SEDAR 33-DW-19: A meta-data analysis of discard mortality estimates for gag grouper and greater amberjack

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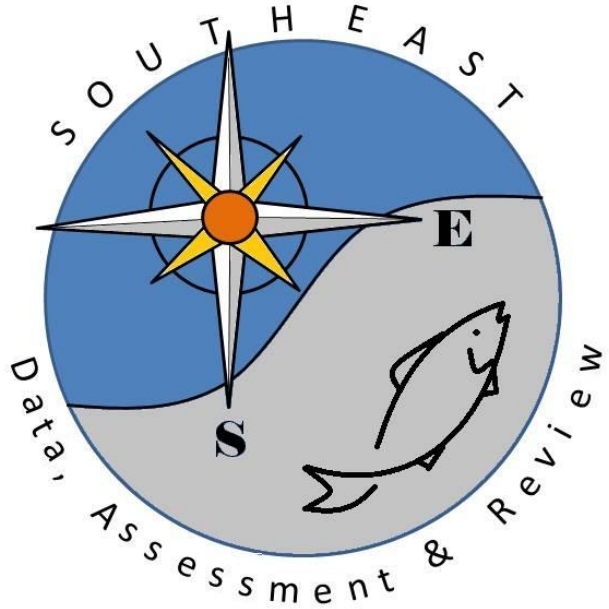

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A meta-data analysis of discard mortality estimates for gag grouper and greater amberjack

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Background

Discard mortality can be measured in three levels: immediate, short-term and long-term (Pollock and Pine 2007). Immediate discard mortally is measured from observations of fish immediately after being handled during normal fishing operations. Short-term mortality is typically measured in experimental studies, such as when fish are held in confinement (i.e., cage, holding tank) following exposure to capture or simulated capture (i.e. barometric chamber). Long-term mortality is tracked with tagging studies by modeling the recapture rate of marked fish or actively tracking individual fish with acoustic tags. Each of these methods (surface observation, experimental, and tagging) has associated caveats and assumptions that need to be considered when using resulting mortality estimates.

There are five terms of reference (TOR) specific to treatment of discard mortality during the SEDAR process: 1) review available research and published literature, 2) consider research directed at gag (*Mycteroperca microlepis*) and greater amberjack (*Seriola dumerili*) as well as similar species from other areas, 3) provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata, 4) include thorough rationale for recommended discard mortality rates and 5) provide justification for any recommendations that deviate from the range of discard mortality provided in the last update or other prior assessments. This report provides documentation of the steps associated with addressing TORs 1, 2, and 3, and each will be addressed separately for gag and greater amberjack.

On-line citation indexes were searched using Web of Science and Google Scholar. In addition, National Sea Grant, Mote Marine Laboratory, NC and FL Sea Grant and National Marine Fisheries Service, Southeast Fisheries Science Center publication series were also

searched. These databases were searched using the keywords: gag grouper, greater amberjack, discard, release, tag-recapture, mortality and reef fish. The result of these on-line searches were 33 citations for gag grouper, 12 citations for greater amberjack and 6 citations involving hook selectivity and/or discard mortality that would be applicable for this review (see Literature Cited).

Previous Assessments Discard (Release) Mortality Estimates

Gag Grouper

There have been four gag grouper assessments in the Gulf of Mexico (GOM)(Schirripa and Goodyear 1994, Schirripa and Legault 1997, Turner et al. 2001, SEDAR 2006a), two assessments in the South Atlantic (Potts and Manooch 1998, SEDAR 2006a), and one GOM update assessment (SEDAR 2010). The most recent assessments for gag in the GOM and South Atlantic used logistic regression to estimate a depth-mortality function, and that function relied on the published estimates of Burns et al. 2002 and McGovern et al. 2005 (Table 1). These estimates were based on both passive tag-recapture and caging studies (Table 2).

The 2001 GOM gag assessment relied on discard mortality values from previous assessments. In this assessment, recreational release mortality was set at 20% and 30% for the commercial sector (Table 1; Turner et al. 2001). The higher discard estimate for the commercial sector was based on the belief that discard mortality increased with depth fished, and it was thought that most commercial vessels fished in deeper waters than recreational vessels.

The 1998 south Atlantic gag assessment applied two release mortality estimates (20% and 50%) to model runs regardless of fishing sector (Table 1; Potts and Manooch 1998). The

lower discard mortality estimate was based on surface observations of gag released on headboat vessels. The investigators felt that a discard estimate of 20% was low; therefore, assessment models were compiled with an additional discard estimate of 50%.

