Round Goby (*Neogobius melanostomus*) Distribution in the Illinois Waterway System of Metropolitan Chicago

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ABSTRACT

There is concern that the range of the round goby (*Neogobius melanostomus*), a nonindigenous fish recently introduced to the Great Lakes drainage basin from Eurasia, may expand to other drainage basins with adverse ecologic consequences. The Illinois Waterway System (IWS) connects the Great Lakes and Mississippi River basins and facilitated the spread of another exotic nuisance species, the zebra mussel (*Dreissena polymorpha*), to several environmentally sensitive drainages of interior North America earlier this decade. We surveyed the distribution of round goby in a portion of the IWS near metropolitan Chicago in autumn 1996 with traps, seines, trawls, set lines, and by angling. A total of 61 round goby were captured in the Little Calumet River in south Chicago at locations upstream of river mile 321.4 (12 miles inland from Lake Michigan). No round goby were captured at sites in connecting channels downstream of this point as far away as Joliet (river mile 283). Bottom trawling, particularly over rocky substrates, was the most successful means of capturing round goby and accounted for 87% of the total catch. Goby captured by trawling were significantly smaller than those captured by other gears and significantly smaller goby were captured at the sampling site furthest upstream. The length frequency distribution of the round goby we captured suggested the presence of fish from the three most recent year classes (1994-1996). The rocky substrate preferred by round goby may be less common in a short reach of the Little Calumet River downstream of river mile 321. Despite this potential habitat deficiency, population growth and human interventions are soon likely to expand the range of the round goby in the IWS.

INTRODUCTION

Ports around the Great Lakes have increasingly become major North American points of entry for several exotic aquatic species in recent years. These invasive species represent several different taxa and trophic levels of the aquatic ecosystem and include species such as the spiny water flea (*Bythotrephes cederstroemi*), the zebra mussel (*Dreissena polymorpha*), and the ruffe (*Gymnocephalus cernua*). Most of these immigrants are native to Eurasia and are presumed to have been initially introduced during the 1980s as a result of unregulated ballast water exchange procedures (Mills et al. 1993). The proliferation of some of these organisms has resulted in adverse ecologic and economic consequences in portions of the Great Lakes region (Griffiths et al. 1989; Mackie 1991). As these unwelcome organisms become more abundant and widely distributed in the Great Lakes region, it is increasingly likely that some will expand their range to suitable portions of other interior drainage basins.

The Illinois Waterway System (IWS; Fig. 1) near Chicago provides a direct connection for the continuous transfer of water from Lake Michigan to the Mississippi River and is presumed responsible for the transmission of zebra mussels to the Mississippi River drainage basin earlier this decade. Many portions of the Mississippi River are now inhabited by zebra mussels (Tucker et al. 1993) and facilitate the distribution of this exotic mollusk to vulnerable sub-basins between the Appalachian and Rocky mountain ranges (Strayer 1991).

The round goby (*Neogobius melanostomus*) is yet another recently introduced aquatic nuisance species that is poised to follow the path of the zebra mussel from the Great Lakes to the interior of North America. The round goby was initially observed in the United States in 1990 in the St. Clair River near Detroit (Jude et al. 1992). By 1995 it had spread to several distant portions of the Great Lakes including Duluth, Cleveland, and Chicago (Marsden et al. 1996). This sedentary benthic

fish resembles a sculpin in its general appearance and certain behavioral traits and may be displacing mottled sculpin (*Cottus bairdi*), deepwater sculpin (*Myoxcephalus thompsoni*), and logperch (*Percina caprodes*) populations from optimal spawning and feeding habitats at some Great Lakes locations (Jude et al. 1995). Lotic populations of native benthic fishes (e.g., cyprinids, darters, sturgeons) could also be adversely impacted should the round goby expand its range to sensitive interior drainages.

The round goby can be readily identified by its fused pelvic fins that form a suction disk on the ventral surface. They also have an abundance of superficial neuromasts that likely aid in detecting prey items at low light intensities (Jude et al. 1995). Round goby are aggressive and will feed on a variety of benthic fauna including small fish, fish eggs, and invertebrates (Marsden et al. 1996). Moreover, they possess robust upper and lower pharyngeal teeth that permit them to eat small mollusks including zebra mussels (Ghedotti et al. 1995) that can concentrate certain contaminants. Round goby are preyed upon by several sport fish species (Jude et al. 1995) and therefore may represent a new link in the transfer of benthic contaminants to higher trophic levels.

Recent surveys by other investigators (Dennison 1996; Manz 1996; Siegart 1996) as well as anecdotal information from sport anglers suggested round goby were entering the IWS from Lake Michigan exclusively via the Calumet River drainage. However, the downstream extent of round goby distribution in the IWS was uncertain. Concern for adverse impacts that could result from the introduction of round goby to the Mississippi River and other interior drainages led the U.S. Fish and Wildlife Service to assess the downstream extent of round goby distribution in this portion of the IWS near Chicago in mid-autumn 1996. This baseline information is necessary to enact and assess the success of management strategies designed to prevent or diminish the spread of this aquatic nuisance species.

STUDY AREA

The study area included portions of four interconnected drainages in the metropolitan Chicago region of the IWS: the Little Calumet River, the Calumet Sag Channel, the Ship and Sanitary Canal, and the Des Plaines River (Fig. 1). Sampling was conducted at 27 sites in the Little Calumet River between river mile (RM) 326.2 and 319.6, 23 sites in the Calumet Sag Channel between RM 319.6 and 311.0, 3 sites in the Ship and Sanitary Canal between RM 290.8 and 290.2, and 25 sites in the Des Plaines River between RM 290.2 and 283.2.

