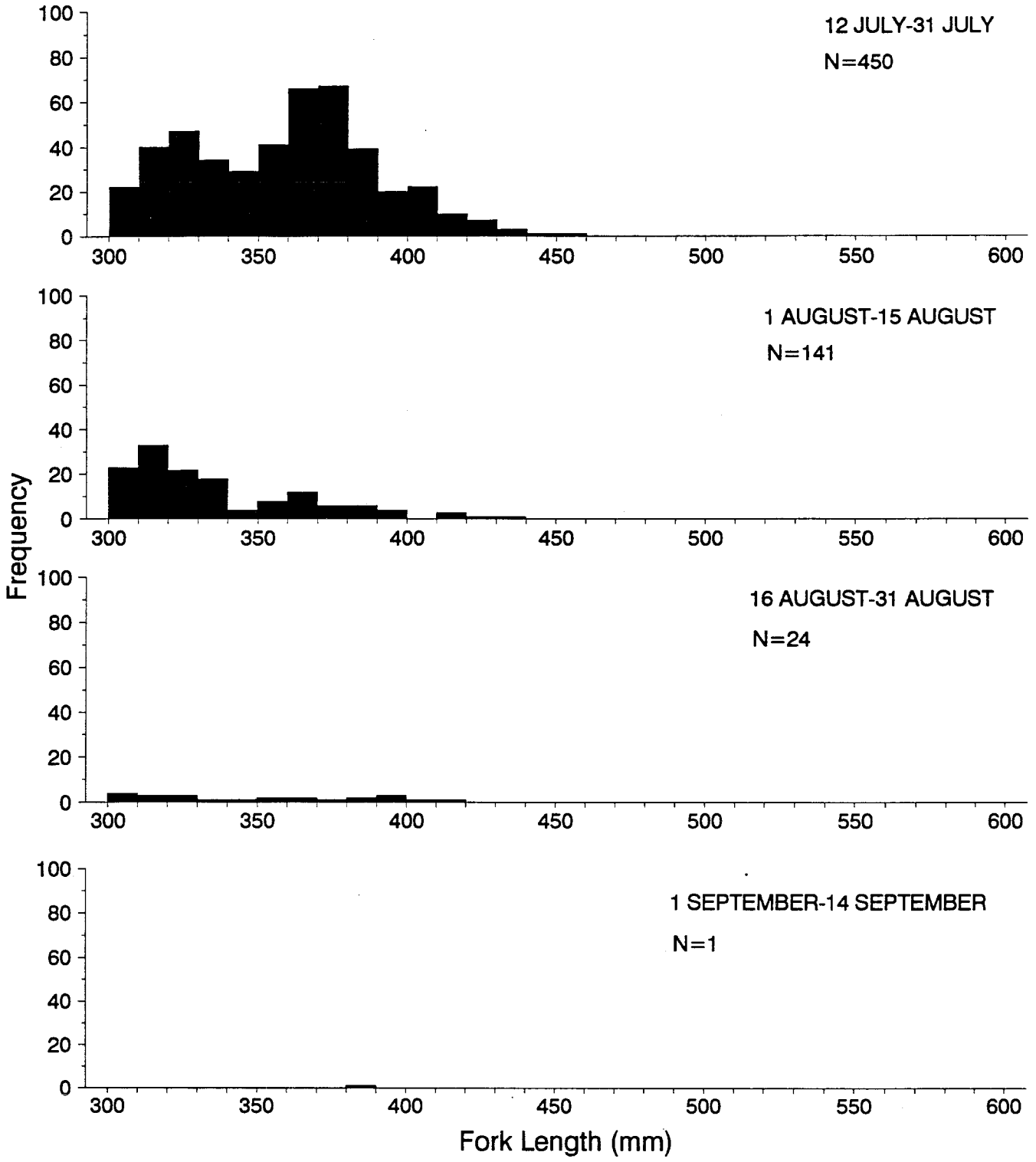


FIGURE 31.– Length frequency of large Arctic cisco (≥300 mm FL) captured by fyke nets in Camden Bay, Arctic Refuge coastal waters, July-September 1990.

