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Diet, resource partitioning and gear vulnerability of Hawaiian jacks captured in fishing tournaments

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Abstract

Stomach content, capture method and capture location data were collected for 401 carangids captured during three annual 1-day fishing tournaments held at a coastal bay in Hawaii. Blue jack (*Caranx melampygus*), white jack (*Caranx ignobilis*) and island jack (*Carangoides orthogrammus*) were the most common species, accounting for 83.5, 8.5 and 5.2% of tournament catches, respectively. Geographical area fished consisted of a sheltered bay and the adjacent seaward coastal reef beyond. Area of capture and fishing method influenced species and size of fish captured. Small (<350 mm fork length) *C. melampygus* and *C. ignobilis* predominated in catches within the sheltered embayment indicating this may serve as a nursery area for these species. Conversely most *C. orthogrammus* and all large (>500 mm) *C. melampygus* were captured outside Kaneohe Bay. Trolling (towing a surface lure) accounted for 80% of *C. melampygus*, 76% of *C. orthogrammus* and 55% of *C. ignobilis* captured. Differential vulnerability to trolling may be related to interspecific differences in diet; captured *C. melampygus* had fed primarily on fish whereas *C. orthogrammus* had consumed both fish and benthic crustaceans, and *C. ignobilis* had eaten mainly benthic crustaceans. Differences in diet may indicate resource partitioning between these sympatric and closely related species. For *C. melampygus* there was a consistent relationship between prey size and predator size. When conducted under scientific scrutiny, fishing tournaments can provide synoptic data on diet and gear vulnerability that would otherwise be very difficult to obtain. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Carangidae; Diet; Fishing tournament; Capture vulnerability

1. Introduction

The family Carangidae (jacks) contains over 200 species in both temperate and tropical seas worldwide. Jacks are highly valued food and gamefish in Hawaii and elsewhere (Thompson and Munro, 1983; James, 1980; Pitcher and Hart, 1982; Sudekum et al., 1991; Holland et al., 1996) and their numbers in the main Hawaiian islands are considered to have been depleted by fishing (Sudekum et al., 1991). Despite their popularity as gamefish, little is known about the biology and ecology of many jack species. Such information is critical to both understanding the role of jacks in marine communities and for rational management

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of carangid stocks. Previous studies have shown that, as a group, jacks are large, active reef associated predators, which feed on fish, crustaceans and cephalopods (Hobson, 1972, 1974; Potts, 1980; Blaber and Cyrus, 1983; Brewer et al., 1989; Sudekum et al., 1991; Holland et al., 1996; Major, 1978).

Three annual 1-day jack fishing tournaments were held during early autumn (September 9, 25 and October 1) in and around Kaneohe Bay, Oahu (Fig. 1), from 1993 to 1995. The tournaments were specifically designed as an opportunity for anglers to interact with fish biologists in an effort to learn more about the ecology of gamefish of Kaneohe Bay. Fishing effort was provided by several hundred competitors who entered the tournaments on the understanding that all fish captured would be processed at official weigh-in stations to facilitate collection of data. In order to win a prize, all fish captured during the tournament had to be made available for measurement and removal of the gut and gonads. Prizes were awarded by 'lottery' and each fish weighed (regardless of size) resulted in an additional chance to win a prize. This system encouraged weigh-in of all fish, regardless of size or species. The intensive 1-day sampling efforts minimized the effects of temporal variation on the data collected, and provided an opportunity to collect simultaneous data from a variety of sympatric jack species.

Several key dietary and habitat questions were addressed in this study. These included dietary habits of sympatric jacks, effectiveness of different fishing techniques for catching different jacks (gear vulnerability) and the influence of habitat on catch composition.