The 1997 GOM gag assessment used discard mortality estimates of 20% (recreational) and 33% (commercial) (Table 1; Schirripa and Legault 1997). These values were slightly higher than what was calculated from observations onboard commercial vessels that recorded immediate mortality of discards (SEFSC 1995), but these values were similar to values used in other reef fish assessments at that time (e.g. red snapper). Discard mortality was higher for the commercial sector based on the belief that commercial vessels fished in deeper waters and had lower opportunities for quick release of gag compared to the recreational sector.

The first GOM gag assessment used a range of discard mortality estimates (0 – 35%) (Table 1; Schirripa and Goodyear 1994). These values were based on the review of discard mortality estimates for a variety of reef fish from a tag and capture project but were not specific to gag grouper (Schirripa et al. 1993).

Greater Amberjack

There have been three GOM greater amberjack assessments (Turner et al. 2000, Diaz et al. 2005, SEDAR 2006b) and one GOM update assessment (SEDAR 2011). The most recent assessment for GOM greater amberjack in the used 20% discard mortality for assessment model base runs and additional discard mortalities of 0% and 40% as model sensitivities (Table 3). These discard mortality rates were based on surface observations from fish caught and released onboard headboat and commercial vertical line vessels. Twelve greater amberjack

were caught off of North Carolina with one fish 'presumed' dead due to floating condition (release mortality = 10%). The 2006 life history group advised release mortality would likely be higher; and recommended sensitivity analyses across a range of release mortalities (20-50%) (SEDAR 2006b). During the 2010 update assessment, two projects reported fairly low discard mortality rates although the results were consideredpreliminary at that time (FL FWC/FWRI, discard mortality = 3.8%; Murie and Parkyn 2010, discard mortality <2%). Three different levels of release mortality (0%, 20%, and 40%) were applied to the 2005 GOM assessment (Diaz et al. 2005) and only one value for discard mortality (20%) was used to the assessment model in 2000 (Turner et al. 2000) (Table 3).

Methods of Estimation

Surface Observation

Discard mortality estimates calculated from surface observations are somewhat subjective since the recorded condition of the fish often relies on the observed behavior of fish during release at the surface after handling. Typically surface observations measure immediate mortality resulting from exposure to catch and release. Release condition categories are described as good if the fish was released alive and immediately submerged beneath the surface, fair if the fish was initially disoriented or floated before slowly descending, poor if the fish floated at the surface, or dead if the fish was either unresponsive or preyed upon (Rudershausen et al. 2005, Rudershausen and Buckel 2007, Stephens and Harris 2010). Release conditions may also include other indicators of injury or impairment, such as hook location, visible barotrauma symptoms, or fitness measures. In addition to research projects onboard

commercial vessels, two observer programs in the US southeast record surface observations for discards in the commercial fishery: Galveston Observer Program (SEFSC 2011) and the Shark Bottom Long-line Observer Program. Observers record the condition of each fish twice: 1) the condition on capture and 2) the condition on release. Surface observations for discards of gag grouper and greater amberjack in the recreational hook-and-line fisheries have been reported by several short-term programs that employed fishery observers on for-hire vessels, including headboats and charter boats and described in SEDAR33-DW04 and SEDAR33-DW05 (Sauls and Cermak 2013a and 2013b).

Gag Grouper

A variety of discard mortality estimates have been calculated for gag grouper based on the condition of the fish on release from commercial and recreational vertical line fishing (Table 2). These values range from 0% (Rudershausen et al. 2005, Rudershausen and Buckel 2007, Stephens and Harris 2010) to 14.7% (based on observer coverage, SEDAR 2006c). Of these studies, discard mortality estimates reported by Rudershausen and Buckel 2007 (preliminary results reported in Rudershausen et al. 2005) appear to be the most useful, since estimates were reported by two depth zones (19-25m and 26-50m). For gag discards (both vented and unvented) observed in the recreational hook-and-line fishery in the eastern GOM, a majority (75-100% during any given year) were released alive and immediately submerged (Sauls and Cermak 2013a), and 77.79% of gags observed in Florida submerged immediately without a need for venting (Sauls 2013). Less than 1% of gags observed were either dead or preyed upon at the time they were discarded.

