

# Intertidal Fixed Stake Net Trap (Hadrach) Fishery in Kuwait: Distribution, Catch Rate and Species Composition

Ali F. Al-Baz, Mohsen M. Al-Husaini, James M. Bishop

**Abstract**—Intertidal fixed stake net trap (Hadrach) is one of the oldest fishing gears used throughout the Arabian Gulf countries since the 1800s and also one of the most efficient methods of capturing fish from the intertidal area. This study describes the hadrach fishery in Kuwait.

From October 2001 to December 2002, more than 37,372 specimens representing 95 species (89 fish, 2 mollusks and 4 crustaceans) were measured from hadrach, located in three different areas along Kuwait's coast. In Kuwait Bay, catch rates averaged 62 kg/sir-day (from 14 kg/sir-day in February to 160 kg/sir-day in October 2002). Commercial species accounted for 41% of the catches. Catches from Failakah Island averaged 96 kg/sir-day from June to September, with 61% of the catch being commercial species. In the southern area, catches averaged only 32 kg/sir-day and only 34% were commercially important.

Forty percent of the hadrach catches were juveniles, which shows that Kuwait's shallow intertidal waters, particularly in Kuwait Bay, served as prime nursery habitat. To maintain ecosystem biodiversity and recruitment success of the fishes, we recommended that all hadrach should be removed from Kuwait Bay. In the future, removal of hadrach from other locations should be considered.

**Keywords**—Catch and effort, Hadrach, Intertidal Fixed stake net, Kuwait, Species composition.

## I. INTRODUCTION

THE intertidal stake trap, locally called *hadrach*, is one of the oldest fishing gears used in the Arabian Gulf countries [1]. It is also one of the most efficient methods of capturing fish from the intertidal area. Hadrachs are made of three parts: the fence, known as the *yad* is placed perpendicular to the shore and leads into the *hawsh*, a gathering corral, which in turn leads into the *sir*, the final catchment area or pocket located at or just below the low tide mark [2]. Where conditions permit, a single hadrach in Kuwait is often constructed of two units, i.e., from the beach to the subtidal water, it consists of a *yad*, a *hawsh*, and a *sir*, followed by another *yad*, *hawsh*, and *sir*. So there is a landward *sir* and a seaward *sir*. Intertidal stake traps fish passively as they rely on the tidal ebb and flood to operate, and with Kuwait's mixed

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semi-diurnal tides, it can be used to fish twice daily. The traditional materials used to construct hadrach in the Arabian Gulf consisted of the rachides of date palm (*Phoenix dactylifera*) fronds or reeds (*Phragmites australis*) bound with *assu*, a rope woven from fibers of the stalk supporting the palm fruit [3]-[7]. Today, hadrach are constructed using wire fencing, with a mesh of 19 to 25 mm, supported by bamboo poles [2]. To be effective, hadrach are located on a gradually sloping bottom with a tidal range of 1½ m or more [2].

Because of their location, hadrach capture fish that are usually littoral species. Abou-Seedo [8] reported that hadrach in Kuwait Bay captured a total of 76 species, representing 36 families. Four species accounted for over 60 % of the total catch for the years 1982 through 1984. These four species were Klunzinger's mullet (*Liza klunzingeri* on Abou-Seedo's *L. caranata*), bluespot mullet (*Valamugil seheli*), Bloch's gizzard shad (*Nematalosa nasus*), and Hamilton's thryssa (*Thryssa hamiltonii*). Al-Husaini et al. [9] reported that *Pomadasys kakaan* juveniles, a highly valued commercial fish, were also commonly captured by hadrach on Mischan and Failakah Islands, just outside Kuwait Bay.

Kuwait's decreasing landings and increasing environmental awareness, resulting from the oil spill during the 1991 Gulf War, and more recently, the 2001 fish kill in Kuwait Bay, has resulted in a public concern about the negative impacts of hadrach on Kuwait's fish stocks. In order to obtain the necessary data to assess the magnitude of any impact, 15-month study was undertaken. Here, we report the results of that study.