METHODS

Several gears were used at different levels of effort to capture round goby over a 5 d sampling period (Table 1). These included minnow traps (20 mm diameter entrance x 6 mm bar wire mesh), collapsible Windermere traps (Edwards et al. 1996), set lines (6, 15, or 30 m braided cotton lines with a 20-30 cm monofilament leader and baited #10 or #12 hook every 0.5 m), shoreline seining (5.3 m x 1.1 m x 3 mm bar nylon mesh), bottom trawling (3.1 x 0.9 m, 19 mm bar nylon mesh body and 15 mm bar nylon mesh cod), and shoreline angling (baited #10 hook). Minnow traps and angling were used at certain sites in all four drainages. Windermere traps and set lines were used at several sites in all but the Ship and Sanitary Canal. Seining was conducted at suitable sites in the Calumet Sag Channel and Des Plaines River while bottom trawling occurred in portions of the Calumet Sag Channel and Little Calumet River.

Nearly 41% of the total hourly effort occurred in the Little Calumet River (mean 177 hr/mi), followed by 31% in the Des Plaines River (mean 131 hr/mi), 26% in the Calumet Sag Channel (mean 90 hr/mi), and 2% in the Ship and Sanitary Canal (mean 86 hr/mi; Fig. 2). Sampling effort with most

gears was concentrated near littoral areas (i.e., outside the channel thalweg), particularly near shoreline outcroppings of rock that could provide suitable habitat for round goby. The river mile location of sampling sites was estimated from navigation charts.

Round goby were measured for total length (TL) and placed in jars containing 70% ethyl alcohol as archival specimens. Length frequency data were plotted to assess the relative abundance of different year classes. Length data were also evaluated by one-way analysis of variance (ANOVA) to assess differences in the size of fish captured due to gear selectivity and sample location. Significant differences ($p < 0.05$) in fish length among the various gears and sample sites were further evaluated by the Bonferroni method of pairwise comparisons ($\alpha = 0.05$).

RESULTS

We captured twenty-five species of fish representing nine families in 2900 hr of sampling effort in the IWS (Table 2). This included a total of 61 round goby caught in south Chicago at sites along the Little Calumet River between RM 326.2 and 321.4 (Fig. 1). No round goby were captured at sites in connecting channels downstream of this point as far away as Joliet (RM 283).

Bottom trawling was the most effective sampling gear. Round goby were collected in three of the four trawls from the upper reach of the Little Calumet River (RM 322.9-326.2) and in one of the three trawls from the lower reach (RM 319.6-322.9). These four successful trawls accounted for 87% of the total round goby catch for the week (Fig. 3). Other gears that captured round goby with less success included set lines (8%), angling (3%), and Windermere traps (2%). Trawling in the Little Calumet River produced the greatest mean catch per unit effort (76/hr or 1.3/min), followed by angling (0.14/hr), set lines (0.02/hr), and Windermere traps (0.002/hr). Catch per unit effort for successful trawls in the Little Calumet River ranged up to 5.2/min at the most upstream sample site (near the

O'Brien Lock and Dam) and decreased incrementally to 0.2/min at the furthest downstream site (Fig. 4).

The length frequency distribution indicated round goby from the 1994-96 year classes inhabit portions of the Little Calumet River (Fig. 5). Young-of-year and age 1 fish were estimated to account for about 95% of the round goby catch. An apparent break in the size of the 1996 (young-of-year) and 1995 (age 1) year classes occurred between 56 and 60 mm TL. However, the extent of size overlap between these classes may range from 46 to 65 mm TL. Most age 1 fish appeared to range in size from 70 to 90 mm TL although certain individuals may have been up to 110 mm TL. The 1994 (age 2) year class accounted for the small number of remaining fish and ranged in size from 121 to 140 mm TL.

Statistical analyses indicated that round goby captured at the most upstream sampling site (RM 326.2) were significantly smaller than those captured elsewhere (Table 3). However, round goby caught by bottom trawling were significantly smaller than those caught with any other gear (Fig. 6). Moreover, only a small number of round goby were captured by means other than trawling at any site (Table 4). Therefore, we also evaluated the spatial relationship for the length of round goby caught only by trawling to reduce the confounding effect caused by the size selectivity of this gear. This approach still indicated that fish captured at the most upstream site near the O'Brien Lock were significantly smaller than those caught elsewhere (Fig. 7).

DISCUSSION

The areas we sampled in the IWS of metropolitan Chicago represent some of those closest to the source population of round goby in Lake Michigan. Although bottom trawling was conducted in portions of only the Little Calumet River and Calumet Sag Channel study areas, it was used at more sites throughout these areas and was much more successful in capturing round goby than any other gear.

Other investigators have likewise found bottom trawling to be an effective means of capturing round goby (Jude et al. 1992, Ghedotti et al. 1995), particularly at night when the fish may feed more actively (Jude 1996). The marked decrease in the trawl catch from RM 326.2 to 321.8 indicates that round goby abundance declined rapidly within 7-12 mi of their origin in Lake Michigan. Moreover, our inability to capture this species by any means downstream of RM 321.4 suggests that the distribution of round goby in the IWS probably did not extend far beyond RM 321 of the Little Calumet River in 1996.