Greater Amberjack

Two studies have provided estimates for immediate discard mortality based on commercial vertical line fishing operations (Table 4). These values ranged from 23.5% (based on observer coverage, SEDAR 2006d) to 94% (Stephens and Harris 2010). Stephens and Harris (2010) reported 199 greater amberjack caught with 47 fish discarded (discard rate 23.6%); but of those fish discarded, 44 were classified as either having experienced difficulty submerging or as fish that floated at the surface. Further discussion is needed to qualify the immediate release mortality condition given the considerable differences in discard mortality rates reported in these studies. A small percentage of greater amberjack observed in the recreational hook-and-line fishery (2.38% from headboats, 5.64% from charter) suffered immediate mortality or were not able to submerge immediately following release (Sauls and Cermak 2013b).

Cage studies

Discard mortality estimates obtained through caging or containment studies rely on the study design (number of cages, replicates, and controls) to obtain an unbiased measure of mortality (Pollock and Pine 2007). Caging studies measure short-term mortality and discard mortality is defined as the number of observed deaths over a defined holding period (Overton et al. 2008). However, some fish can become more stressed and/or suffer additional injuries during containment, generally are not subjected to predation during containment, and are likely more vulnerable to predators after containment.

Gag

Three caging studies reported a range of discard mortality rates for gag grouper (Table 2). Each of these studies used vertical line with circle or J hooks to investigate post-release mortality for undersized reef fish. The cages used in these studies were also similarly constructed with wire mesh and PVC pipes. In each study, cages were lowered to various designated depth.

The first cage study reported only three gag grouper all of which died after being in cages (cage depths 55 and 75 m) for a minimum of 24 hrs (Wilson and Burns 1996). A second caging study estimated mortality rates using two different cage types (circle and square) and investigated differences between 2 hr and 48 hr holding periods, which resulted in an immediate mortality rate of 22%, and with mortality increasing with the increase in holding period (Overton and Zabawski 2003, Overton et al. 2008). The third study collected a total of 67 gag grouper (<500 mm) and divided the fish among cages at four depths (20 m, 35 m, 45 m, and 50 m) and resulted in a depth-mortality function with discard mortality of 50% at 43.7 m (Burns et al. 2002). This data formulated the depth-mortality function that was used in the 2006 GOM and south Atlantic assessments as well as the 2010 GOM update assessment.

Greater Amberjack

None to date

Passive and Acoustic Tags

Discard mortality estimates obtained through passive or acoustic tagging studies rely on the design of the study, the number of fish tagged, and the willingness of anglers to report tags (Pollock and Pine 2007). Tag-recapture percentages should not be interpreted as an estimate of survival (typically, only around 10% of fish in passive tagging studies are recaptured), though these percentages may be used to derive estimates of total mortality and discard mortality. Recapture rates are also highly dependent on fishing effort. Comparisons of tag-recapture percentages and long-term mortality estimates derived from recaptures reported by commercial and recreational fishers should be viewed with caution when factors that influence fishing effort (and hence, tag-recapture rates) across spatial and temporal scales are not accounted for in models.

Gag Grouper

Gag grouper (n = 3876) were tagged off the US South Atlantic coast over a four year period (1995-1999) through a cooperative program with the South Carolina Department of Natural Resources and commercial captains (McGovern et al. 2005, SEDAR 2006e). Tag and recapture rates were reported by depth at capture (Table 2). These recapture rates formulated the depth-mortality function that was applied to the 2006 assessment in the Gulf of Mexico and South Atlantic and the 2010 update assessment in the Gulf of Mexico. A tag-recapture study in Florida described in SEDAR33-DW06 modeled relative survival of gags in good, fair and poor condition categories (Sauls 2013). The model included covariates that controlled for variable recapture rates for gags tagged in different time periods and regions in the study. The

majority of gags were released in good condition (77.8%), and gags released in fair and poor condition were 69.1% and 46.1% as likely to survive, respectively, compared to gags released in good condition. Estimated mortality percentages in depths >40m were lower in this study compared to McGovern et al (2005).

Gag grouper were also tagged and released over the course of 15 years (1991-2005) using volunteers onboard commercial and a variety of recreational vessels (charter and headboats, private vessels) through the Mote Marine Laboratory tagging program (SEDAR 2006f). This program tagged 6,353 gag and 586 were recaptured, a recapture rate of 9%. Recapture rates were provided only by year and by fishing mode (commercial, recreational) (Table 2).