## II. MATERIALS AND METHODS

Kuwait's coastal zone was partitioned into four areas: North, Failakah Island, Middle, and South. The northern area includes Kuwait Bay; Failakah Island is located in the northern area, but outside Kuwait Bay; the middle area encompasses the coast from the south of Kuwait Bay to the city of Fahaheel; and the southern area includes that portion of the coast from the south of Fahaheel to the border with Saudi Arabia. Eight hadrach in three areas were chosen for investigation. These included three in Kuwait Bay, two at Failakah Island, and three from the middle area (Fig. 1). None was selected from the southern area because the coast south of Fahaheel was almost completely occupied by private beach houses.

Each of the eight hadrach had two catchment pockets (*sirs*). From October 2001 to December 2002, the catches of each

hadrah were collected, and the effort was expressed as one day's catch from a single sir, i.e., kg/sir-day. Each sir and hawsh was cleared of fish, crabs, and cuttlefish, and then everything captured after approximately 24 h was considered the catch for that pocket (and hawsh). Catches from each pocket were sorted into five categories: commercial (bony) fishes; non-commercial (bony) fishes; all elasmobranchs (sharks and rays); crustaceans (mostly crabs); and mollusks (cuttlefish and squid). Species identification followed that of Carpenter et al. [10] and FishBase World website [11]. Except for the rays, the total length and the body weight of each fish captured were measured to the nearest 1cm and 1g respectively. Crustaceans and mollusks were only weighed.

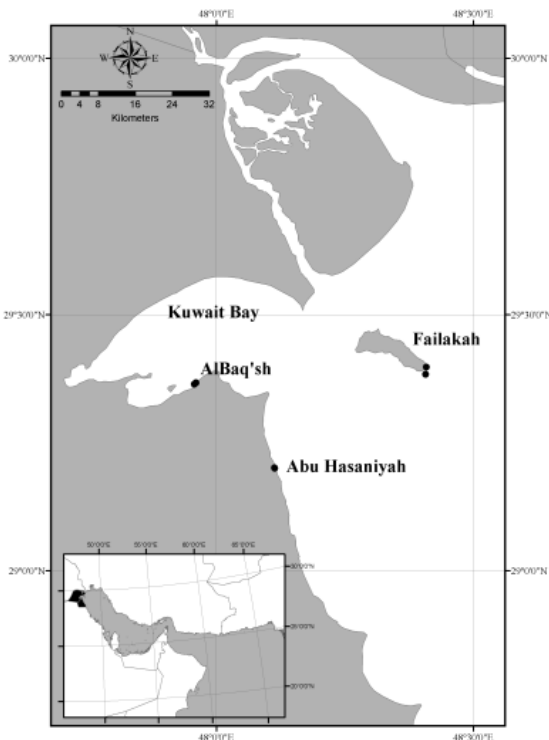


Fig. 1 Kuwait map showing hadrahs sampled from October 2001 to December 2002

Fishing season for hadrahs was determined by their location, which was affected by prevailing winds. For example, hadrahs in Kuwait Bay, which is relatively sheltered from the open sea, were sampled throughout the study period (from October 2001 to December 2002) (Table I). Hadrahs located in areas exposed to the south winds, locally known as the *Sarayah*, however, could not be constructed until after the wave action was reduced. Consequently, hadrahs located at Failakah Island were sampled only from June to September 2002, after which they had to be removed for security purposes. Those in the middle area were fished from October 2001 to February 2002 and again from May to October 2002 (Table I).

TABLE I  
HADRAH LOCATIONS AND MONTHLY NUMBER OF HADRAH SIRs SAMPLED  
FROM OCTOBER 2001 TO DECEMBER 2002

Month	Kuwait Bay	Failakah	Middle Area	Total
Oct-01	7	*	4	11
Nov-01	5	*	4	9
Dec-01	5	*	2	7
Jan-02	10	*	4	14
Feb-02	6	*	1	7
Mar-02	4	*	*	4
Apr-02	12	*	*	12
May-02	15	*	2	17
Jun-02	19	6	11	36
Jul-02	16	8	13	37
Aug-02	8	13	12	33
Sep-02	12	11	19	42
Oct-02	11	**	8	19
Nov-02	14	**	*	14
Dec-02	6	**	*	6
Total	150	38	80	268

\*Hadrahs were not established.

