible Database System (LEADS), which were integrated into a single dataset covering all closed enforcement incidents between January 2001 and October 2011 (hereafter, jointly, LEADS). The data set contains records of enforcement actions involving alleged violations of federal laws and regulations under OLE jurisdiction, including fisheries regulations, originating with NOAA, the United States Coast Guard (USCG), state enforcement agencies, and other sources. As discussed more fully below, the database excludes instances in which enforcement agencies detected potential noncompliance but did not refer the interaction to OLE for inclusion in the enforcement database. The LEADS records therefore represent a subset of all enforcement actions related to federal fisheries.

Integration of the EMIS and LEADS data sets resulted in a single national data set with 24,187 separate enforcement records. Each record contains multiple fields, including but not limited to OLE region, field office, source (i.e., originating agency), vessel and gear type, resolution of the incident, relevant statute or regulation, and a text description of the alleged violation. Data on sanctions and penalty amounts were present in the EMIS data but are not accessible through LEADS and therefore were excluded from the integrated data set.

To select the subset of cases needed to assess enforcement and compliance in the Gulf of Mexico reef fish fishery, cases were limited to those that: (1) cited a provision of the Gulf of Mexico reef fish management plan; (2) originated in the OLE Southeast regional office or a field office bordering the Gulf of Mexico; (3) based on a record-by-record review by the authors, were related to reef fish regulations; and (4) derived from the vertical line or longline sectors. Limitation of the data set to violations of the reef fish FMP excluded many records associated with laws other than the Magnuson Stevens Act, such as those occurring in marine sanctuaries; as a result, this study does not capture the full range of enforcement incidents derived from fishing activity, particularly incidents relating to area closures, habitat damage, or endangered species interactions. Cases where no field office was specified were excluded unless they could be positively associated with the Gulf of Mexico on the basis of the violation description. Each remaining record was examined to determine whether it applied to Gulf of Mexico reef fisheries management, and apparently unrelated records—including but not limited to those specifying other fisheries or non-reef fish species, were excluded.

Landings assessments indicate that snapper and grouper fishing in the Gulf of Mexico is concentrated in the vertical line and longline sectors ([48], p. 27). The analysis below therefore uses vessel category as a proxy for the commercial reef fish sector and is based solely on records assigned to these vessel categories. Vessel and gear type fields were used to develop a new vessel category field. The "vertical line" vessel category includes records

identified as: bandit rig; handline; handler; jig; and bottomfish vessels or gear. The "longline" category includes identified longline fishing vessels and records without vessel or gear specified but with longline indicated in the violation description. Limitation of the dataset to vertical line and longline records likely excludes some relevant records; sport fishing vessels may hold commercial permits, and some records for which the vessel type was indeterminate likely involved the commercial reef fish sector. On the other hand, some recreational cases may be included in the data set, as in the case of a vertical line vessel participating in the charter sector. Thus, vessel type is a reasonable but imperfect method to distinguish the commercial reef fish sector.

The resulting data set included 357 records related to the Gulf of Mexico commercial reef fish fishery between 2001 and 2011. Each count of a multi-count case is separately recorded in the dataset; when only records indicating the first count of an enforcement incident are counted, this data set includes counts 255 unambiguously distinct cases. This paper uses "counts" (367) and "cases" (255) to distinguish these concepts.

The authors used the original data fields to further characterize the data by source type, resolution, and violation category. The source field was used to create a new category, source type. Each record was assigned to one of the following source types: VMS, USCG, tip, state, other, observer, or NMFS. While VMS and observer cases are technically recorded by NOAA, these cases are assigned independent types from NOAA because they represent substantially different modes of detection from dockside or at-sea enforcement action by NOAA agents. Records assigned to NOAA include "complaint directly through region/agent," "NMFS initiated," and "NMFS surface." State records include "Authorized state agency/official initiated," "state or local government agency," and "JEA [joint enforcement agreement]." USCG records include "Coast Guard surface," "Coast Guard aerial," and "other source of Coast Guard initiated report." "NMFS/State" and "NMFS/Coast Guard" were assigned as Cooperative. Tip cases include those with a listed source as "member of the general public," "U.S. fishing vessel," "hotline complaint," or "marine sanctuary contractor." Other sources, except for "NMFS observer" or "VMS initiated," were categorized as other.