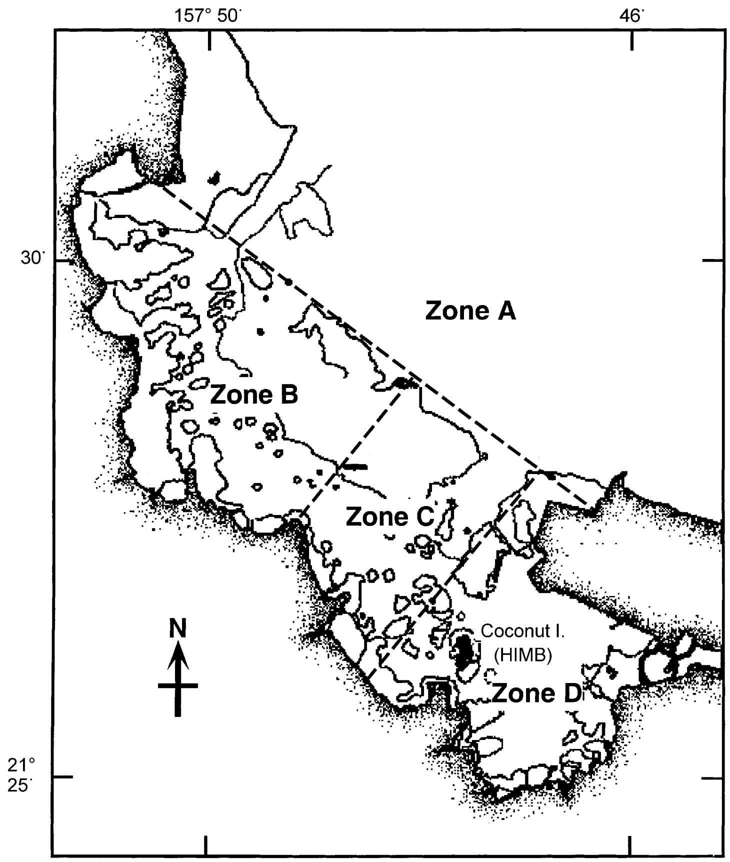

Fig. 1. Kaneohe Bay showing arbitrary fishing tournament zone boundaries (dashed line).

2. Methods and materials

2.1. Study area

Kaneohe Bay (Fig. 1) situated on the northeast coast of Oahu (Hawaii), covers an area of approximately 50 km^2 and is sheltered from the ocean by a barrier reef. The lagoonal habitat inside the barrier reef consists of numerous isolated patch reefs rising to the surface from a 9 to15 m deep mud bottom. Several streams drain into the bay. The southeast end of Kaneohe Bay forms a moderately isolated basin enclosing 20% of the total bay area. Low salinity and high turbidity are typical in this area of the bay. The high-energy outer margin of the barrier reef slopes gently away and at about 18 m gives way to a spur and groove ocean floor.

2.2. Collection of data at tournament weigh-in

Each tournament commenced at 7:00 h and finished with a weigh-in at 15:00 h at the Hawaii Institute of Marine Biology (Coconut Island). Anglers reported the method, area and time of capture for each fish declared at official weigh-in stations. Three methods were used to catch fish in the tournament; trolling (towing a fish or artificial lure through the water behind a boat), whipping (repeated surface casting and rapid retrieval of a small bait or lure) and bottom fishing (dropping a baited hook to the seabed). It was not possible to determine the overall distribution of fishing effort during the tournament because only participants who had caught fish reported to the weigh-in stations. Fish were identified, weighed and measured (fork length in mm), and the viscera (digestive tract, liver and reproductive organs) of each fish were removed and stored individually in labelled plastic bags. Samples were placed on ice for subsequent laboratory examination.

2.3. Laboratory examination of stomach contents

Each stomach was carefully opened and the contents sorted, and identified to the lowest possible taxonomic level. The weight (g), volume (ml) and number of prey items in each category was recorded for each fish. For each jack species and each size class, significance of the various prey items was quantified by using the index of relative importance (IRI) as defined by Pinkas et al. (1971). Dietary overlap of jacks captured during tournaments was evaluated by calculating Pianka's (1973) index of dietary overlap (A_{yz}). The index varies from 1 when diets are identical, to 0 when diets are distinct.

3. Results

3.1. Species composition

A total of 401 jacks were caught during three annual jack fishing tournaments (Table 1). Blue jack (*Caranx melampygus*) predominated in catches, accounting for over 83% of all jacks taken (Table 1). White jack (*Caranx ignobilis*) and island jack (*Carangoides orthogrammus*) were relatively common, accounting for 8.5 and 5.2% of the catch, respectively (Table 1).