The passive sampling gears we deployed were the least effective means of capturing round goby. A portion of this gear inadequacy was due to the loss of several traps in narrow shipping channels. However, the aggressive territorial behavior of the round goby was likely a more important factor. In addition, the entrance to the Windermere trap was 10 cm above its base and may have been beyond the benthic microhabitat range preferred by this species. Moreover, the mesh size may have been too large to retain all but the largest round goby encountered (the only specimen we trapped was 110 mm TL). Modifications to the traps such as the addition of an appropriate bait, a smaller mesh size, and an entrance located closer to the base of the trap could perhaps increase the vulnerability of round goby to these passive gears. Traps that incorporate different combinations of these and other appropriate modifications could be deployed at sites within the known range of the fish in future surveys to determine an optimum passive sampling strategy for round goby in the IWS.

Reports of anglers who incidentally catch round goby along portions of the Lake Michigan shoreline near Chicago are common. We therefore thought the use of baited hooks near shore could be an effective means of sampling round goby in the IWS. A substantial proportion of the total set line and angling efforts (50% and 23%, respectively) occurred in the Little Calumet River downstream of RM 323.7 (where bottom trawling indicated a declining abundance of goby) and accounted for 11% of the

total catch. Our ability to catch round goby with baited hooks in this reach could perhaps have been improved by the consistent use of smaller hooks (e.g., #12 or #14) and stronger set lines (e.g., braided nylon). Moreover, sampling with set lines and by angling would likely be more effective during the summer than in autumn when warmer water temperatures would promote increased feeding activity.

Round goby prefer to reside among macrophytes or rocky substrate in littoral areas (Jude et al. 1992, Jude et al. 1995) but are not restricted to these habitats (Jude and DeBoe 1996). No macrophyte beds were present during this mid-autumn survey and most trawls that successfully captured round goby also contained rocky debris. Moreover, our trawl results and shoreline observations suggested that the rocky substrate favored by round goby may be less common over a short reach (about 1 mile) of the Little Calumet River downstream of RM 321. However, population growth and human interventions are soon likely to promote the continued range expansion of round goby in the IWS. Refinement of sampling techniques and continued monitoring of the distribution of round goby in the IWS is needed to enact appropriate management strategies in a prompt and precise manner to help control the North American distribution of this exotic nuisance species.

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Table 1. Total hours of standardized sampling effort for gears used to collect round goby in drainages of the Illinois Waterway System near metropolitan Chicago, 28 October - 1 November 1996.

Gear	Drainage			
	Little Calumet River	Calumet Sag Channel	Sanitary and Ship Canal	Des Plaines River
Minnow trap	255.1	318.3	50.1	374.3
Windermere trap	641.1	376.2	0	297.5
Set line*	259.6	53.9	0	199.8
Angling	14.4	14.2	1.3	33.2
Bottom trawling	0.7	0.7	0	0
Seining†	0	1204	0	446

*15.3 m long
†Total area (m^2)

Table 2. Species occurrence in the Illinois Waterway System of metropolitan Chicago, 28 October - 1 November 1996.

Family / *Species*	Drainage			
	Little Calumet River	Calumet Sag Channel	Sanitary and Ship Canal	Des Plaines River
Atherinidae				
Labidesthes sicculus				_
Catostomidae				
Catostomus commersoni		_		
Centrarchidae				
Ambloplites rupestris	_			_
Lepomis cyanellus	_	_	_	_
L. gibbosus	_			
L. humilis				_
L. macrochirus	_	_		_
Micropterus salmoides	_			
Pomoxis annularis	_			_
Clupeidae				
Dorosoma cepedianum	_	_		_
Cyprinidae				
Carassius auratus		_		
Cyprinus carpio	_	_	_	_
Notemigonus crysoleucas	_			
Notropis atherinoides	_	_		_
N. hudsonius	_	_		
Pimephales notatus	_	_		_
P. promelas		_		_
Gobiidae				
Neogobius melanostomus	_			
Ictaluridae				
Ameiurus melas	_	_		
A. natalis	_	_		_
Ictalurus punctatus	_		_	_

Table 2. Species occurrence in the Illinois Waterway System of metropolitan Chicago, 28 October - 1 November 1996 (continued).

Family / *Species*	Drainage			
	Little Calumet River	Calumet Sag Channel	Sanitary and Ship Canal	Des Plaines River
Percichthyidae				
Morone americana	–	–		–
M. chrysops	–	–		–
M. mississippiensis	–	–		–
Sciaenidae				
Aplodinotus grunniens	–			–

Table 3. Total length of round goby captured by all gears in portions of the Little Calumet River, 28 October - 1 November 1996 (values followed by the same letter are statistically similar; $p < 0.05$).

River reach (mile)	Total length (mm)	
	Mean (± standard deviation)	Range
326.2	52.4 (± 13.7)a	30-77
323.8-323.7	75.8 (± 18.6)b	39-110
323.6-322.6	70.2 (± 27.3)b	35-136
322.5-321.4	92.5 (± 16.1)b	78-124

Table 4. Number of round goby captured in portions of the Little Calumet River with various sampling gears, 28 October - 1 November 1996.

River reach (mile)	Gear				
	Minnow trap	Windermere trap	Set line	Angling	Bottom trawling
326.2	NE*	NE	NE	NE	26
323.8-323.7	NE	1	NE	NE	11
323.6-322.6	NE	0	0	NE	15
322.5-321.4	0	0	5	2	1

*No effort with this gear in this area.