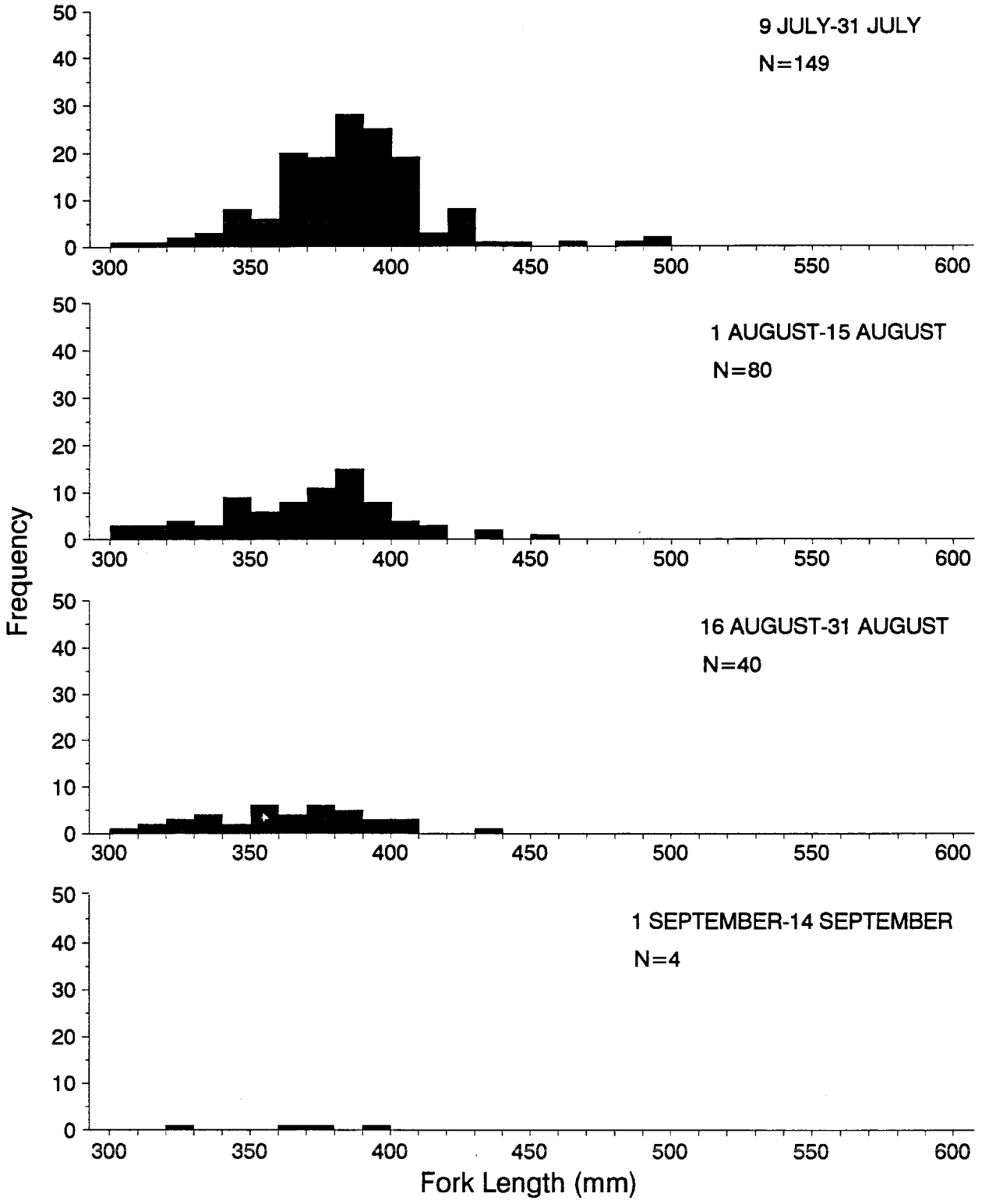


FIGURE 32.– Length frequency of large Arctic cisco (≥300 mm FL) captured by fyke nets in Kaktovik and Jago lagoons, Arctic Refuge coastal waters, July-September 1990.

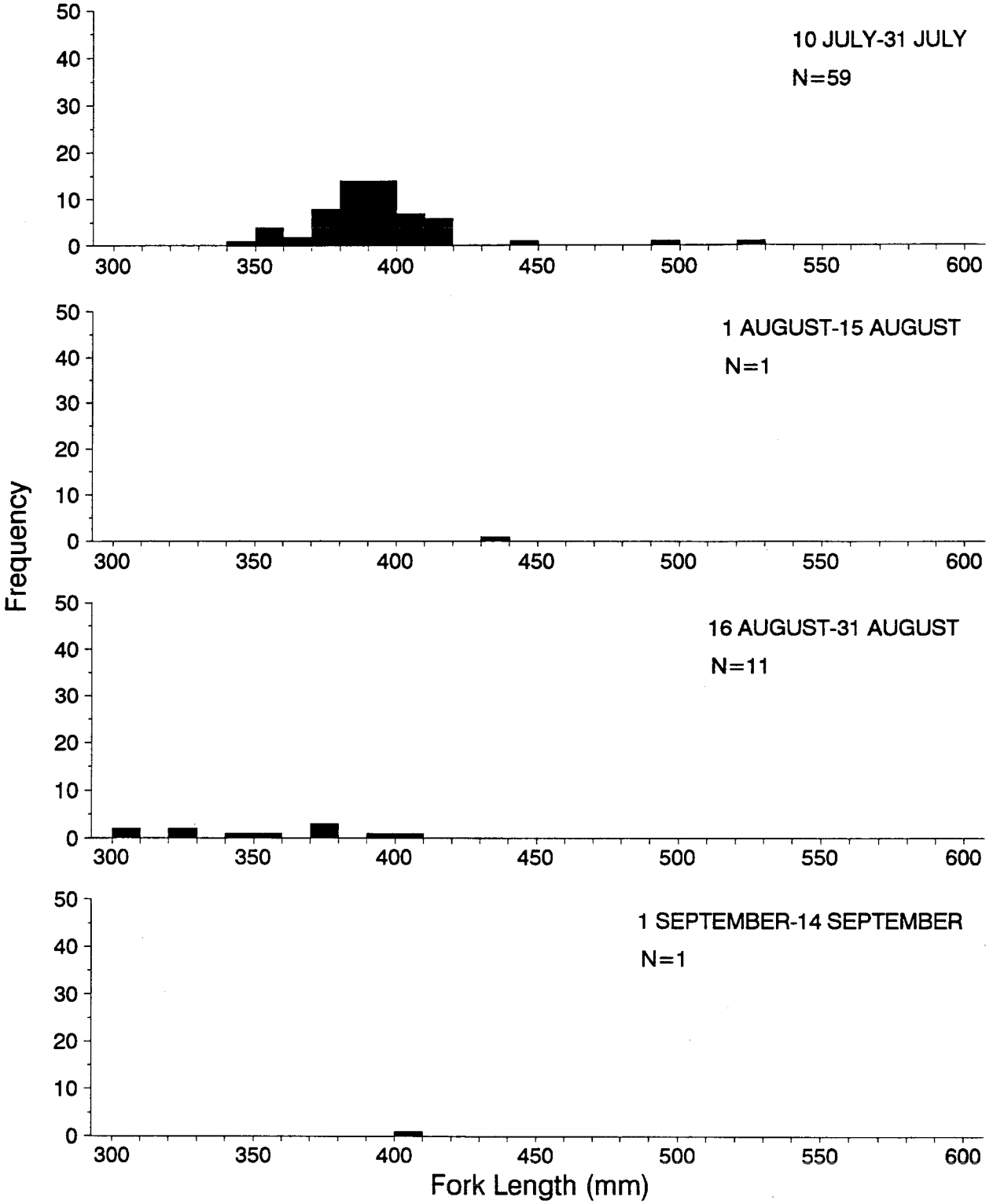


FIGURE 33.– Length frequency of large Arctic cisco (≥300 mm FL) captured by fyke nets in Beaufort Lagoon, Arctic Refuge coastal waters, July-September 1990.