Table 1
Summary of numbers and sizes of species captured in Annual Kaneohe Bay Jack Tournaments 1993–1995

Species name	Common name	*N*	% of total catch	Mean FL (mm)	S.D. (mm)	Min. FL (mm)	Max. FL (mm)
C. melampygus	Blue jack	335	83.5	327	±83	161	733
C. ignobilis	White jack	34	8.5	314	±129	150	877
C. orthogrammus	Island jack	21	5.2	304	±78	162	405
Alectis ciliaris	Mirror jack	4	1.0	411	±106	338	570
Scombroides lysan	Leather jacket	3	0.8	420	±73	362	502
Gnathanodon speciosus	Barred jack	2	0.5	414	±26	395	432
Caranx sexfasciatus	Big eye jack	1	0.3	518	–	–	–
Seriola dumerili	Amber jack	1	0.3	847	–	–	–
Total		401					

Five other carangid species captured accounted for nearly 3% of the catch (Table 1).

3.2. Area of capture

To examine distribution of jacks in and around Kaneohe Bay, the bay and surrounding waters were divided into four zones (Fig. 1). Approximately half of all jacks were captured outside the barrier reef of Kaneohe Bay and approximately 40% of jacks were caught inside Kaneohe Bay. Area of capture was not reported for the remaining 10% (Table 2). Significant interspecific differences were found in the numbers of fish captured inside and outside of Kaneohe Bay ($\chi^2 = 20.3$, d.f. 2, $P < 0.001$); 76.5% of all *C. ignobilis* were taken inside Kaneohe Bay, but only 36.1% of *C. melampygus* and 28.6% of *C. orthogrammus* were captured in this area (Table 2).

3.3. Method of capture

Although over 78% of all jacks were caught by trolling (Table 2), this statistic was heavily influenced by the high numbers of troll caught *C. melampygus* and there were significant interspecific differences in the numbers of fish caught by different fishing techniques ($\chi^2 = 11.43$, d.f. 2, $P < 0.01$). For example, although over 80% of *C. melampygus* and over 76% of *C. orthogrammus* were caught by trolling, only 55% of *C. ignobilis* were captured using this technique (Table 2).

3.4. Size composition of jack catches

The majority of the three most common carangid species caught (*C. ignobilis*, *C. melampygus* and *C. orthogrammus*) were between 200 and 450 mm fork length and there were no significant differences in mean sizes of these species (ANOVA, $F_{2,382} = 0.902$, $P > 0.05$). Maximum size varied among species, ranging from 405 mm (*C. orthogrammus*) to 877 mm (*C. ignobilis,* Table 1). Both fishing method and area appeared to influence catch size composition. For *C. melampygus*, mean size of bottom caught fish (399 mm, S.D. $\pm$ 180 mm) was significantly greater than that of troll caught fish (325 mm, S.D. $\pm$ 73 mm) ($t = 1.79$, d.f. 18, $P < 0.05$) and mean size of troll caught fish was significantly greater than that of fish caught by whipping (247 mm, S.D. $\pm$ 42 mm) ($t = -3.99$, d.f. 4, $P < 0.01$). Thus, there was a hierarchy of size of fish caught by different methods, possibly because of different lure or bait sizes.

Large *C. melampygus* (>500 mm) were only captured outside Kaneohe Bay and the mean size of *C. melampygus* caught outside Kaneohe Bay (347 mm, S.D. $\pm$ 9.4 mm) was significantly greater ($t = 5.61$, d.f. 299, $P < 0.01$) than mean size of *C. melampygus* caught inside the bay (297 mm, S.D. $\pm$ 59 mm). Within Kaneohe Bay, mean size of *C. melampygus* captured in the south end of the bay (zone D) (272 mm, S.D. $\pm$ 53 mm) was significantly smaller than that elsewhere in the bay ($t = 2.82$, d.f. 48, $P < 0.01$). Thus there was a gradient of sizes depending on area,

Table 2
Summary of pooled 1993–1995 jack catches by area of capture (inside or outside Kaneohe Bay, unknown) and by fishing method (trolling or other methods)[a]