Violation categories were determined on the basis of the text descriptions of each record. Violation categories include: bycatch reduction; catch limits; closed area or season; observer program; permit violation; reporting and recordkeeping; unlawful purchase or sale; or other. Records without information in either the "remarks" or "activity comments" were assigned to "other" unless the regulation cited supported placement in a specific category. Subcategories were developed for each violation category as appropriate to allow further and more specific characterization of enforcement incidents.

Finally, a resolution category field was created based on the "case prosecution status" and "case clearance type" fields. Based on the information in these fields, each record was assigned to one of the following resolution categories: settlement after NOVA; summary settlement; verbal warning; written warning (together, these resolutions are considered enforcement action); declined; lack of evidence; no violation (together considered not to be prosecuted); or transferred/referred (prosecution status unknown).

### 2.2. Survey data

In addition to historical enforcement data, this study draws on the results of two surveys of Gulf of Mexico red snapper IFQ allocation holders conducted in 2007 and 2011. The 2007 results include the relevant responses to a national survey described in King et al. [52], which fully describes the survey methodology. In

most respects, the 2011 survey followed the protocol and format used in 2007. Unlike the 2007 survey, however, the 2011 survey was limited to the Gulf of Mexico commercial red snapper IFQ fishery, was conducted exclusively online, instead of by mail, and did not include a financial incentive. Participants were notified of the survey by an initial and a follow-up letter; the surveyor's contact information was provided, and the letters indicated that a hard copy was available upon request. With few exceptions, the questions included in the survey were identical in 2007 and 2011 to facilitate comparisons over time. The exceptions include the inclusion of new questions regarding leasing of annual allocation, use of reef fish for bait, and effects of the shrimp fishery and recreational sector on the commercial red snapper IFQ fishery. The 2007 survey was delivered to a total of 396 IFQ allocation holders, yielding 186 respondents for a response rate of 47%, assuming all addresses were valid. The 2011 survey was sent to 408 red snapper IFQ allocation holders identified based on a list maintained by NOAA [53], of which 20 had invalid addresses. This yielded 67 responses, for a response rate of 17%. Analysis of survey questions differed by question type. For questions requesting a numerical response, a one-sample, two-tailed t-test was used to determine whether the 2007 mean was significantly different from the 2011 mean. A two-sample method was not used because the variance of 2007 responses is unknown. For questions seeking agreement with assertions, the chi-square test for homogeneity was used to determine the significance of differences in responses from 2007 to 2011.

### 3. Enforcement in the Gulf of Mexico commercial reef fish fishery

Enforcement in the commercial reef fish sector is affected by general trends in enforcement as well as by regulatory changes, which are expected to increase noncompliance in the short term. Enforcement agency effort may change over time; for example, USCG enforcement effort was reallocated away from fisheries missions in the aftermath of the terrorist attacks of September 11, 2001 [54]. This analysis does not correct for the effects of agency practice or effort. In addition, the many regulatory changes occurring during the timeframe under consideration complicate the task of linking particular enforcement records with IFQ implementation and limit our ability to propose causal relationships between enforcement trends and the IFQ program, except in the few cases where violation descriptions make such a connection explicit.

Some records, however, can be excluded from consideration, including incidents citing the observer program, VMS, and bycatch mitigation requirements. Introduction of the observer program in 2006 and 2007 created substantial numbers of cases, all of which resulted from alleged observer coverage violations (Fig. 1). While area closures did occur prior to VMS introduction, VMS substantially changed enforcement practice: VMS was used to detect 29 of the 32 area closure counts recorded after 2007, and 11 additional counts were associated with missing or fraudulent VMS transmission or coding. Finally, changes in sea turtle mitigation planning and handling requirements for bottom longline fishing gear took effect in 2006 [55]. Bycatch reduction violations at that time cite to the new requirements and therefore are not attributable to catch share implementation; prior to these requirements, bycatch reduction was not an issue in the reef fish fishery; while several records indicate noncompliant gear prior to 2006, these are noted in the comments to be a product of shrimp fishing by longline vessels.