\*\*Hadrahs were removed for security reason during Iraqi military operation.

### III. RESULTS AND DISCUSSION

#### A. Hadrah Distribution

In 2002, 355 licenses for hadrahs were issued in Kuwait (Table II). Of these, 83% (291) were for locations in Kuwait Bay, and 5% (19) were for Failakah and Mischan islands. The remaining 40 licenses were for the locations along the 90-km stretch of the coast south of Kuwait Bay (Table II). Having a hadrah license, however, did not necessarily result in the construction of a hadrah. The Consortium of International Consultants conducted an aerial survey along Kuwait's coast by helicopter in July 2002. The resulting video, which incorporated a geo-reference system, documented a total of 153 active hadrahs. Of this total, 116 (76%) were located in Kuwait Bay, and 18 (12%) were at Failakah, Mischan, and Auha islands. The middle area and southern areas held 9 (6%) and 10 (7%) respectively (Fig. 2). Thus, only 40, 95, 60, and 40% of licensed hadrahs were actually established in Kuwait Bay, Failakah island, middle area, and the southern area, respectively, during the second month of the hadrah fishing season, which started in June 2002. In 1981, 129 hadrahs were used for being fishing in Kuwait waters [12]. Six years later, in 1987, hadrahs numbered 137 with 65 in Kuwait Bay and 24 on Failakah and Mischan islands [13]. So, on average, hadrahs had been increasing at a rate of nearly one per year over the 22-year period from 1981 to 2002.

TABLE II  
THE DISTRIBUTION OF LICENSED AND ESTABLISHED HADRAH ALONG THE  
KUWAITI COAST

Geographical Area	Portion of Coast	Number of Hadrah Established	Number of Hadrah Licensed
Kuwait Bay	Between Ras Al Ardh and Shuwaikh Port	4	21
	Doha Area	93	102
	Aum A'namel	4	13
	From Kazimah to Ras Hummar	14	62
	Khor al Sabiya	1	93
Failakah Island	Failakah Island	2	4
	Mischan Island	15	15
	Auha Island	1	-
Middle Area	Between Ras Al Ardh and Fintas	9	15
Southern Area	From Fahaheel to Nuwaisseb	10	25
<b>Total</b>		<b>153</b>	<b>355</b>



Fig. 2 The current distribution of hadrah along the Kuwaiti shoreline

### B. Catch Rate Trend

We examined 268 hadrah sir catches from October 2001 to December 2002: 150 from Kuwait Bay, 38 from Failakah island, and 80 from the middle region (Table I). To determine if the catches of the landward pocket and those of the seaward pocket differed, the analysis of variance (ANOVA) compared the mean monthly catch rates for each fishing area. None was found to differ significantly (ANOVA,  $P > 0.61$ ,  $P > 0.94$  and  $P > 0.26$  for Kuwait Bay, Failakah Bay, and the middle area, respectively). The catch rates did vary considerably between areas and also within an area between locations. The overall catch rate for each area varied from 32 kg/sir-day for the middle area to 96 kg/sir-day for Failakah island (Tables III to V).

Daily catch rates of Kuwait Bay occurred in three levels:  $>100$  kg/sir-day (October), 60 to 83 kg/sir-day (January, April, May and November), and  $<46$  kg/sir-day (December) (Table III). Commercial fish species dominated the fish catch only from October to November 2001, and January and April 2002, while non-commercial fishes dominated the catches for the remaining months (Table III). Crustaceans were captured every month, but only from October to December 2001, and January, May, and October 2002 did their catch rates exceed 2 kg/sir-day. Mollusks catches peaked in March at 11 kg/sir-day and decreased thereafter to  $<1$  kg/sir-day by September (Table III).