Species	% inside the bay	% outside the bay	% area unknown	% caught trolling	% caught by other methods[b]
A. ciliaris	25 (1)	75 (4)	0	100 (4)	0
C. ignobilis	76.5 (26)	17.6 (6)	5.9 (2)	55.9 (19)	44.1 (15)
C. melampygus	36.1 (121)	54.3 (182)	9.6 (32)	80.9 (273)	19.1 (65)
C. orthogrammus	28.6 (6)	71.4 (15)	0	76.2 (16)	23.8 (5)
C. sexfasciatus	0	100 (1)	0	100 (1)	0
G. speciosus	0	100 (2)	0	0	100 (2)
S. lysan	66.7 (2)	33.3 (1)	0	0	100 (3)
Seriola dumerili	0	100 (1)	0	100 (1)	0
All jacks	38.9 (156)	52.6 (211)	8.5 (34)	78.3 (314)	21.7 (87)

[a] Numerical equivalents are given in parentheses.
[b] Other methods include bottom fishing, whipping and method unknown.

the smallest coming from the most sheltered area, the largest from the most exposed area.

3.5. Diet

Of 335 *C. melampygus* stomachs examined, 264 (78.8%) contained prey items identifiable to some taxonomic level (Table 3). Of the 264 *C. melampygus* stomachs with prey, 86.3% contained the remains of fish (Table 3). A total of 14 families of fish were positively identified in stomach contents. Wrasses (Labridae) were the most common family of fish, occurring in 14.1% of stomachs. Parrotfish (Scaridae), goatfish (Mullidae), blennies (Blennidae), gobies (Gobidae), lizardfish (Synodontidae) and damselfishes (Pomacentridae) were also common components of *C. melampygus* diet. Crustaceans (alphaeid shrimps, stomatopods and crabs) occurred in 22.7% of stomachs with identifiable prey, but accounted for only 4% of total prey volume. Cephalopods were a minor component of *C. melampygus* diet, occurring in only 1.6% of all stomachs with prey, and accounting for <1% of total prey volume. Comparison of stomach contents of *C. melampygus* above and below minimum size of maturity (350 mm standard length; Sudekum et al., 1991) revealed a significant decrease in the frequency of stomachs containing crustacean prey in mature fish ($\chi^2 = 116.7$, d.f. 1, $P < 0.001$); 28.8% of immature *C. melampygus* stomachs contained crustacean prey compared to 9.1% of adult stomachs.

Table 3
Summary of stomach content analysis for *C. melampygus* based on 264 specimens containing prey identifiable to some taxonomic level[a]

Prey item	Numerical (%)	Volume (%)	Frequency (%)	% of summed IRI
Fish	*65.14*	*95.29*	*86.33*	*94.11*
Labridae (*Thalassoma duperrey*)	9.16	22.18	14.08	28.05
Scaridae	6.87	15.76	9.86	14.18
Mullidae (*Mulloides flavolineatus*)	3.82	8.1	7.04	5.33
Blennidae	3.82	7.39	6.34	4.51
Synodontidae	3.05	7.31	4.93	3.25
Gobidae	4.58	1.17	7.75	2.83
Pomacentridae	2.67	9.94	3.59	2.22
Dascyllus albisella	[2.29]	[6.95]	[3.52]	[2.07]
Abudefduf abdominalis	[0.38]	[2.99]	[0.7]	[0.15]
Acanthuridae	1.53	7.49	2.82	1.61
Chaetodontidae	0.76	8.38	1.41	0.82
Scorpaenidae	1.53	1.32	2.11	0.38
Clupeidae (*Spratelloides delicatulus*)	2.67	1.02	1.41	0.33
Sphyraenidae	0.38	2.4	0.7	0.12
Unidentified eels	0.76	0.12	1.41	0.08
Cirrhitidae	0.38	0.9	0.7	0.06
Fistulariidae	0.38	0.02	0.7	0.02
Unidentified fish	(*42.86*)	(*42.7*)	(*64.45*)	(*91.78*)
Crustaceans	*34.1*	*4.09*	*22.66*	*5.88*
Alphaeid shrimp	37.79	0.73	8.45	20.68
Stomatopods	9.92	3.13	9.86	8.18
Crabs	4.19	0.77	7.42	0.18
Pachygrapsus sp.	[0.76]	[0.18]	[1.41]	[0.08]
Charybdis japonica	[7.63]	[1.29]	[11.97]	[6.78]
Unidentified crustacean	(*1.14*)	(*0.09*)	(*2.34*)	(*0.05*)
Cephalopods	*0.76*	*0.61*	*1.56*	*0.01*
Octopus	1.53	1.17	2.82	0.48

[a] At the highest systematic level of analysis, unidentified fish were included in the total number of prey individuals. Unidentified fish and unidentified crustaceans were not included in any analysis at lower taxonomic levels. Percentages for a few identifiable species appear within brackets [].