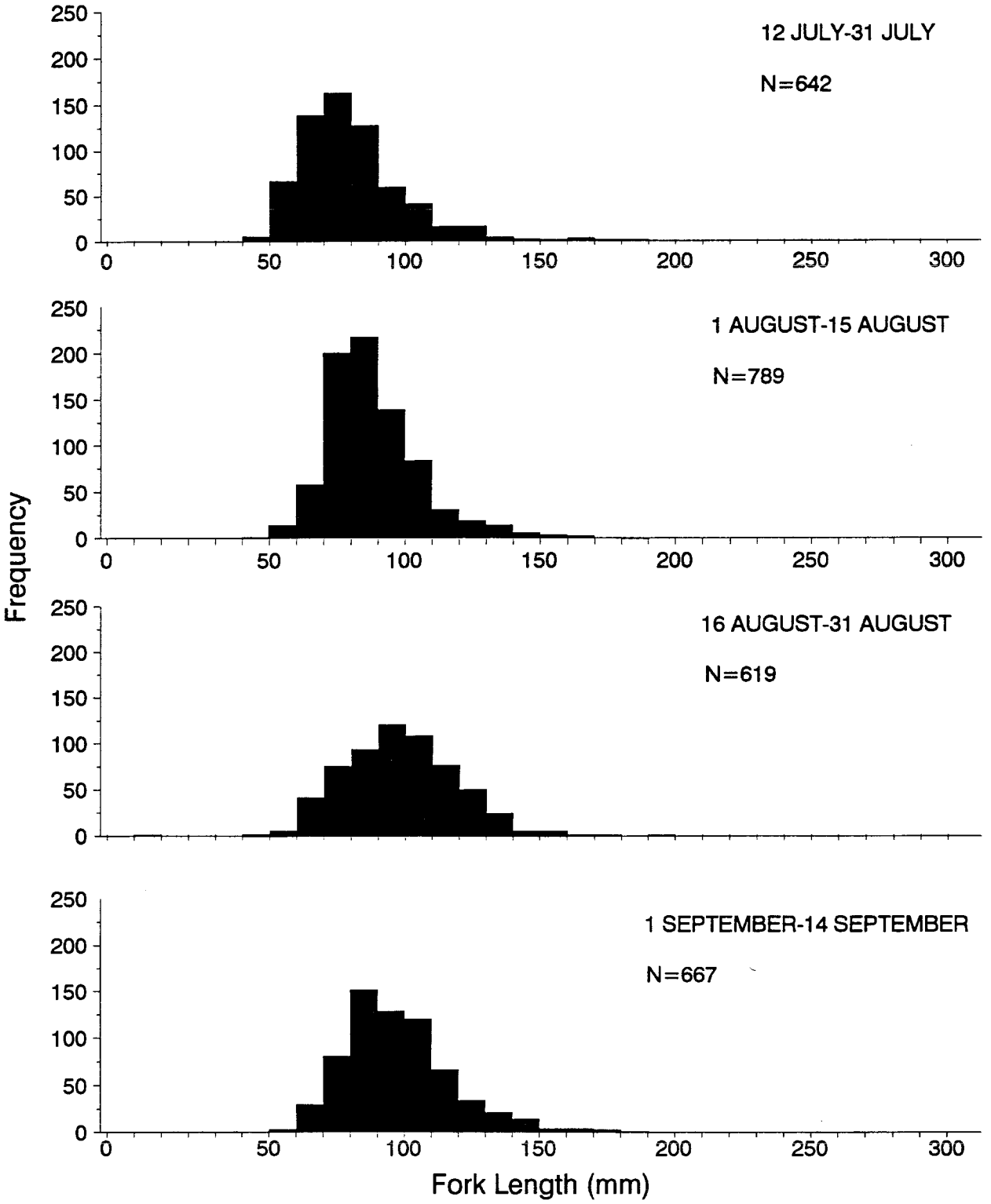


FIGURE 34.– Length frequency of Arctic cod captured by fyke nets in Camden Bay, Arctic Refuge coastal waters, July-September 1990.

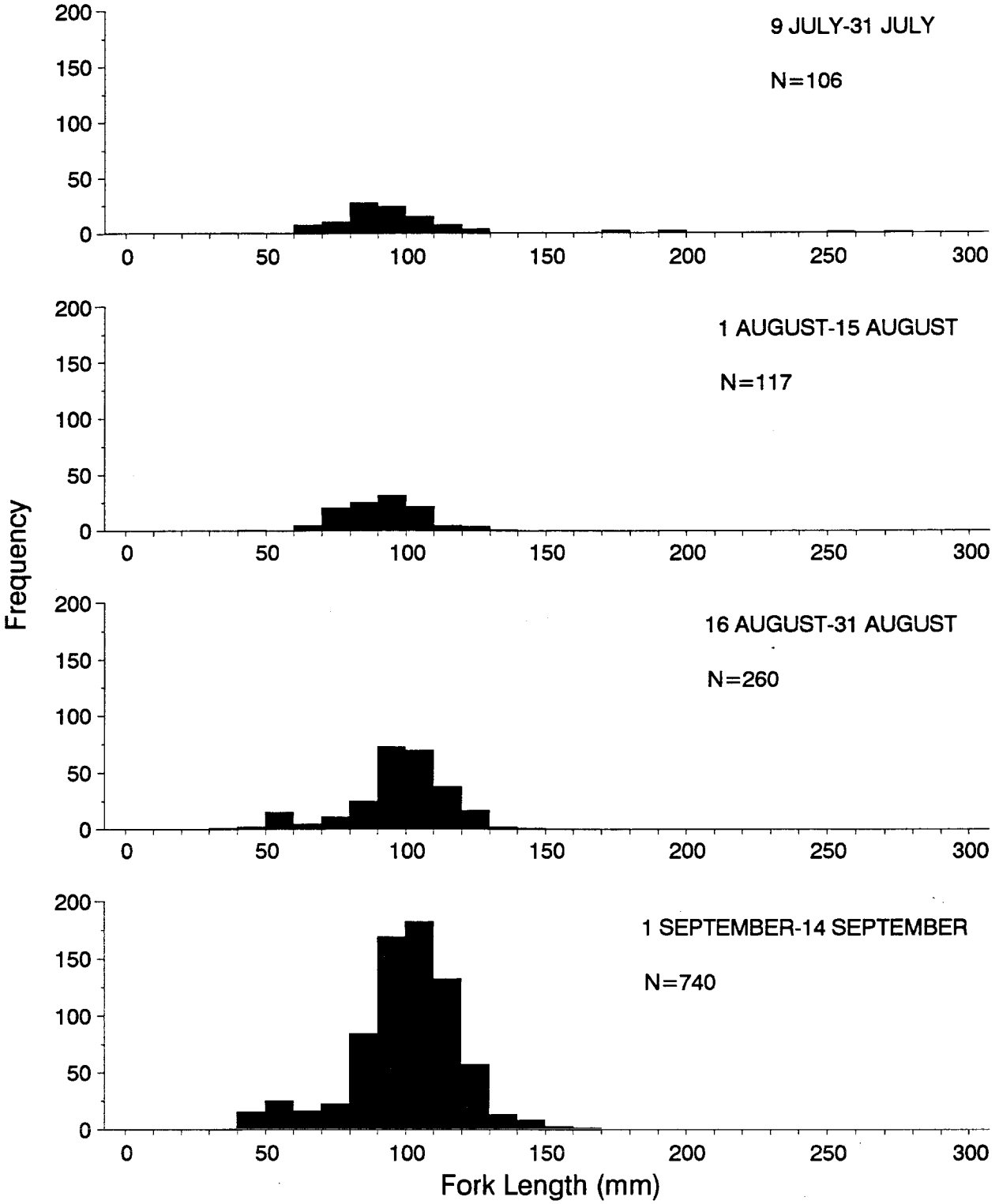


FIGURE 35.- Length frequency of Arctic cod captured by fyke nets in Kaktovik and Jago lagoons, Arctic Refuge coastal waters, July-September 1990.