Greater Amberjack

The University of Florida, Fisheries and Aquatic Science Program, professors Deb Murie and Daryl Parkyn have been leading both a passive and an acoustic tagging program for greater amberjack beginning in 2007 (Murie et al. 2011, Parkyn and Murie 2012, SEDAR33-DWXX). Greater amberjack (n = 1,493) were caught by both commercial and recreational fishing vessels using a variety of gears, with 169 tags returned (11.3%) as of 2011 (Murie et al. 2011). Five large mature fish were tagged with pop-up archival satellite tags, three of the fish experienced similar depth and environmental profiles, while two fish showed more variability (Murie et al. 2011). Additional data from this program will be made available during the data workshop for SEDAR33.

Conclusion

This report summarizes the first three terms of reference (TOR) specific to the discard mortality: 1) review available research and published literature and provide ratioinale for irrelevant studies (see Table 5), 2) consider research directed at gag and greater amberjack and 3) provide estimates of discard mortality rate by fishery, gear type, depth, and other feasible or appropriate strata. Immediate discard mortality estimates from surface observations are available from four studies involving gag caught by the commercial vertical line fishery and one study using recreational vessels (Table 2). In addition, short-term discard mortality estimates are available for gag from three caging studies and from two tag-recapture studies reporting long-term discard mortality estimates (Table 2). Fewer studies have reported immediate discard mortality estimates for greater amberjack from surface observations, but of those studies discard mortatliy estimates are avaible from two studies using the commercial vertical line fishery and one study using recreational vessels (Table 4). Long-term mortality estimates for greater amberjack are currently preliminary and final estimates will be provided during SEDAR data workshop (SEDAR33-DW-XX).

The discard mortality working group will revise this report after the data workshop by addressing the final two TORs: 4) include thorough rationale for recommended discard mortality rates and 5) provide justification for any recommendations that deviate from the range of discard mortality provided in the last update or other prior assessment and reviewing additional data/reports provided at the SEDAR33 data workshop. In addition, the discard mortality working group will discuss the effect of depth, hook type, and venting in estimating discard mortality.

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Table 1. Discard mortality estimates applied to previous assessments for gag grouper in the Gulf of Mexico (GOM) and South Atlantic (SA).

Assessment Year	Region	Discard mortality
2010 update[a]	GOM	Depth-mortality function Mortality = 1/(1+exp(-k(depth-50%mortality))) k = 0.058649; 50% mortality = 45.5 m
2006[a]	GOM SA	Depth-mortality function Mortality = 1/(1+exp(-k(depth-50%mortality))) k = 0.058649; 50% mortality = 45.5 m
2001	GOM	20% (Recreational), 30% (Commercial)
1998	SA	0%, 20%, 50%
1997[b]	GOM	20% (Recreational), 33% (Commercial)
1994[c]	GOM	0%, 20%, 33% (most realistic)

[a]Burns et al. 2002 and McGovern et al. 2005
[b]SEFSC 1995
[c]Schirripa et al. 1993

Table 2. Meta-data of discard mortality estimates for gag grouper (in order by year of citation).

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard rate	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
0-90	All Year	NE Gulf of Mexico (west FL shelf)	Immediate mortality upon release	Mean=463-585	<1%	3,832	11	3,821	Circle or J	Recreational, hook and line	Selective	Yes	Sauls 2013
0-10	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		2.5%, 11.9%, 21.3%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
11-20	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		1.9%, 11.5%, 21.1%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
21-30	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		9.0%, 16.4%, 23.8%	3,832			Circle or J	Recreational, hook and line	Selective	Yes, range of mortalities based on varied assumption of survival for fish in good condition that may be used for sensitivity runs	Sauls 2013
31-40	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		21.2%, 24.9%, 28.6%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
41-50	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		25.8%, 28.4%, 31.0%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
51-60	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		20.1%, 24.2%, 28.3%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
61-90	All Year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		26.3%, 30.4%, 34.5%	3,832			Circle or J	Recreational, hook and line	Selective		Sauls 2013
Range of depths	All Year	NE Gulf of Mexico (west FL shelf)	Hook location	500	3.77% potentially lethal hook injuries	1,433			Circle	Recreational, hook and line	Selective		Sauls and Ayala 2012
Range of depths	All Year	NE Gulf of Mexico (west FL shelf)	Hook location	500	5.44% potentially lethal hook injuries	772			J	Recreational, hook and line	Selective	Yes, low percentage of potentially lethal hook injuries for both circle and J hooks, no significant reduction with circle hooks	Sauls and Ayala 2012