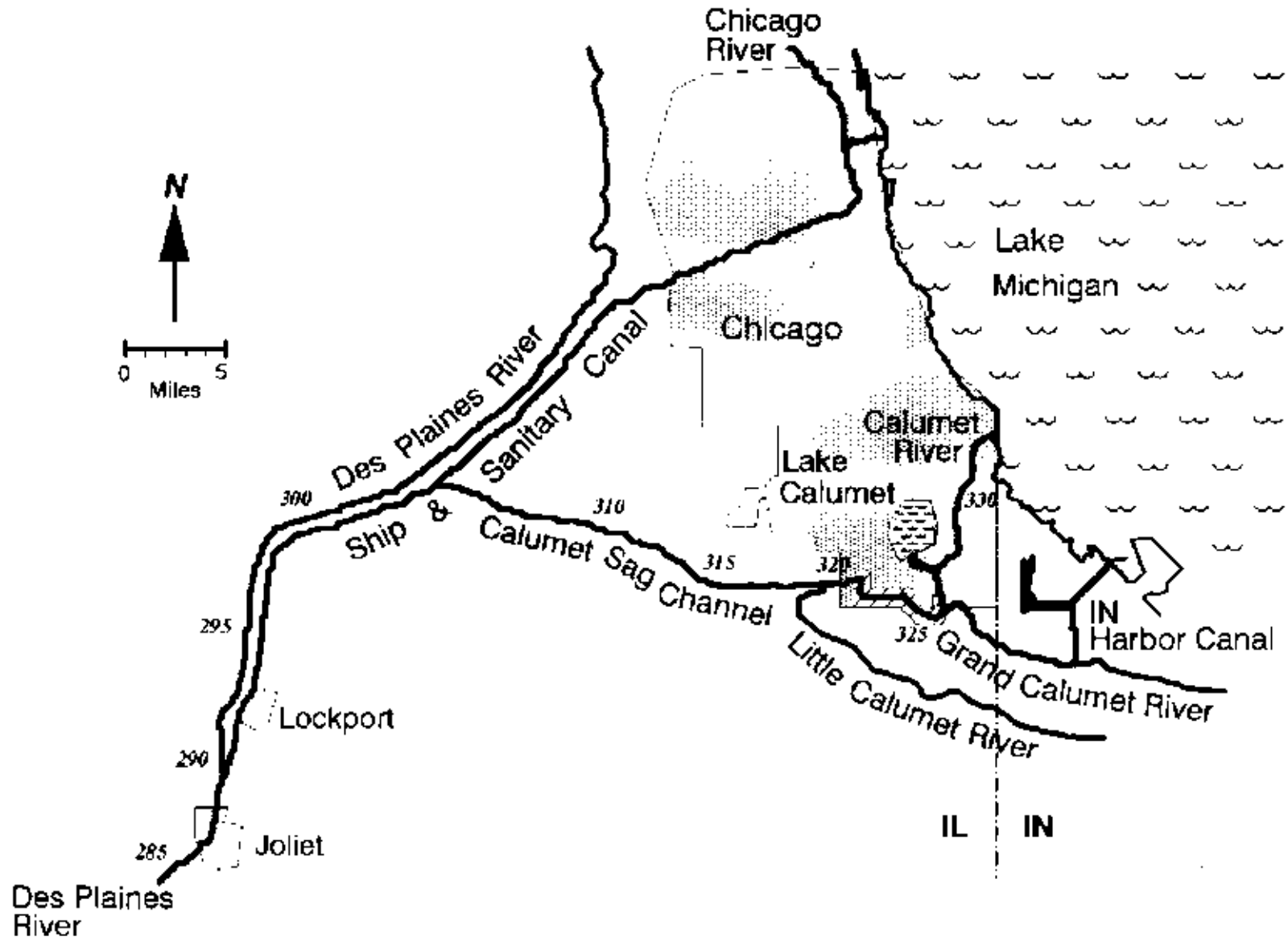

Figure 1. Illinois Waterway System of metropolitan Chicago. Values indicate river miles from the confluence with the Upper Mississippi River. Hatched area indicates river reach where round goby were found in this survey.