Table 4
Summary of stomach content analysis for *C. ignobilis* based on 19 specimens containing prey identifiable to some taxonomic level[a]

Prey item	Numerical (%)	Volume (%)	Frequency (%)	% of summed IRI
Fish	*13.16*	*7.31*	*22.22*	*2.78*
Blennidae	3.23	2.79	7.14	0.63
Unidentified fish	(*10.53*)	(*4.76*)	(*16.67*)	(*1.56*)
Crustaceans	*86.84*	*91.84*	*88.89*	*97.22*
Stomatopods	12.9	8.83	14.29	4.57
Unidentified shrimp	(*7.89*)	(*2.97*)	(*16.67*)	(*1.11*)
Crabs				
Portunus sanguinolentus	[3.23]	[51.12]	[7.14]	[5.71]
Portunus japonicas	[1.29]	[24.72]	[57.14]	[72.32]
Pachygrapsus sp.	[19.35]	[12.55]	[35.71]	[16.77]

[a] At the highest systematic level of analysis, unidentified fish were included in the total number of prey individuals. Unidentified fish and unidentified crustaceans were not included in any analysis at lower taxonomic levels. Percentages for a few identifiable species appear within brackets [].

Nineteen (55.9%) of 34 *C. ignobilis* stomachs examined contained prey (Table 4). Crustaceans (crabs, stomatopods and shrimp) were the most common prey group occurring in 88.9% of stomachs with prey. Crabs were the most common prey item, occurring in two thirds of stomachs with prey. Fish occurred in only 22.2% of *C. ignobilis* stomachs and accounted for only 7.3% of total prey volume. Blennidae were the only identifiable fish family, occurring in 7.14% of stomachs with prey identifiable to family level.

Eighteen (94.1%) of 21 *C. orthogrammus* stomachs contained prey (Table 5). Crustaceans were the most common prey group occurring in 94.1% of stomachs with prey. Crabs and stomatopods were the most common crustacean prey, occurring in 60 and 40% of stomachs, respectively. Alphaeid shrimp were a minor component of diet occurring in 17.6% of stomachs but accounting for only 2.2% of prey volume. Fish were also common *C. orthogrammus* prey occurring in 41.2% of stomachs, and accounting for 21.5%

Table 5
Summary of stomach content analysis for *C. orthogrammus* based on 18 specimens containing prey identifiable to some taxonomic level[a]

Prey item	Numerical (%)	Volume (%)	Frequency (%)	% of summed IRI
Fish	*32.35*	*21.54*	*41.18*	*14.64*
Gobidae	25.00	6.75	20.00	8.64
Dactyloptera orientalis	[3.57]	[0.89]	[13.33]	[0.81]
Scorpaenidae	1.79	4.44	6.67	0.56
Unidentified eels	3.57	1.78	6.67	0.49
Synodontidae	1.79	3.55	6.67	0.48
Unidentified fish	(*2.94*)	(*6.13*)	(*17.65*)	(*1.06*)
Crustaceans	*64.71*	*71.54*	*94.12*	*84.59*
Stomatopods	33.93	53.11	40.00	47.38
Unidentified shrimp	10.29	2.20	7.65	1.45
Crab (*C. japonica*)	[26.79]	[21.67]	[60.00]	[39.57]
Unidentified crustacean	4.41	3.14	17.65	0.88
Cephalopods	*2.94*	*6.92*	*11.76*	*0.77*
Octopus	3.57	7.82	13.33	2.07

[a] At the highest systematic level of analysis, unidentified fish were included in the total number of prey individuals. Unidentified fish and unidentified crustaceans were not included in any analysis at lower taxonomic levels. Percentages for identifiable species appear within brackets [].

of prey volume. Five families of fish (Gobidae, Dactylopteridae, Scorpaenidae, Synodontidae, unidentified eels) were identified in stomach contents. The Gobidae and Dactylopteridae were the two fish families most commonly found in *C. orthogrammus* stomachs. Cephalopods (octopus) occurred in 11.8% of *C. orthogrammus* stomachs and accounted for 6.9% of total prey volume.