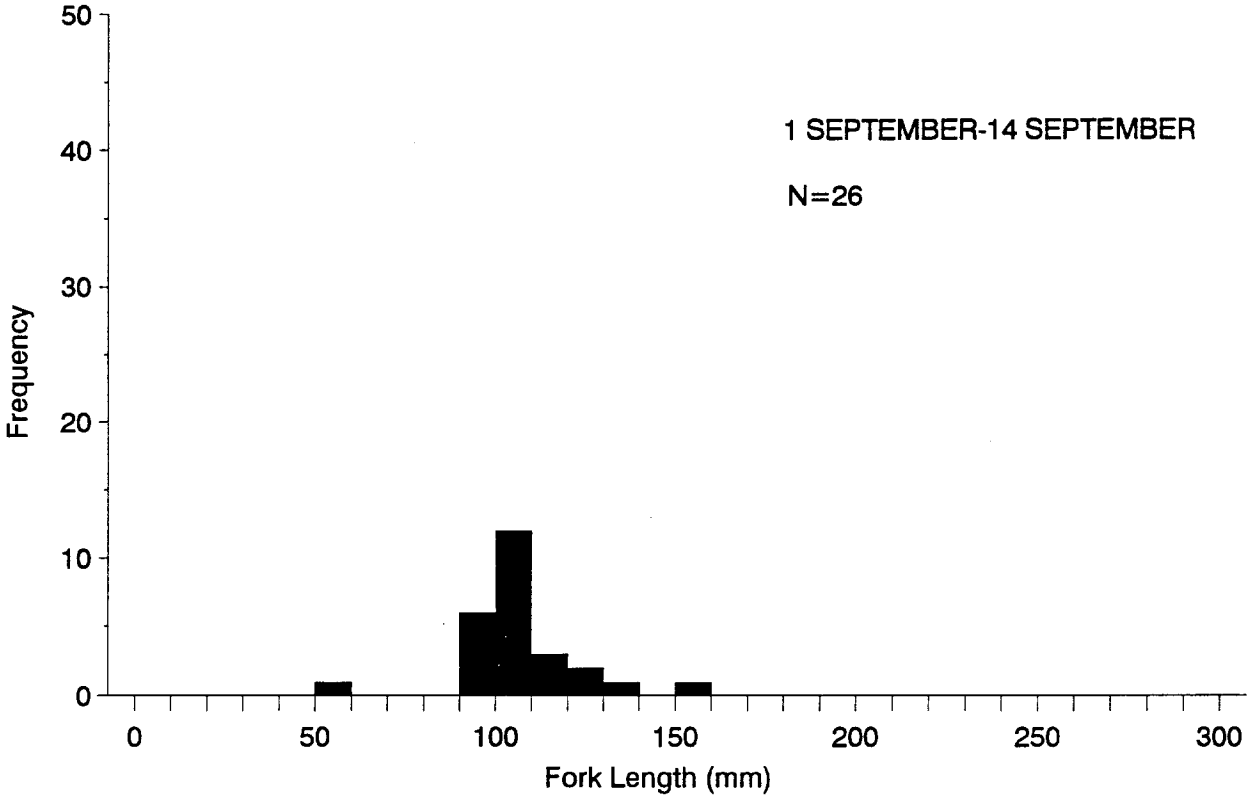


FIGURE 36.– Length frequency of Arctic cod captured by fyke nets in Beaufort Lagoon, Arctic Refuge coastal waters, July-September 1990.

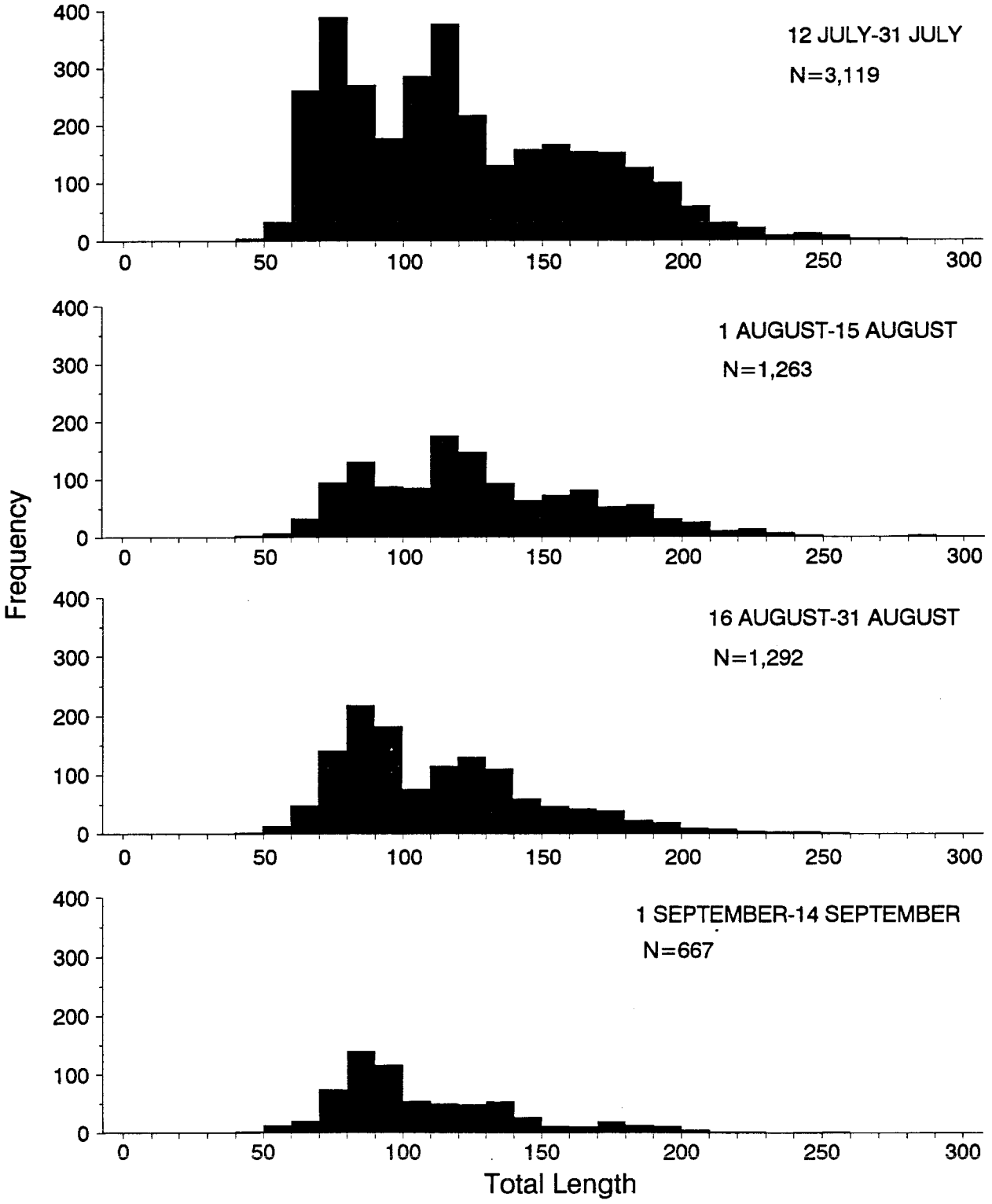


FIGURE 37.– Length frequency of fourhorn sculpin captured by fyke nets in Camden Bay, Arctic Refuge coastal waters, July-September 1990.