The catch rates of Failakah Island ranged from 49 to 147 kg/sir-day (Table IV). Commercial fishes dominated Failakah catches during the four months samples were available, especially in June and July when they exceeded non-commercial fish catches by 90 to 205% (Table IV). In August and September, commercial fish catches were about equal or only 40 % more than non-commercial fish catches. Other catch categories accounted for 10 % or less of the monthly catch.

In the middle area, monthly catch rates ranged from 15 to 65 kg/sir-day (Table V), and the non-commercial component of the landings accounted for 15 to 98% of the monthly catches. Commercial species dominated the catches in November and May (Table V). Crustacean catch rates tended to be more during the fall months, i.e., September, October and November, with a maximum of 30 kg/sir-day in October 2001 (Table V).

Historically, hadrah catches averaged much higher than reported here. In 1981, daily catches throughout the year averaged 220 kg/sir-day, 63% of which was commercial species (Table V). In 1987 and 1988, daily catch rates averaged 252 and 320 kg/sir-day, and commercial species accounted for 59 and 65% respectively. The overall catch rate for all areas in this study was 54 kg/sir-day, representing an 83% decrease in 14 y. Kuwait's fish landings peaked in 1995 at 8.54 thousand tons. In 2009, the most recent data available, landings totaled 4,706.6 thousand tons, representing a 45% decline. Reasons for this decline were attributed to the decreased flow of the Shatt Al-Arab, which is the northern Gulf's primary source of nutrients and freshwater [14], and along with resuspended sediments from the wave action,

responsible for the northern Gulf's productivity [15]. Dam construction on the Tigris and Euphrates rivers in Turkey resulted in significant reductions of the Shatt Al-Arab discharge and the absence of flood events [16]. Bishop et al. [17] attributed the decline of fish and shrimp landings in Kuwait to the reduced discharge of the Shatt Al-Arab as well as overfishing and destruction of nursery grounds.

TABLE III  
AVERAGE DAILY CATCH RATE (KG/SIR-DAY) BY MONTH FOR KUWAIT BAY AREA HADRAHS FROM OCTOBER 2001 THROUGH DECEMBER 2002

Month	n*	COM	NCM	CRU	MOL	ELA	Total
Oct-01	7	82.1	9.8	8.7	0	0	100.6
Nov-01	5	71.1	5.1	5.6	0	0	81.8
Dec-01	5	7.7	22.5	3.9	1.3	0	35.4
Jan-02	10	44.2	28.9	2.9	7.1	0	83.0
Feb-02	6	2	8.4	1.7	1.5	0	13.6
Mar-02	4	7.6	16.4	0.7	10.9	0	35.6
Apr-02	12	37.3	34.9	1.8	5.8	0.3	80.1
May-02	15	28.3	35.7	3.5	3.1	0.6	71.2
Jun-02	19	14.5	26.1	0.9	1.3	0.2	43.0
Jul-02	16	8.8	23.5	0.5	0.4	0.5	33.7
Aug-02	8	16.1	20.4	1.8	0.2	0.3	38.8
Sep-02	12	13.6	19.5	1.4	0.1	0.5	35.1
Oct-02	11	21	137.9	2.2	1.2	2.2	164.5
Nov-02	14	15.5	53.1	1.3	1.1	0	71.0
Dec-02	6	9.5	35	0.5	0.3	0	45.3
Average	10.0	25.3	31.8	2.5	2.3	0.3	62.2

\*n = number of sir catches processed; COM = commercial (bony) fishes; NCM = non-commercial (bony) fishes; ELA = elasmobranchs; CRU = crustaceans; and MOL = mollusks.