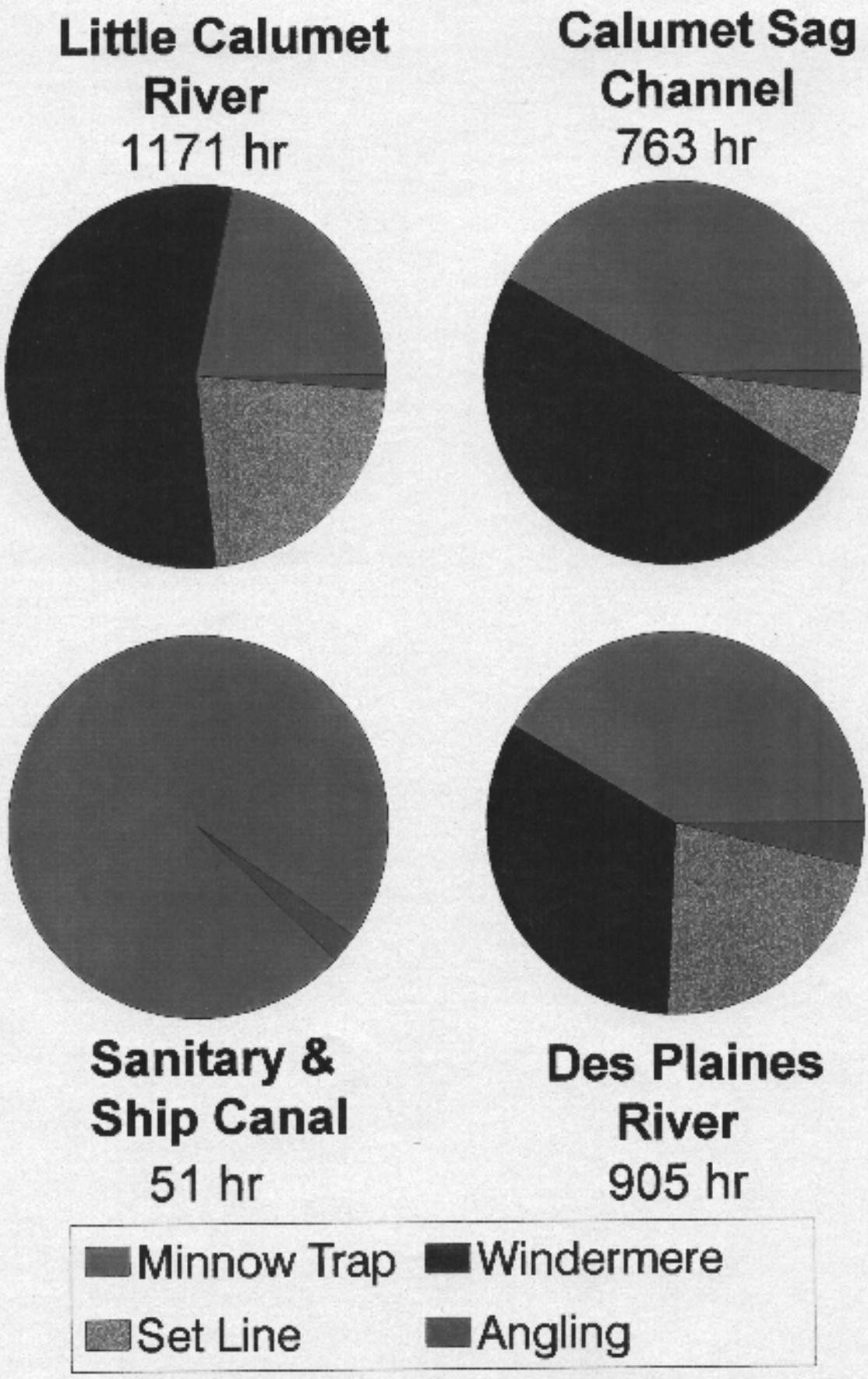

Figure 2. Total standardized effort (hr) for each gear used to sample round goby in the metropolitan Chicago area of the Illinois Waterway System, 28 October - 1 November, 1996 (excludes shoreline seining and trawling).

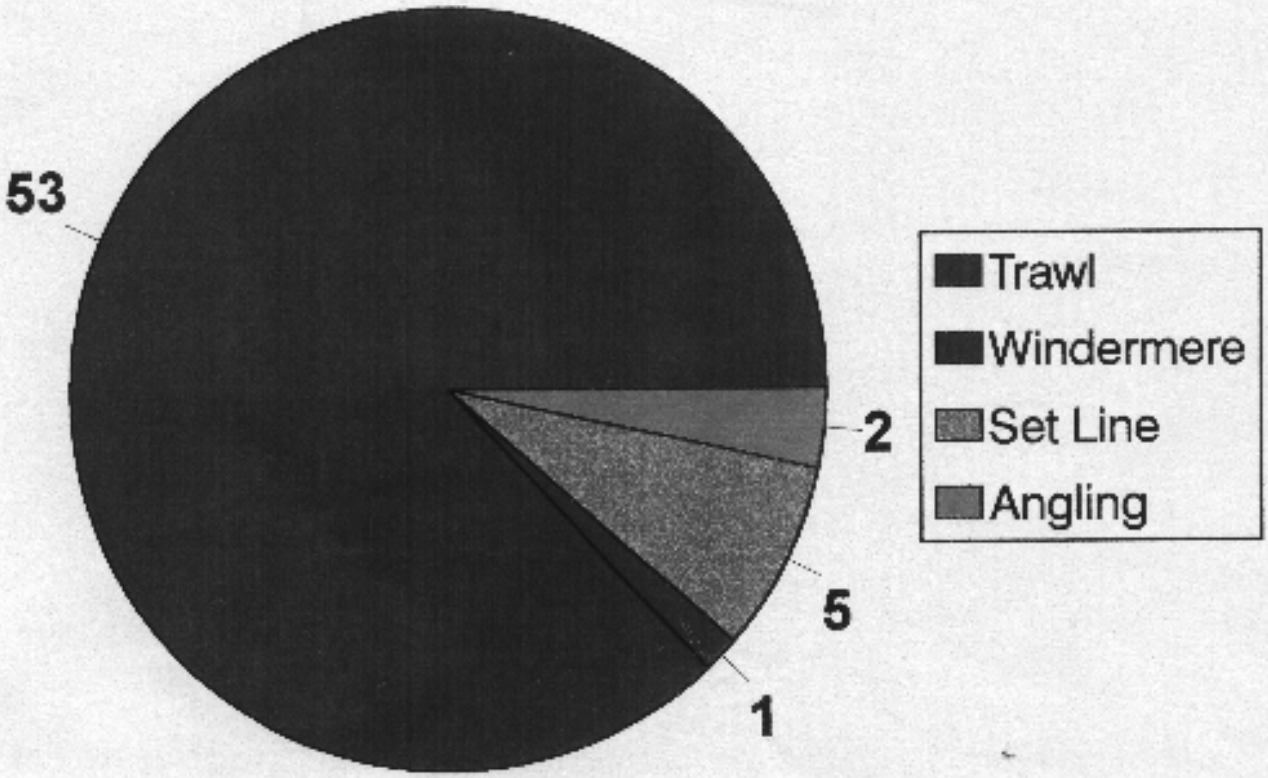

Figure 3. Total number of round goby collected by sampling gears type in the Little Calumet River (mile 326.2-321.4) of the Illinois Waterway System near metropolitan Chicago, 28 October - 1 November 1996.