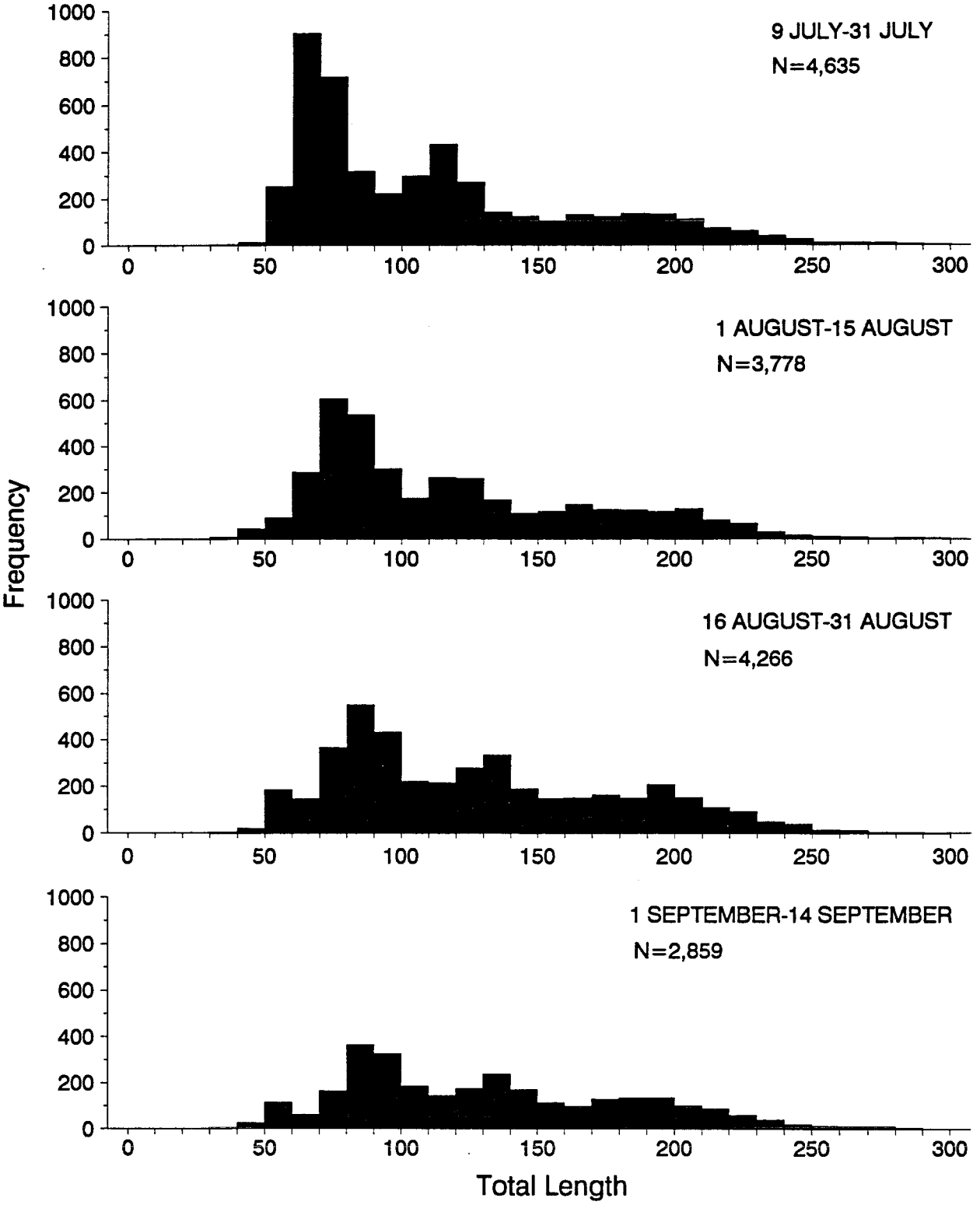


FIGURE 38.– Length frequency of fourhorn sculpin captured by fyke nets in Kaktovik and Jago lagoons, Arctic Refuge coastal waters, July-September 1990.