The Pianka (1973) index of overlap was used to measure the degree of similarity in the diets of *C. melampygus*, *C. ignobilis* and *C. orthogrammus*. The index was calculated from the proportional IRI (% summed IRI) of the major prey groups in each of the species. Dietary overlap between *C. melampygus* and *C. ignobilis*, and *C. melampygus* and *C. orthogrammus* was minor ($A_{yz} = 0.2$ and 0.23, respectively). Diets of *C. orthogrammus* and *C. ignobilis* were almost identical ($A_{yz} = 0.99$) when Pianka's index was calculated from proportional IRI of major prey groups (cephalopods, crustaceans and fish). However, closer examination revealed no overlap in fish families consumed by *C. orthogrammus* and *C. ignobilis,* and there were significant interspecific differences in numbers of stomachs containing crabs, stomatopods and shrimps ($\chi^2 = 5.07$, d.f. $= 1$, $P < 0.05$).

3.6. Prey size vs. predator size

The relationship between predator size and prey size was determined for *C. melampygus*, *C. ignobilis* and *C. orthogrammus* by calculating the mean intact (i.e. minimally digested) prey item weight in each stomach examined, and comparing this mean prey weight with the total weight of the fish from which the stomach was removed (Fig. 2). Highly significant positive correlations between predator weight and mean prey weight existed for *C. melampygus* ($r = 0.77$, $P < 0.001$). However, no significant correlation between predator weight and mean prey weight was observed for *C. ignobilis* ($r = 0.37$, $P > 0.5$) or *C. orthogrammus* ($r = -0.11$, $P > 0.5$). A linear regression fitted to data for *C. melampygus* (Fig. 2) suggested that the relationship between prey weight and predator weight was fairly constant ($r^2 = 0.59$, $P < 0.001$), with this species typically consuming individual prey equivalent to approximately 0.7% of their total body weight.

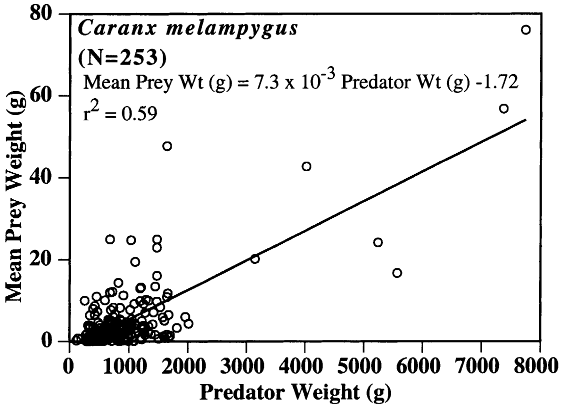

Fig. 2. Relationship between mean prey weight and predator weight for *C. melampygus* caught during annual Kaneohe Bay jack fishing tournaments 1993–1995.

4. Discussion

The three Kaneohe Bay jack fishing tournaments integrated sport fishing with scientific data collection and provided mutual benefits to both competitors and researchers. The tournaments provided an opportunity for local fishermen to contribute to scientific study of highly valued food and game fishes, and to interact with scientists. Competitors captured 401 jacks from a variety of habitats in only 3 days, providing quantities of synoptic data that would be difficult for scientific researchers to collect independently in the same time period. The distribution of fishing effort during tournaments was not quantified and this makes interpretation of some aspects of the data (for example, differences in species abundance by habitat type) more difficult. A better quantification of effort should be made in future events. Nevertheless, certain aspects (diet, distribution and gear vulnerability) were probably independent of fishing effort.

C. melampygus accounted for over 80% of all jacks caught in tournaments. The two next most common carangid species (*C. ignobilis* and *C. orthogrammus*) were 10 times less common than *C. melampygus*. Dominance of *C. melampygus* in catches may reflect either a greater abundance of this species, or greater vulnerability to fishing methods used in the tournaments (or a combination of both these factors). The importance of fish as prey items for *C. melampygus* may indicate that this species is more vulnerable to trolled lures than are *C. orthogrammus* or *C. ignobilis*, which feed mainly on benthic crustaceans.