Table 2. Meta-data of discard mortality estimates for gag grouper (in order by year of citation)…continued

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard rate	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
20 - 80	Summer/ Fall	South Atlantic - SC	Surface observations		0 %	53	2		J	Commercial, vertical line	No	Yes	Stephen and Harris 2010
15-45	All Year	South Atlantic - NC	Cage and onboard holding tanks	295-573 476 (SE 14)	21.9 %	33	7	26	Circle or J	Recreational, Hook and line	Vented by lowering in cages	Yes. Low sample size.	Overton et al. 2008 Overton and Zabowski 2003
19-150	All Year	South Atlantic - Onslow Bay, NC	Surface observations		0%	55	0	55	J Hooks electric reels	Commercial, vertical line	No	Yes. Fishing depths not readily apparent. Great info on hooking location with J hooks	Rudershausen and Buckel 2007
unknown	All Year	NE Gulf of Mexico (west FL shelf)	Surface observations		14.7% dead, 0.9% kept	41,683			Not reported	Commercial, vertical line	Not reported	Yes	SEDAR 2006c
unknown	All year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		8.98 % recapture N = 569	6336			Not reported	Commercial and Recreational, Gear unknown	Not reported	Yes, annual estimates	SEDAR 2006f
unknown	All year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		9.17% recapture N = 504	5495			Not reported	Recreational, Gear unknown	Not reported	Yes, annual estimates	SEDAR 2006f
unknown	All year	NE Gulf of Mexico (west FL shelf)	Tag-recapture		7.85% recapture N = 35	446			Not reported	Commercial, Gear unknown	Not reported	Yes, annual estimates	SEDAR 2006f
11-20	All Year	South Atlantic - NC-FL	Tag-recapture	578 (SE 166)	14.2463%	253			Not reported	Commercial, gear unknown	Yes-all	Provides estimates of M; however, 81% tagged off SC; noted large differences in recapture rates among regions attributed to uneven effort, which was not controlled for in the model. Also, M is estimated from survival across years after subtracting natural mortality, may still include mortality not related to initial catch-and-release event?	
21-30	All Year	South Atlantic - NC-FL	Tag-recapture	70.9 (SE 119)	23.0274%	1,221			Not reported	Commercial, gear unknown	Yes-all		
31-40	All Year	South Atlantic - NC-FL	Tag-recapture	771 (SE 105)	35.0113%	730			Not reported	Commercial, gear unknown	Yes-all		
41-50	All Year	South Atlantic - NC-FL	Tag-recapture	828 (SE 77)	49.2420%	871			Not reported	Commercial, gear unknown	Yes-all		
51-60	All Year	South Atlantic - NC-FL	Tag-recapture	842 (SE 81)	63.5966%	357			Not reported	Commercial, gear unknown	Yes-all		
61-70	All Year	South Atlantic - NC-FL	Tag-recapture	832 (SE 56)	75.8801%	321			Not reported	Commercial, gear unknown	Yes-all		
71-80	All Year	South Atlantic	Tag-recapture	787	84.9966%	39			Not reported	Commercial,	Yes-all		McGovern et al. 2005

Table 2. Meta-data of discard mortality estimates for gag grouper (in order by year of citation)…continued

Depth (m)	Season	Region	Method	Size Range (mm) Mean or Range	Discard rate	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
		- NC-FL		(one length)						gear unknown			
81-90	All Year	South Atlantic - NC-FL	Tag-recapture	Not reported	91.0728%	57			Not reported	Commercial, gear unknown	Yes-all		
91-100	All Year	South Atlantic - NC-FL	Tag-recapture	Not reported	94.8377%	11			Not reported	Commercial, gear unknown	Yes-all		
18.8-85.2 Mean = 29.2	Summer/ Fall	South Atlantic - NC	Surface observations	683 (SE 119)	0%	29	0	29	J Hooks electric reels	Commercial, hook and line	No	Yes. Low sample size. Fishing depths not readily apparent. Great info on hooking location with J hooks	Rudershausen et al. 2005
20-50	Sumer	NE Gulf of Mexico (Apalachicola)	Cage	< 500	Estimated LD50 = 43.7 m (50% of the gag die at this depth)	67	n/a	n/a	Circle	Commercial Gear electric reels	Vented by lowering in cages.	Yes. Problem may exist in exclusion of subjects due to lost cages, shark attacks, gill and gut hooked fish not included. Logistical functional response with depth, data modeled with data from McGovern et al. 2005.	Burns et al. 2002
54 and 75	Summer/ Fall	NE Gulf of Mexico (west FL shelf)	Cage	790-840	100%	3			Not reported, likely J	hook and line	No	Low sample size	Wilson and Burns 1996