Noncompliance with VMS, observer program, and bycatch reduction requirements are relevant to the question of how catch shares affect restrictions intended to protect non-target species

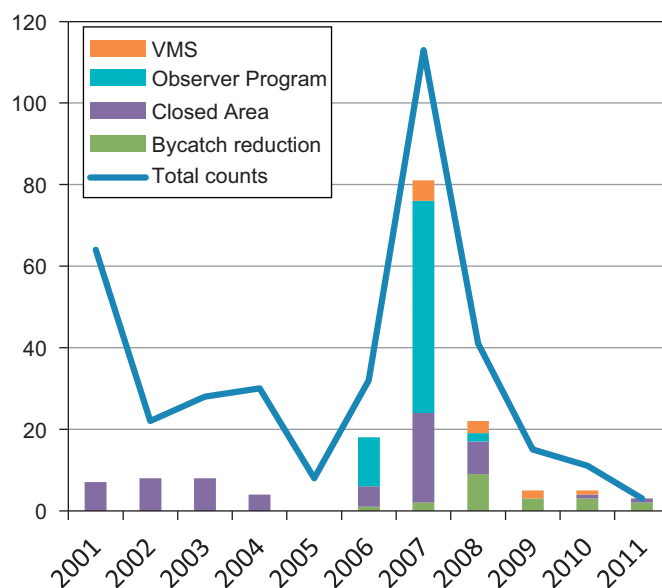


Fig. 1. Counts originating in the Gulf of Mexico commercial reef fish sector, with observer program, VMS, and bycatch reduction measure counts highlighted.

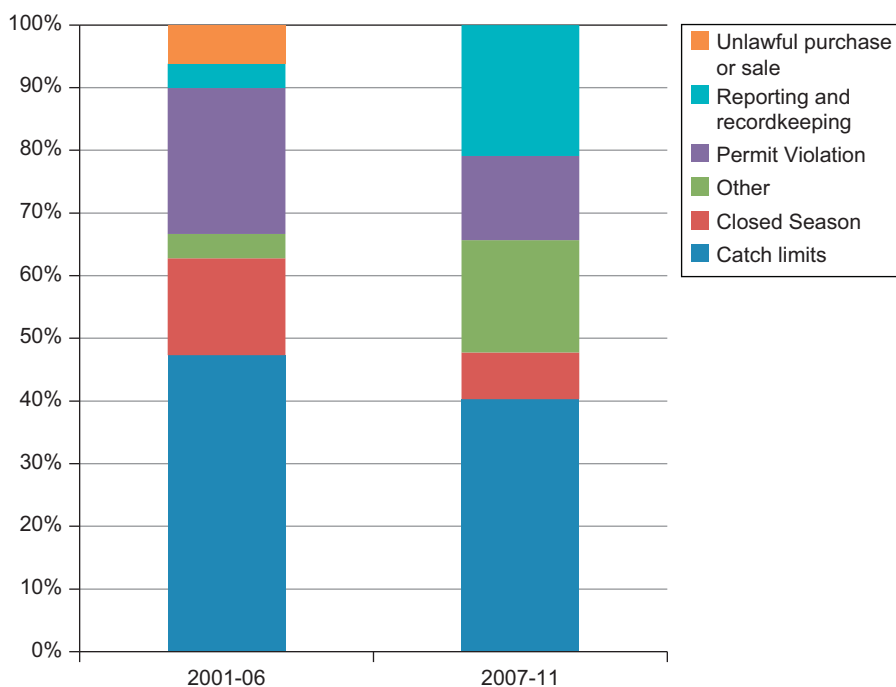
and habitats. However, as these restrictions were implemented contemporaneously with the IFQ program, comparison of enforcement prior to and after the IFQ is impossible. As a result, exclusion of these records allows directed comparison of enforcement practice before and after implementation of catch shares. These counts are therefore excluded from the analysis in the remainder of this section, which considers the 196 remaining counts, representing 158 separate cases. These remaining records are used to compare enforcement from 2001 to 2006 and from 2007 to 2011—i.e., prior to and after red snapper IFQ implementation.

Enforcement records indicate that the number of enforcement incidents has declined in the fishery over the past decade. In addition, the proportion of potential catch limit violations experienced a small decline, while the proportion of other violation categories has shifted more substantially. “Recordkeeping and reporting” and “other” records were more common after IFQ implementation, while “permit,” “closed season,” and “unlawful purchase or sale” records declined in representation (Fig. 2). These trends represent associated increases and decreases, respectively, in the number of potential violations identified per year in each category.