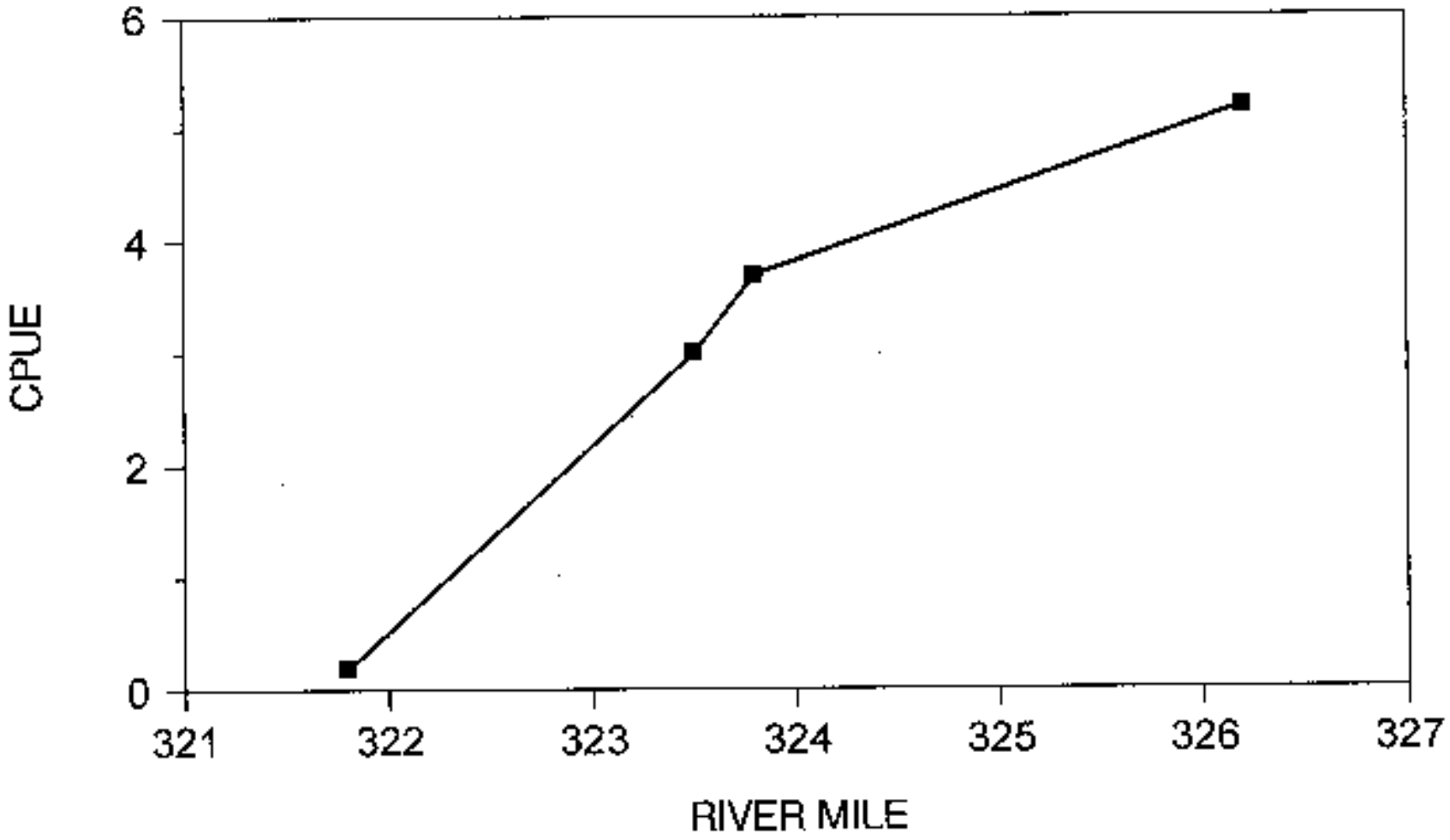

Figure 4. Round goby catch per minute of effort (CPUE) for successful trawls in the Little Calumet River (mile 326.2 - 321.4) near metropolitan Chicago, 28 October - 1 November 1996.