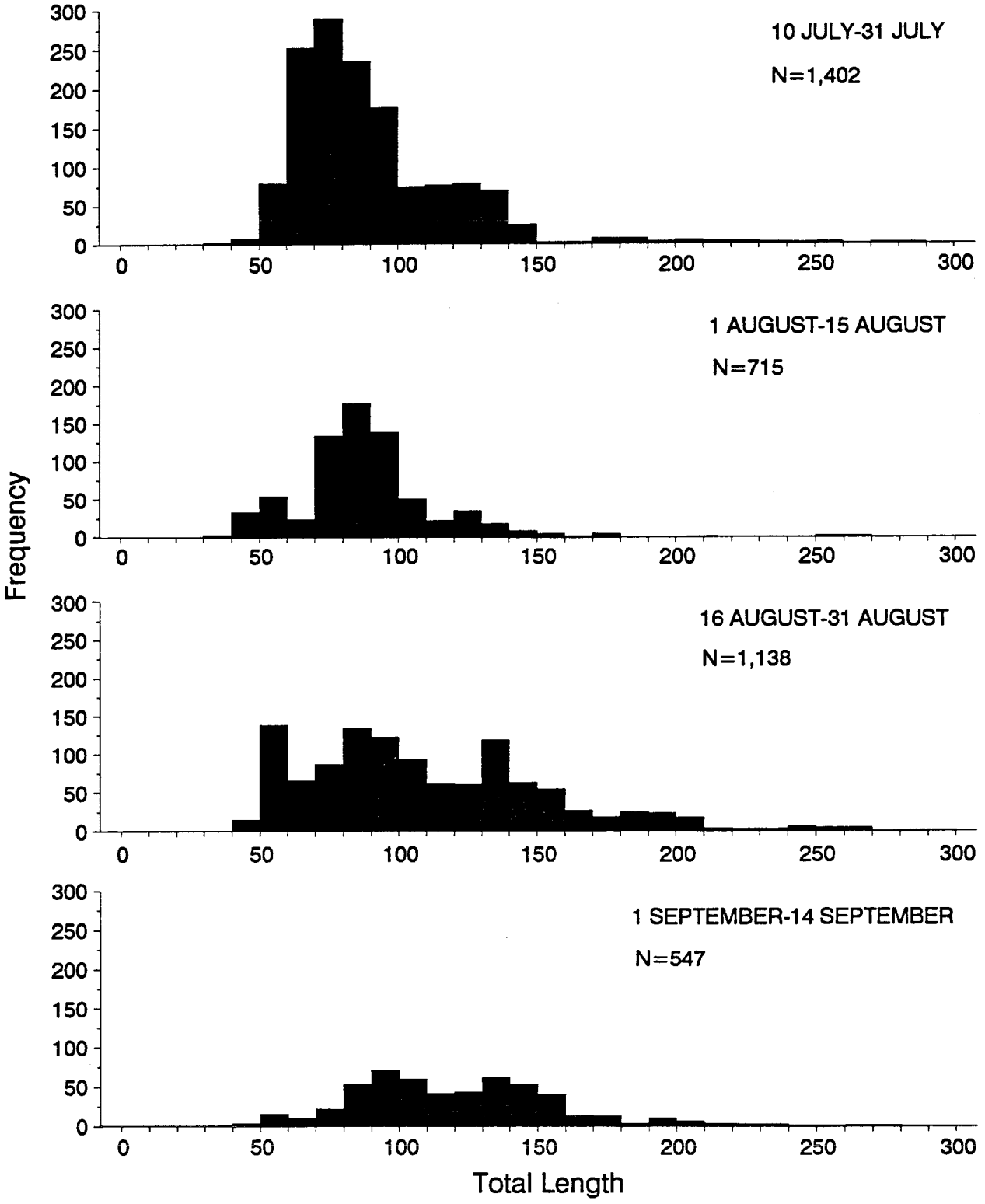


FIGURE 39.– Length frequency of fourhorn sculpin captured by fyke nets in Beaufort Lagoon, Arctic Refuge coastal waters, July-September 1990.

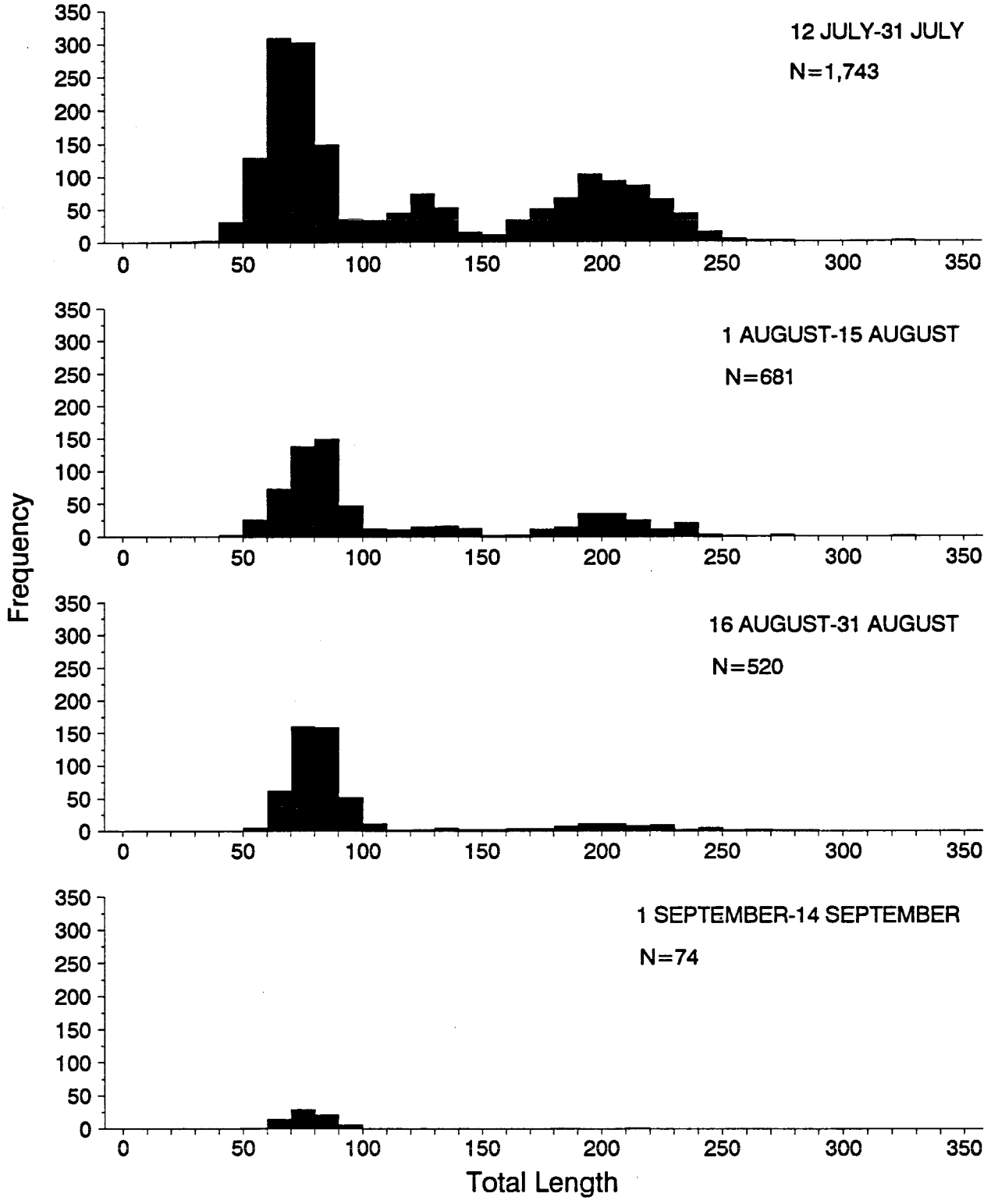


FIGURE 40.– Length frequency of Arctic flounder captured by fyke nets in Camden Bay, Arctic Refuge coastal waters, July-September 1990.