While the small sample size precludes meaningful statistical analysis, these trends suggest that catch shares have affected enforcement practice in detectable ways. Although the increased number of records in 2007 may represent year-to-year fluctuation, consideration of the proportional representation of violation categories suggests that this increase may be related to IFQ implementation. The number of reporting and recordkeeping counts was expected to increase after introducing catch shares because of the new requirements for prior notice of landing time and location and for landing reports. In fact, 10 of the 14 reporting counts recorded after 2007 were due to a missing, incorrect, or fraudulent landing time, landing location, or landing report. Similarly, review of the violation descriptions associated with the counts in the “other” indicates that 10 of 17 of these counts explicitly refer to IFQ noncompliance, and two others refer to illegal red snapper harvest. Closed season cases were expected to decline, as the red snapper season expanded dramatically after IFQ implementation, leaving less opportunity for noncompliance.

On the other hand, the correlation between IFQ program implementation and permit and catch limit violations requires





**Fig. 2.** Proportion of counts by violation category in the commercial reef fish sector, prior to and after implementation of catch share management, exclusive of counts related to the observer program, area closure/VMS, and bycatch requirements.

further consideration. With the exception of the replacement of trip limits with annual overages for red snapper, imposition of IFQ management made few changes to catch limits. Trip limits for other species, minimum size, prohibited species, and other catch restrictions, such as the requirement to land reef fish with head and tail intact,<sup>2</sup> remained unchanged. Examination of catch limit records reveals that the proportion of overages declined as percent of catch limit counts after IFQ implementation, falling from 19 potential violations from 2001 to 2006 to six from 2007 to 2011. Given that most catch limit restrictions were unchanged, it is unsurprising that despite this decline, the proportion of all catch limit records in the reef fish dataset declined only slightly during the decade.

Like catch limits, the IFQ program did not substantially alter commercial reef fish permit requirements, but potential violations of these requirements declined after IFQ implementation. A review of these records indicates that 31 of 39 permit-related counts pertain to fishing without an operator permit or license. The decline in these counts is not obviously associated with catch share implementation.

In addition to examining types of enforcement records, consideration of how records are detected and their resolution is instructive. After excluding observer program, closed area/VMS, and bycatch reduction cases, the number of state-sourced cases remained stable before and after the IFQ program, cooperative NMFS/state cases increased, and tip-based and NMFS- and USCG-sourced cases decreased in number (Table 1). While the source of cases shifted substantially from 2001 to 2011, these data do not support a correlation with IFQ management. For example, Gulf of Mexico IFQ programs allow participants to obtain additional annual allocation after harvesting but prior to landing their catch, which makes at-sea enforcement of overages difficult. However, consideration of USCG-sourced records reveals only four overage cases among

the 29 identified by USCG between 2001 and 2011. The prevalence and decline of catch limit cases unaffected by the IFQ program, such as size and condition limitations, suggests that IFQ implementation had little bearing on USCG detection in this area; as a result, management changes may be less important than changes in agency priorities, practice, and resources in interpreting these results. The same management cases may be associated with the previously discussed decline in the number of permit cases from 2007 to 2011.

Case resolution changed before and after IFQ program implementation. Most notably, the number of cases resulting in a settlement increased from 7 before IFQ implementation to 35 afterwards, while the number of cases declined for prosecution decreased from 41 to 0, and those resolved by written warning decreased from 36 to 8 (Table 1). In all, the percentage of cases successfully prosecuted, defined as any resolution involving financial penalty or a warning, exclusive of transferred or unknown resolution cases, increased from 46% to 98%, and the proportion receiving a financial penalty increased from 10% to 80% of cases. The increase in financial penalties was centered on cases sourced by NMFS, states, or NMFS/state cooperative efforts, which together make up 30 of the 35 cases settled between 2007 and 2011, but which yielded only 5 settlements from 2001 to 2006. While a causal link cannot be established between the increase in settlements and IFQ implementation, the timing of the settled cases suggests some correlation, with a dramatic rise in 2007 followed by a subsequent slow decline until 2009 (Fig. 3). Whether this pattern resulted from the structure of the IFQ regulations, increased enforcement effort in support of the new system, or other reasons, the high rate of settlement for cases in this fishery post-IFQ implementation indicates that enforcement agencies can effectively prosecute regulations in the reef fish fishery – including those related to the IFQ system – when they are detected.