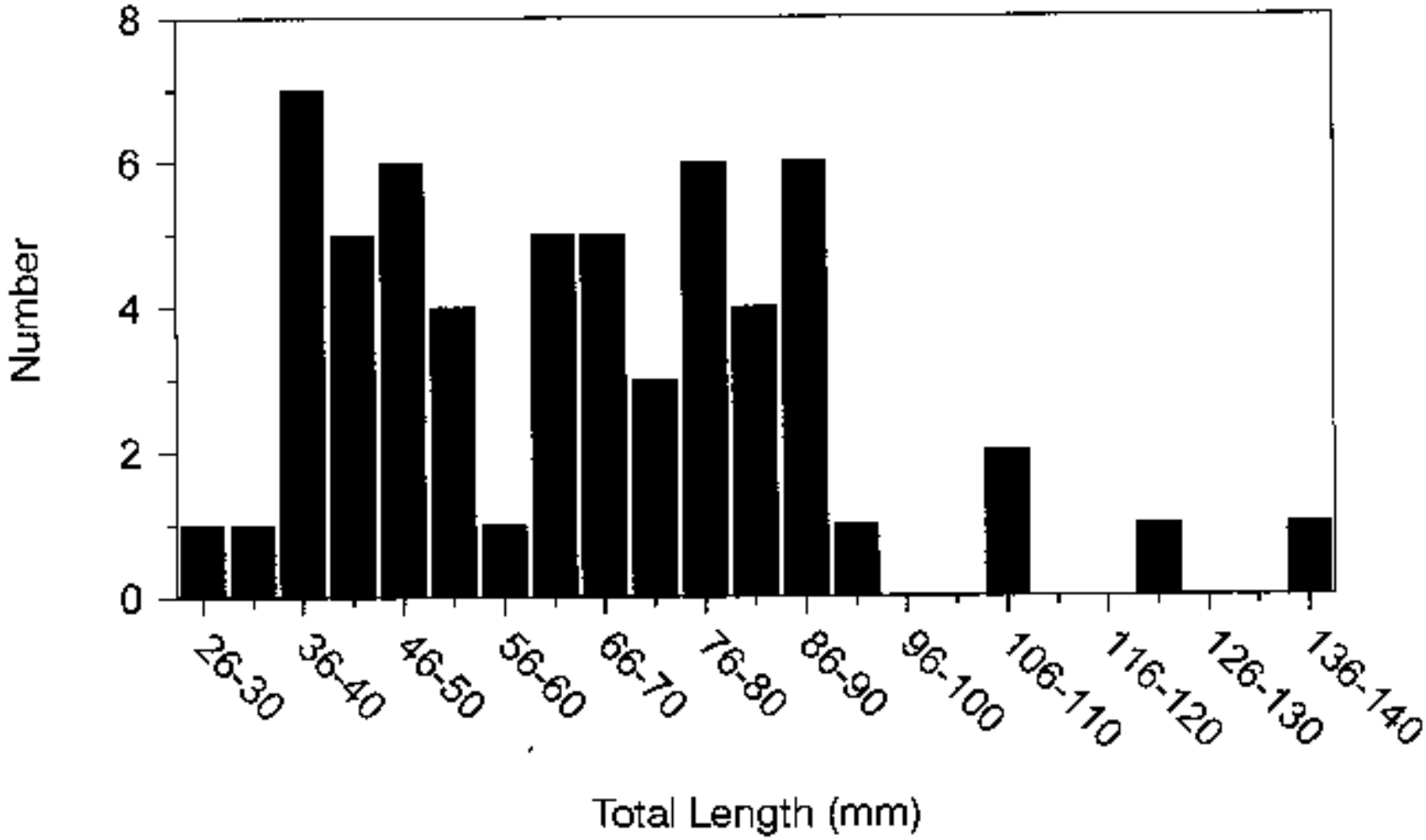

Figure 5. Length frequency distribution of round goby captured in the Little Calumet River (mile 326.2-321.4) near metropolitan Chicago, 28 October - 1 November 1996.