The size range of trolled lures and baits may have contributed to the fairly uniform size of *C. melampygus* captured because stomach content data for this species suggest a consistent relationship between predator size and the size of prey item selected. In a previous study, Potts (1980) noted that at Aldabra Atoll (Indian Ocean) a positive correlation existed between the length of a hunting *C. melampygus* and the size of prey that made an avoidance reaction to it. Prey size preference probably explains why *C. melampygus* caught by bottom fishing with large fish baits were significantly larger than those taken by trolling, and troll caught fish were significantly larger than those taken by whipping (which typically employs the smallest lure sizes).

Geographical area apparently influenced species and size composition of catches. Although distribution of fishing effort was not known, the total carangid catch was approximately evenly distributed inside and outside the Kaneohe Bay barrier reef. Most of the small (<350 mm) *C. ignobilis* (76%) were captured inside Kaneohe Bay, whereas the majority (71%) of *C. orthogrammus* taken were captured outside the Bay. Large (>500 mm) *C. melampygus* were only captured outside Kaneohe Bay and those caught at the south end of Kaneohe Bay were significantly smaller than those caught elsewhere. These results suggest that areas of Kaneohe Bay may serve as nursery grounds for juvenile *C. ignobilis* and *C. melampygus*, and that there are size differences even within the bay. The environment in Kaneohe Bay (sheltered, high turbidity, relatively low salinity with patch reefs and fringing mangroves) is markedly different to that outside the barrier reef and is possibly similar to estuarine environments favoured by juvenile *C. ignobilis* and *C. melampygus* elsewhere in the Indo-Pacific region (Blaber and Cyrus, 1983). However, uneven distribution of different types of fishing effort (i.e. trolling, whipping and bottom fishing) within the fished area during the tournament and historically high fishing effort inside Kaneohe Bay could also have influenced the size of fish captured in the different areas. For example, *C. melampygus* caught and measured in the Coconut Island marine refuge, which lies within Kaneohe Bay (but where little or no fishing mortality occurs), cover a wide range of sizes, including large adult fish not seen in tournament catches from inside Kaneohe Bay (Holland et al., 1996).

Fish and crustaceans were the most important prey for jacks captured in tournaments but relative importance of these prey varied significantly between species. For example, the tournament data indicate *C. melampygus* eat mainly fish, while *C. ignobilis* and *C. orthogrammus* eat mainly crustaceans. Dietary overlap between *C. melampygus* and the latter two species was low ($A_{yz} = 0.20$ and 0.23, respectively). These findings contrast with those of Sudekum et al. (1991) who found that both *C. melampygus* and *C. ignobilis* in the north western Hawaiian Islands (NWHI) were >90% piscivorous, with a dietary overlap of 0.42. Although diets of *C. ignobilis* and *C. orthogrammus* were superficially almost identical ($A_{yz} = 0.99$), closer examination of diet showed significant differences in importance of different crustacean prey and no overlap in fish species consumed. In view of the fact that all jacks were captured from the same areas on the same 3 days, differences in diet strongly suggests interspecific resource partitioning.

Dietary data obtained from tournament catches also indicated an ontogenetic shift away from consumption of crustaceans in *C. melampygus*. Similarly, Sudekum et al. (1991) found that the importance of crustacean prey in the diet decreased with increasing *C. melampygus* size in the NWHI. Blaber and Cyrus (1983) noted an ontogenetic change in diet from crustaceans to teleosts for *C. melampygus*, *Caranx papuensis* and *Scomberoides lysan* in South Africa and a similar ontogenetic dietary shift has been observed in *Caranx bucculentus* in the Gulf of Carpentaria (Brewer et al., 1989).

Fishing tournaments have previously been used opportunistically by researchers to acquire scientific information (e.g. Holland et al., 1990). The results reported here show that when the tournaments are specifically designed around scientific objectives, they can provide a variety of high quality data that would be otherwise very difficult to obtain. The tournaments also provide an opportunity for resource users to participate in data collection and to interact with the scientific community. For these reasons, it may be useful to expand use of angling tournaments as methods for improving resource management.

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