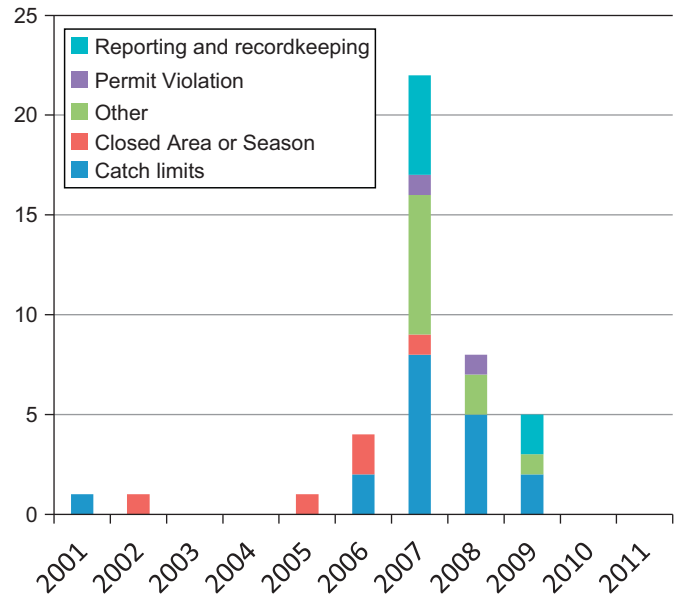
#### 4. Compliance in Gulf of Mexico IFQ fisheries

IFQ management in the Gulf of Mexico commercial reef fishery is correlated with shifts in the types of violations detected, the

<sup>2</sup> Amendment 18A to the FMP, finalized in 2006, strengthened this requirement by closing a loophole that allowed reef fish to be used as bait in some cases [56]. This amendment did not fundamentally alter the pre-existing bar on landings of filleted reef fish.

**Table 1** Cases by source and resolution before and after IFQ program implementation, exclusive of observer program, area closure/VMS, and bycatch cases.

	NMFS/state		NMFS		State		USCG		Tip/other			Total	
	2001-2006	2007-2011	2001-2006	2007-2011	2001-2006	2007-2011	2001-2006	2007-2011	2001-2006	2007-2011	2001-2006	2007-2011	
	Declined	2	0	14	0	5	0	6	0	14	0	41	0
Lack of evidence	0	0	0	0	1	0	1	0	2	0	4	0	
No violation	0	0	0	1	3	0	5	0	0	0	8	1	
Settlement after NOVA	0	10	0	5	5	15	2	3	0	2	7	35	
Summary settlement	0	0	0	0	0	0	3	2	0	0	3	2	
Transferred/referred	0	0	1	1	2	0	4	0	3	0	10	1	
Unknown	0	0	0	0	1	0	0	0	0	0	1	1	
Written warning	0	0	2	1	4	3	30	4	0	0	36	8	
Total	2	10	17	8	21	18	51	9	19	3	110	48	



**Fig. 3.** Settled cases in the Gulf of Mexico commercial reef fish fishery by violation category, 2001-2011, exclusive of observer program, area closure/VMS, and bycatch restriction cases.

mix of agencies detecting violations, and the rate of successful prosecution. Many of these changes are expected based on changes to fishery management structure and operation associated with catch shares. However, enforcement records are only a proxy for understanding the extent of noncompliance in the fishery. The low number of relevant records in the dataset could result from high compliance rates, low detection of noncompliance, data limitations, or other factors. This section considers alternative sources to better understand compliance behavior, which suggest that the LEADS database incorporates only a portion of all detected instances of noncompliance in this fishery and that noncompliance is higher than LEADS data would indicate. These data also suggest that while compliance is increasing under IFQ management, increased dockside enforcement resources are needed.

*2.1. Evidence of noncompliance outside of the LEADS database*

If LEADS does not include information on all detected instances of noncompliance, then the use of LEADS data would result in an overestimate of compliance rate. Consideration of state agency detection and reporting and NOAA annual IFQ program reports suggest that some instances of detected non-compliance are not included in the LEADS database. As a result, the LEADS database is more accurately considered a record of instances of major noncompliance in the Gulf of Mexico, which may account for the low number of records pertaining to commercial reef fishing. As a result, the use of LEADS data to estimate noncompliance is not recommended.