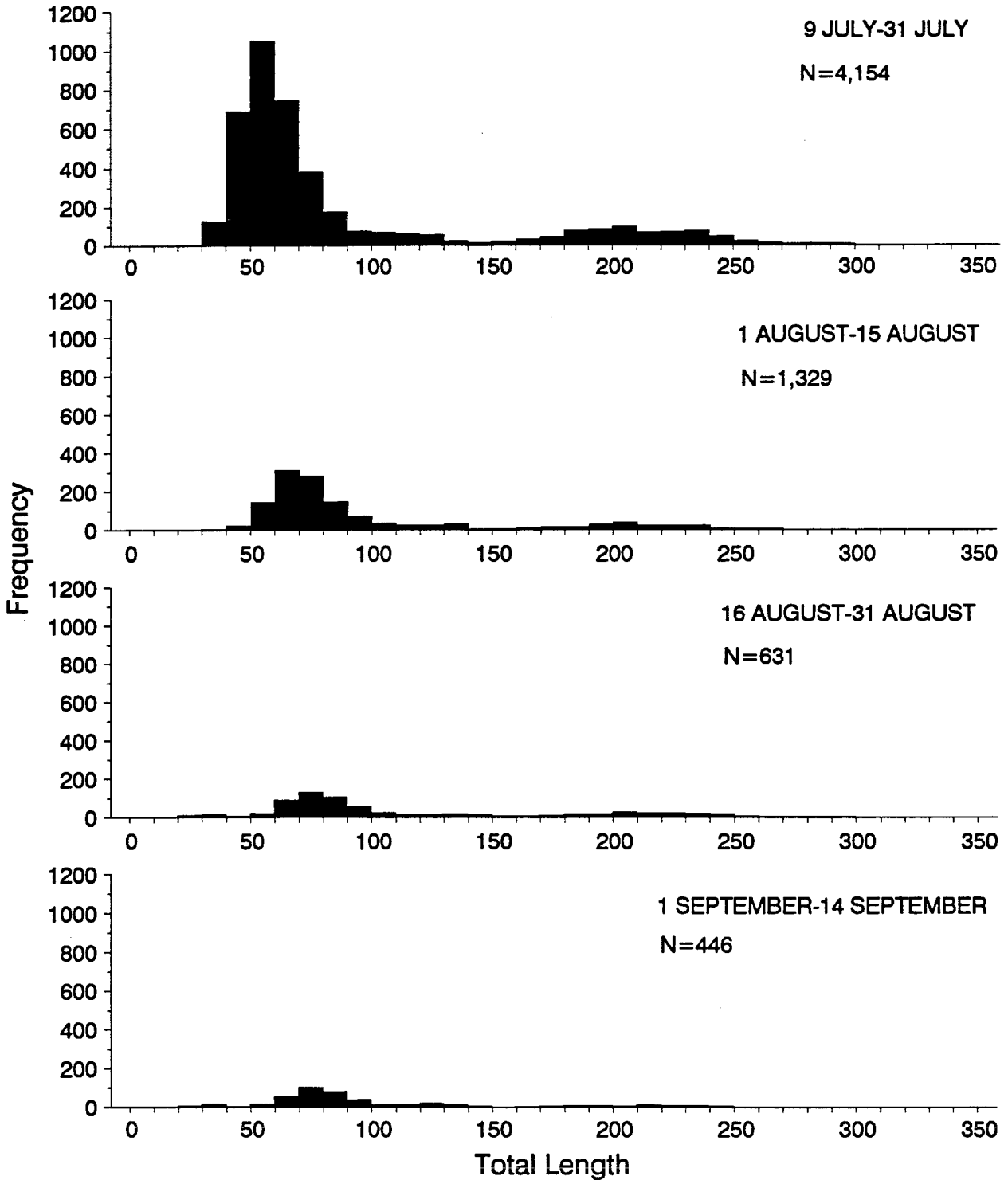


FIGURE 41.– Length frequency of Arctic flounder captured by fyke nets in Kaktovik and Jago lagoons, Arctic Refuge coastal waters, July-September 1990.

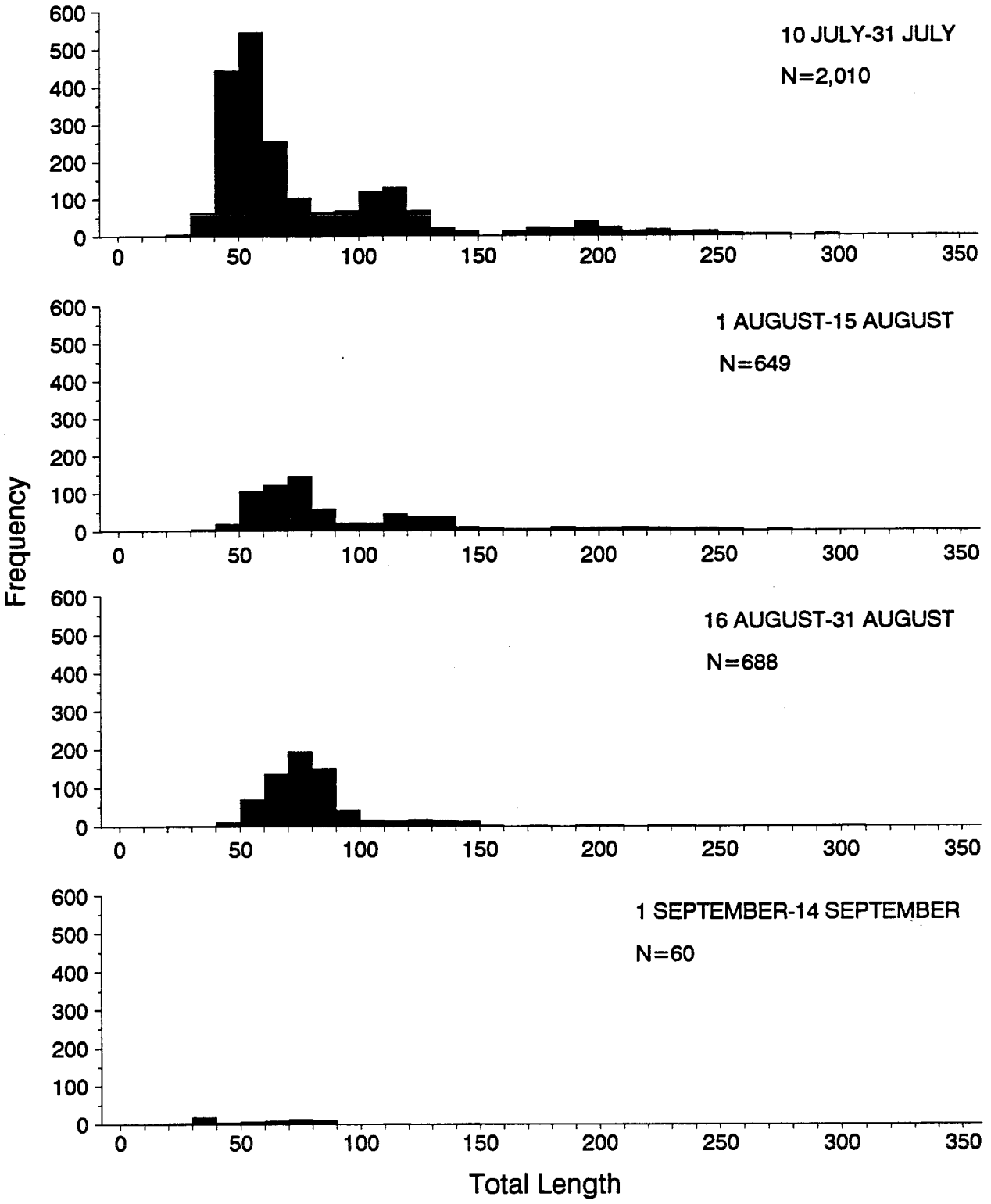


FIGURE 42.- Length frequency of Arctic flounder captured by fyke nets in Beaufort Lagoon, Arctic Refuge coastal waters, July-September 1990.