TABLE IV  
MONTHLY CATCH RATE (KG/SIR-DAY) OF THE MAIN CATCH CATEGORIES FOR FAILAKAH ISLAND HADRAHS FROM JUNE TO SEPTEMBER 2002

Month	n	COM	NCM	CRU	MOL	ELA	Total
Jun-02	6	54.4	28.4	1.1	0.1	0.0	84.0
Jul-02	8	72.5	23.7	0.9	0.1	8.0	105.2
Aug-02	13	22.3	20.9	0.5	0.1	5.5	49.3
Sep-02	11	86.0	60.2	0.3	0.5	0.0	146.9
Average	9.4	58.8	33.3	0.7	0.2	3.4	96.3

\*n = number of sir catches processed; COM = commercial (bony) fishes; NCM = non-commercial (bony) fishes; ELA = elasmobranchs; CRU = crustaceans; and MOL = mollusks.

### C. Catch Composition

More than 36,741 fishes, crustaceans, and mollusks representing at least 95 species were identified and recorded from the hadrah catches during the period from October 2001 to December 2002. These 95 species represented 53 families, 16 of which are considered to be commercial. Ten families accounted for 74% of the biomass and 83% of the numerical catches; six of the 10 families were ranked both in biomass and in numerical catches (Fig. 3). Biomass rankings included four families, which were not among the numerical rankings, but the catches of two of the families i.e., crabs and cuttlefish were not enumerated. Unique to the numerical rankings were families with typically abundant species, but individually small in size such as Pristigasteridae, Engraulidae, Teraponidae, and Leiognathidae (Fig. 3).

TABLE V  
MONTHLY CATCH RATE (KG/SIR-DAY) OF THE MAIN CATCH CATEGORIES FOR MIDDLE AREA HADRAHS FROM OCTOBER 2001 TO OCTOBER 2002

Month	n	COM	NCM	CRU	MOL	ELA	Total
Oct-01	4	4.0	6.3	30.0	0.0	0.9	41.2
Nov-01	4	8.9	5.8	5.9	0.8	0.9	22.3
Dec-01	2	9.6	17.7	0.4	0.3	0.0	28.0
Jan-02	4	4.9	8.2	0.4	1.5	0.0	15.0
Feb-02	1	0.2	15.1	0.0	0.0	0.0	15.3
Mar-02	0	--	--	--	--	--	--
Apr-02	0	--	--	--	--	--	--
May-02	2	33.1	9.2	0.8	2.6	0.0	45.7
Jun-02	11	19.8	41.9	0.5	3.1	0.1	65.4
Jul-02	13	9.6	18.1	0.6	0.9	0.0	29.2
Aug-02	12	6.4	22.9	0.9	0.7	0.0	30.9
Sep-02	19	12.0	23.3	1.1	0.7	0.0	37.1
Oct-02	8	3.2	13.4	2.8	1.1	0.3	20.8
Average	7.3	10.2	16.5	3.9	1.1	0.2	31.9

\*n = number of sir catches processed; COM = commercial (bony) fishes; NCM = non-commercial (bony) fishes; ELA = elasmobranchs; CRU = crustaceans; and MOL = mollusks.

Six fish species accounted for 47% of the total numerical catch: onspot seabream (11%), striped piggy (10%), compressed ilisha (7%), Klunzinger's mullet (7%), Talag queenfish (6%), and the orangemouth anchovy (6%) (Fig. 4). However, dominant species differed among areas. Of the 88 fish species captured by hadrah during the study (assuming mixed jacks and rays each representing one species), 80 (91%) were captured from Kuwait Bay. Hadrah in Failaka and the middle area captured 60 (68%) and 62 (70%) of the fish species, respectively. Kuwait Bay species consisted of 78 bony fishes representing 46 families, 1 ray, 1 shark, 4 crustaceans, and 3 mollusks. Nearly 18% of the total numerical fish catch from Kuwait Bay comprised of Sparidae, followed by Carangidae (11%), Mugilidae (11%), Gerreidae (10%), and Haemulidae (10%). Engraulids and clupeids accounted for 7 and 5% respectively, of the Kuwait Bay catch. The most numerically abundant species were onspot seabream (13%), striped piggy (12%), Klunzinger's mullet (10%), talag queenfish (8%), orangemouth anchovy (8%), and the compressed ilisha (8%) (Fig. 4).