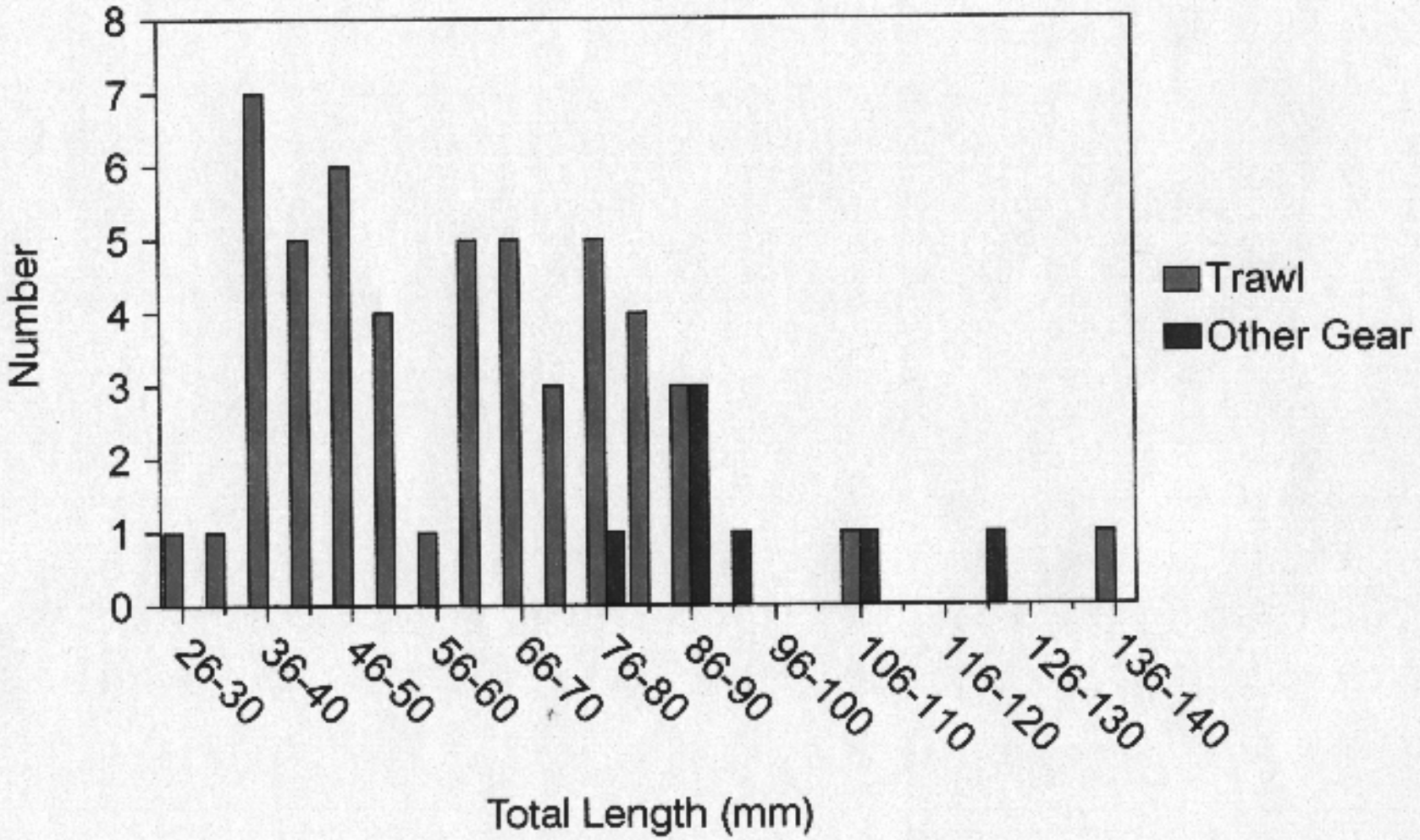

Figure 6. Length frequency distribution of round goby caught in the Little Calumet River (mile 326.2-321.4) by trawling and all other gears, 28 October - 1 November 1996.

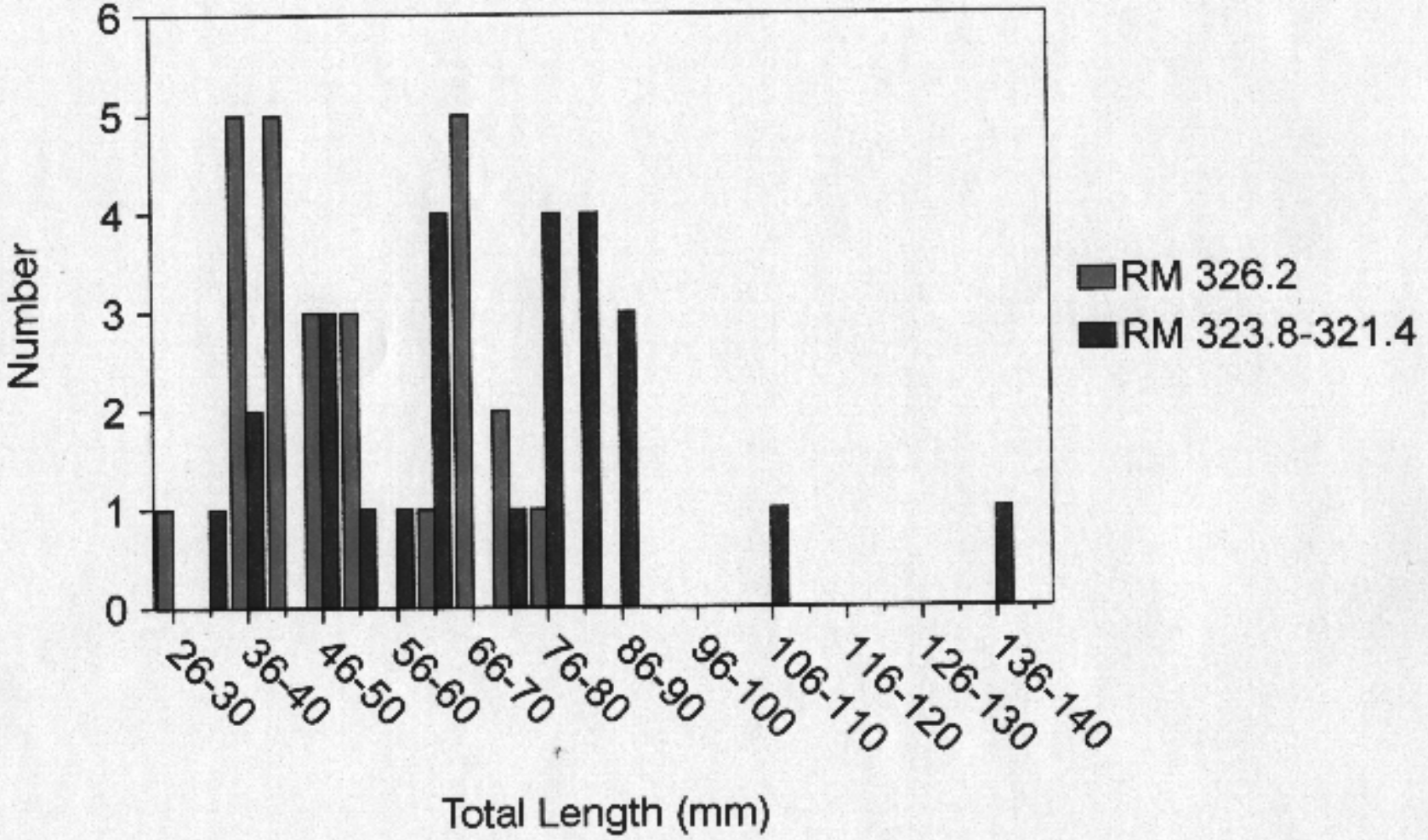

Figure 7. Length frequency distribution of round goby collected by trawling in the Little Calumet River (mile 326.2-321.4), 28 October - 1 November 1996.