Fisheries enforcement in the Gulf of Mexico relies heavily on state agencies, which enforce federal fisheries regulations pursuant to cooperative and joint enforcement agreements with NOAA. State agencies prosecute some detected reef fish violations – particularly less serious violations – under corresponding state law rather than forwarding them to NOAA for federal prosecution. The JEA program requires states to report these cases to NOAA [57], but LEADS does not include all cases reported pursuant to the JEA program [personal communication]. As a result, LEADS includes some, but not all, potential violations identified by state agencies.

**Table 2**

Summary data on landings transactions and notifications showing the number of notifications without transaction and transactions without a notification, each of which may represent a violation [50,59–61].

Year	Program	Cases	LT	LN	LN without LT (% LN)	LT without LN (% LT)
2007	Snapper	20	Unavailable	Unavailable	Unavailable	Unavailable
2008	Snapper	17	2861	2872	305 (10.6%)	103 (3.6%)
2009	Snapper	20	2451	2767	262 (9.5%)	195 (8.0%)
2010	Snapper	9	3228	3366	107 (3.2%)	163 (5.0%)
2010	Grouper	Unavailable	9962	9986	417 (4.2%)	756 (7.6%)
Total		66	18502	18991	1091 (5.7%)	1217 (6.6%)

NOAA's annual red snapper and grouper-tilefish IFQ program reports offer an additional data source on noncompliance in these sectors. These reports identify major and typical violation types, provide information on enforcement cases and seizures, and report on compliance with the landing notification and transaction systems. This information thus provides a secondary information source for comparison against the LEADS data. The annual reports indicate that OLE investigates between 9 and 20 cases per year per IFQ program. These cases are likely to be major violations or typical violations, as defined in the reports. "Major violations" include mislabeling species and underreporting landing weights; "typical violations" include landing earlier than indicated in the landing notification; landing to a site other than that indicated in the landing notification; transporting landed fish without an approval code (all fisheries and years); offloading after hours<sup>3</sup> (both IFQ programs, 2010 only); and landing fish without a prior landing notification (grouper-tilefish, 2010) [50,59–61]. While direct correlation between the program reports and LEADS data is impossible, the number of IFQ cases identified in the program reports is consistent with the data from LEADS discussed in the prior section.

The annual reports indicate the number of landings notifications (LN), landings transactions (LT), and missing or mismatched LN and LT for each program-year. Not every mismatch necessarily indicates a violation; for example, the 2010 grouper-tilefish IFQ report notes that multiple landing notifications are sometimes issued for a single landing transaction [59]. Nonetheless, many of the LT and LN errors surely represent violations of IFQ program requirements, and the number of notification and transaction mismatches greatly exceeds the number of cases investigated by OLE during the year (Table 2). This difference likely results from a reasonable exercise of OLE discretion and resource allocation; however, potential violations that are not pursued also do not appear in LEADS.

The low level at which LN and LT discrepancies are investigated suggests that these violations are not viewed as a significant threat to the fishery resource that would warrant devotion of substantial resources for monitoring and verification. Nonetheless, prior notice of landings and landings transactions are essential for verifying the accuracy of landings data—a critical input for management decisions. While individual incidents of reporting noncompliance may represent a minimal risk to fishery sustainability, in aggregate they could mask substantial overages if not sufficiently deterred. Enforcement agencies currently lack the resources to allow agents to be present at most landings, so the accuracy of landings reports and the effects of noncompliance on the resource remain unclear. Confidence in LT accuracy could be improved through increased allocation of resources to landing and sale report verification—an action under consideration within NOAA [personal communication].

The potentially substantial incidence of noncompliance that is not represented in LEADS indicates that the enforcement dataset should be interpreted as an underestimate of noncompliance. In other words, the true rate of noncompliance is likely substantially greater than suggested by the enforcement data (e.g., the number of LN and LT violations indicated in LEADS is likely an order of magnitude less than the true number).