Species composition of hadrah catches in Kuwait Bay in 1982, 1983, and 1984 reported by Abo-Seedo [8] differed somewhat from our study. Over the three years of analyzing hadrah catches, Abo-Seedo [8] identified 76 species representing 36 families. Klunzinger's mullet (previously identified as *Liza carinata*) accounted for 35 to 44% of the catch and ranked first numerically, whereas the onspot seabream accounted for only 3% of the catches. Striped piggy accounted for 3 to 8% of the catches in Abo-Seedo's study, whereas this species ranked second in our study. Some of the catch differences may be due to the fishing location as Abo-Seedo analyzed catches from only one hadrah on the northern side of the Doha Peninsula. Additionally, there may be some problems with species identification because Abo-Seedo's study occurred prior to the publication of Carpenter *et al.* [10].

Thw hadrah at Failakah Island captured 59 fish species during the study. Just 4 families accounted for 62% of the

numerical fish catch: Carangidae (26%), Pristigasteridae (14%), Clupeidae (12%), and Engraulidae (9%). The most abundant species among the catches from Failakah Island were compressed ilisha (13%), shrimp scad (11%), talang queenfish (10%), and the orangemouth anchovy (8%) (Fig. 4). These four species contributed to 43 % of the total fish catch from Failakah.

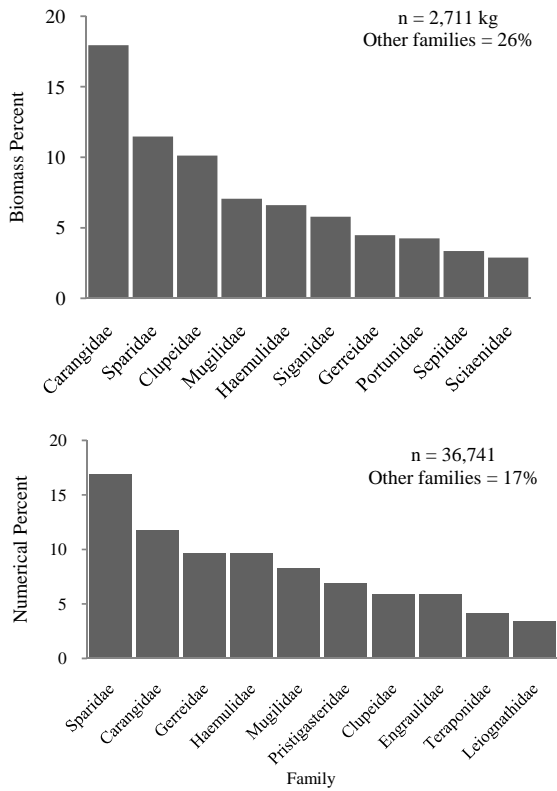


Fig. 3 Percent biomass and numerical abundance for the top 10 families captured by hadrah from October 2002 through December 2003 in Kuwait waters

A total of 62 fish species were caught from the hadrah in the middle area. Nearly 75% of the total catch was represented by six families: Sparidae (24%), Haemulidae (12%), Gerreidae (12%), Siganidae (12%), Carangidae (8%), and Clupeidae (7%). Five species contributed to more than one-half of the total numerical catch: onspot seabream (20%), striped piggy (11%), white-spotted spine foot (11%), and the compressed ilisha (9%) (Fig. 4). The white-spotted spine-foot was only a minor component in catches from Kuwait Bay and Failakah Island hadrahs.