Table 3. Discard mortality estimates applied to previous assessments for greater amberjack in the Gulf of Mexico (GOM).

Assessment Year	Discard mortality
2010 update	0%, 20% (base), 40%
2006	0%, 20% (base), 40%
2005	0% (base for SSPASM), 20%, 40%
2000	20%

Table 4. Meta-data of discard mortality estimates for greater amberjack (in order by year of citation).

Depth (m)	Season	Region	Method	Size Range mm Mean or Range	Discard rate	N	# dead	# alive	Hooks	Mode	Vent	Relevant	Citation
10-70 (mean 38.5)	All year	Eastern Gulf of Mexico – FL, AL	Surface observation	160-1070	5.64% fair, poor, or dead	1,046	6	1,040	Circle and J	Hook and line, Headboats	Selective	Yes	Sauls and Cermak 2013b
10-70 (mean 47.3)	All year	NE Gulf of Mexico— FL	Surface observation	280-960	2.35% fair, poor or dead	496	1	495	Circle and J	Hook and line, charter boats	Selective	Yes	Sauls and Cermak 2013b
Not reported	Not reported	Gulf of Mexico	Tag-recapture	Not reported	Recapture rates: 15.9% circle, 8.2% J hooks	Not reported			Circle and J	Hook and line	Not reported	Need more information	Parkyn and Murie 2012
Not reported	Summer/Fall	Gulf of Mexico – LA, FL	Tag-recapture	226-1412	11.3% recapture rate, N = 169	1493			Circle and J	Commercial Recreational Variety of gear	Not reported	Yes	Murie et al. 2011
20 - 80	summer/fall	Atlantic - SC	Surface observations		94% immediate	47	44	3	J-hooks	Commercial, vertical line	No	Yes	Stephen and Harris 2010
unknown	year round	Gulf of Mexico	Surface observations		23.5% dead, 0.7% kept	74,579			Unknown	Commercial, vertical line	Unknown	Yes	SEDAR 2006d

Key to Tables 2 and 4:

Depth Range: 5 meter increments
Region: specific area study conducted
Size Range: of fish in study
N: sample size for study
alive: # of fish discarded alive
Fishing Mode: Commercial, Recreational
Literature Relevant: Yes or No, explanation
Season: Spring, Summer, Fall, Winter, or year round
Method: hyperbolic, cage, SCUBA, Surface observation, acoustic tags, etc.
Discard mortality estiamte: # discarded dead/total N
dead: # of fish discarded dead
Hook Type: J or Circle or both
Venting: Yes or No
Citation: for study

Table 5. List of citations irrelevant for discard mortality estimates for both gag grouper and greater amberjack.

Citation	Rationale for irrelevant research
Patterson et al. 2012	Primarily reporting hook selectivity for red snapper
Rudershausen et al. 2010	Passive tag-recapture study in North Carolina but did not include gag grouper or greater amberjack
Burns et al. 2008	No discard mortality rate reported. The report simply evaluates tag returns with no consideration of effort.
Bacheler and Buckel 2004	No discard mortality rate reported. Hooking and barotrauma injury rates reported. Circle hooks greatly reduced the number of gut hooking incidents
Burns et al. 2002	No discard mortality rate reported. The report simply evaluates tag returns with no consideration of effort.
Burns and Restrepo 1999	No discard mortality rate reported. Report evaluates tag returns. No consideration of effort. Seasonal returns. Venting vs Non-venting by depth tag returns.
McClellan and Cummings 1997	No applicable, looked at movement only, recapture rate did not adjust for biases in fishing effort across regions over 56 years
Wilson and Burns 1996	No discard mortality rate reported. The project did not account for regional or annual variation in effort
Moe 1972	Does not report any data, just a review of movement study
Moe 1966	No discard mortality rate reported