#### 4.2. Fisher perspectives on compliance

Survey results suggest that the compliance rate is lower than implied by LEADS, but that the red snapper IFQ program is correlated with increased compliance. 73% of respondents from the 2011 survey agree or strongly agree that both the enforcement program and compliance improved over the previous five years; similar responses were obtained in 2007. Other responses also indicate improvement. Based on the mean of respondent estimates, 13% of commercial fishermen routinely violate fisheries laws and 12% do so occasionally. These figures are both less than the mean recorded in 2007, although only the decrease in the percent of occasional violators is significant at the 95% level ( $p=0.006$ ). Responses indicating that violations are having a highly significant or extremely significant effect on the health and manageability of red snapper also decreased from 10.6% in 2007 to 3.8% in 2011, although this difference is not statistically significant ( $p=.13$ ).

The survey results suggest that the relationship between enforcement and industry in this fishery is positive, but that additional enforcement effort may be necessary to effectively deter violations. Nearly three in four respondents indicated that dedication to and effectiveness of both dockside and at-sea enforcement is adequate, more than adequate, or excellent. This suggests that most IFQ holders are satisfied with enforcement, but a substantial minority disagrees. Respondents estimate on average that only 31% of violations are detected, which is not significantly different than the estimated detection rate of 35% recorded in 2007 but suggests a continuing, high level of non-compliance. In addition, nearly one third of respondents indicated that the number of dockside enforcement agents, the number of dockside inspections, and the effectiveness of dockside inspections are somewhat or very inadequate. In each case, the 2011 responses echo those provided in 2007. Finally, 29% of respondents agree or strongly agree that it is easy for those violating fishing laws and regulations to evade dockside detection by NMFS and state agents; this response was indistinguishable from the 2007 data. Responses to parallel questions regarding USCG enforcement were comparable but slightly more favorable, with fewer respondents indicating that more at-sea personnel or inspections are needed to effectively deter noncompliance.

Taken together, the survey results indicate minimal change in comparison to 2007. There is some indication that compliance has improved, with a significant reduction in the percent of violators estimated to occasionally violate fisheries laws. It is reasonable to speculate that occasional violators may be rational violators who

<sup>3</sup> The IFQ regulations require all landings be made between 6 A.M. and 6 P.M. local time [58].

make compliance decisions based on the associated benefits and costs [15]; if so, this change might suggest that catch shares have reduced noncompliance in this group, though less so among regular violators. While rational decision-making may have led to increased compliance, these data do not show that enforcement action is responsible for the change, with no related significant change from 2007 responses, and a continuing minority of the fleet who would likely support increased enforcement at dockside. As a result, catch share management itself or external factors—including increased ex-vessel value and increased allowable catch of red snapper and other regulatory changes, such as VMS requirements—may be responsible for all or part of the observed compliance gains. Further research is needed to determine the relative importance of these factors.

## 5. Conclusion

Imposition of IFQ programs in the Gulf of Mexico over the past decade appears to have produced small shifts in enforcement outcomes and compliance behavior. While subject to sample size limitations, enforcement data suggests that the red snapper IFQ program has shifted noncompliance in expected ways, increasing the prevalence of reporting violations while minimizing other types of violations, such as closed seasons. In addition, IFQ cases appear to be capable of effective prosecution, as rates of financial penalty assessment substantially increased after 2007. These conclusions could be strengthened by incorporating all detected potential violations of federal fisheries laws into the LEADS database, including incidents detected by state agencies and those detected by federal agencies but not investigated or prosecuted. While costly in the short term, data improvement efforts may be justified and economically beneficial over the long term because they could result in improved fishery sustainability. Comprehensive enforcement data would support future efforts to deter noncompliance, identify how enforcement actions affect compliance behavior, and increase the accuracy of the compliance assumptions that are incorporated in stock assessment models.

While direct links between enforcement and compliance were not determinable, survey data suggests that compliance has increased under IFQ management but that levels of noncompliance remain substantial—a finding supported by NOAA landings records. Given literature suggesting that inadequate enforcement presence affects long-term compliance in catch share fisheries [10] and survey responses suggesting that dockside enforcement could be improved, devotion of additional resources to detect and deter noncompliance may be justified to support the persistence of recent compliance improvements. NOAA could achieve this goal by dedicating more of the cost recovery fees derived from Gulf of Mexico IFQ fisheries [50,59] to enforcement and, specifically, to monitoring IFQ landings.

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