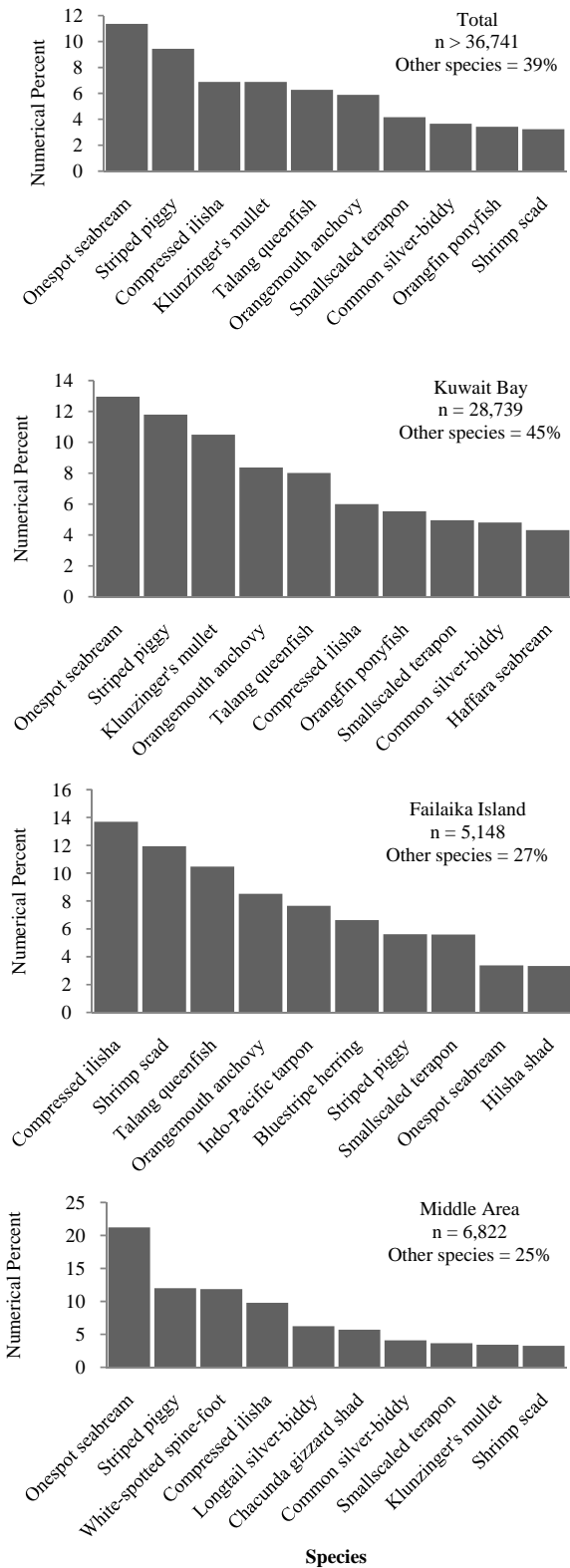


Fig. 4 Numerical abundance (percent) by species for each area for the 10 most common species captured by Hadrah from October 2002 to December 2003. NB: fishing effort differs among areas

## IV. CONCLUSIONS

The results of this study show that Kuwait's shallow coastal waters, particularly those in Kuwait Bay, serve as prime nursery habitats for many commercial as well as non-commercial species. Due to their particular fishing location, all hadrahs in Kuwait cause heavy mortalities on juvenile populations that occupied the shallow, intertidal waters. One of Kuwait's fisheries management strategies is to protect the spawning stock biomass to ensure sufficient progeny for recruitment. This strategy, however, assumes that there are sufficient protected nursery habitats to allow juveniles to grow and survive to adulthood. The effort to reduce juvenile mortality by increasing the mesh size of hadrah was inconclusive due to clogging by algae (mostly *Enteromorpha* sp., [2]), and additional studies should be considered. Hadrah catches analyzed during this study consisted of more than 40% juveniles, which mean hadrahs significantly impact the recruitment of fishes and negatively affect ecosystem biodiversity. Based on this study's recommendations, the Kuwaiti cabinet issued a decree in September 2003 to remove all hadrahs from Kuwait Bay and Khor Al-Sabiyah, two areas considered to be Kuwait's most important nursery grounds. The number of licenses in the remaining areas of Kuwait's coastal waters has been allowed to remain for the present.

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