Arctic flounder from 40 to 100 mm TL were the most prevalent size group at all stations. Additional modal groups generally occurred at 90 to 130 mm TL and 160 to 240 mm TL. Larger fish were less prevalent in September.

Gill Nets

Arctic char captured in experimental gill nets ranged from 182 to 695 mm FL (Figure 43). The majority of fish were from 200 to 450 mm FL with a mode occurring at 225-275 mm FL. Arctic cisco ranged in size from 166 to 406 mm FL (Figure 43) with only one fish captured less than 250 mm FL.

WEIGHT-LENGTH RELATIONSHIPS

Weight-length relationships were calculated for the five target species (Figures 44-48). A comparison to determine whether to pool data from early and late collected fish indicated significant differences at the $\alpha = 0.05$ level in all species except Arctic char. Data for Arctic char were pooled. Relationships of early and late sampled fish of the other four species are presented separately. Allometric growth was indicated for all species except Arctic cod. Correlation coefficients for the regressions ranged from 0.96 to 0.99.

FISH CONDITION

Condition differed significantly ($\alpha = 0.05$) between early and late collection periods for all target species except Arctic char. Fourhorn sculpin relationship changed in both intercept and slope. The other species that changed in condition did so in only one of the estimated parameters. Graphic comparison of modeled early and late fish condition show that predicted weight for a given length increased from early to late season except for Arctic cisco (Figures 49 and 50).

INSTANTANEOUS GROWTH

Otoliths were collected from 443 Arctic cisco (<250 mm), 281 in the early collection period and 162 during the late collection period. Nine otoliths could not be aged. Length at age data for Arctic cisco overlapped considerably for the five age groups (Table 10). Instantaneous growth rates ranged from -0.28 to 1.00 g/day (Table 11).

FISH MOVEMENTS

A total of 1,186 Arctic char and 1,965 Arctic cisco were dye marked during the 1990 field season. Forty Arctic char (3%) and three Arctic cisco (0.2%) were recaptured (Table 12). One Arctic cisco was dye marked in Kaktovik Lagoon and recaptured in Camden Bay. All other recaptured fish were recovered in the same sampling area where dye marking occurred.

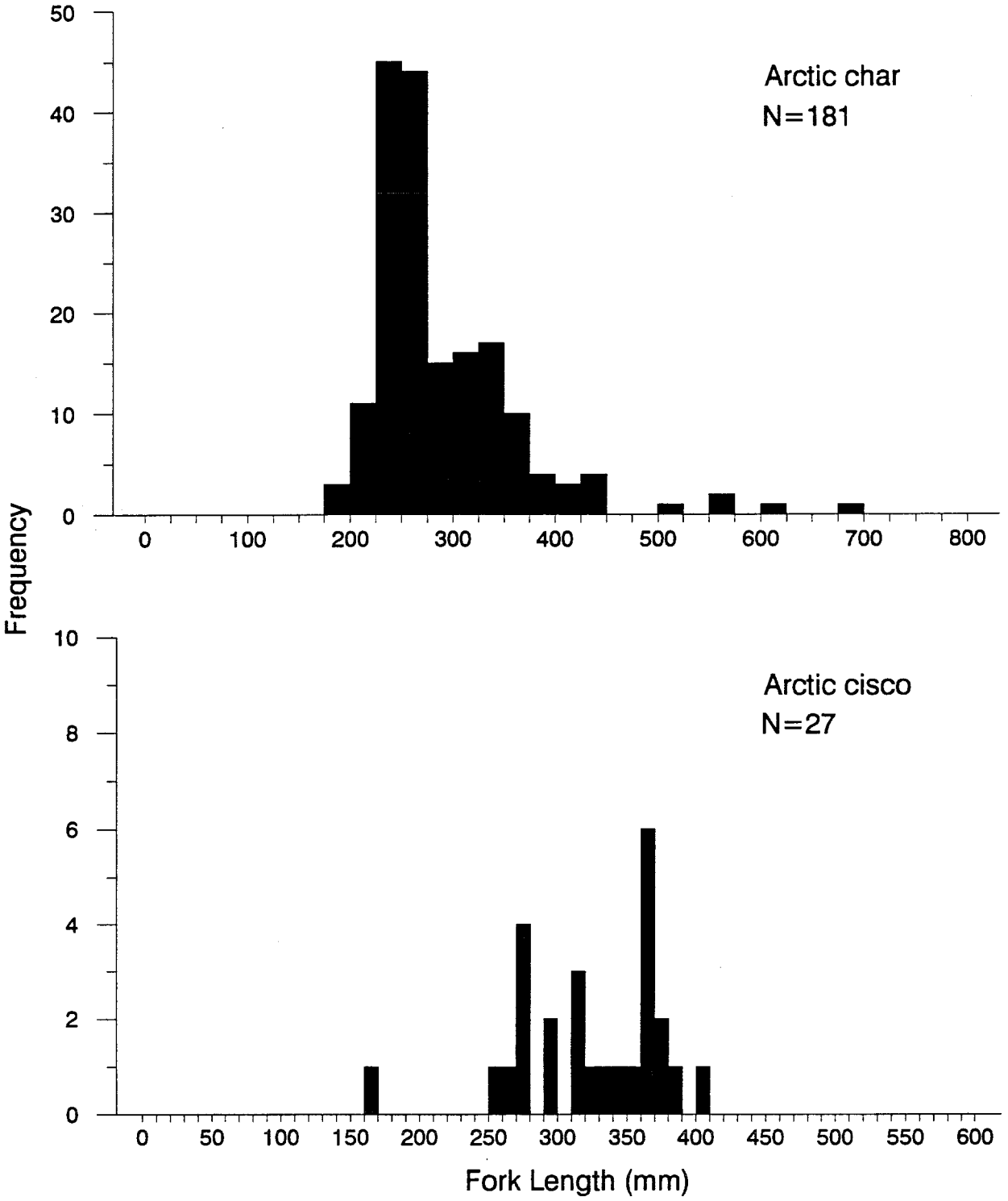


Figure 43.– Length frequency of Arctic char and Arctic cisco captured by gill nets in Camden Bay, Arctic Refuge coastal waters, July-September 1990.

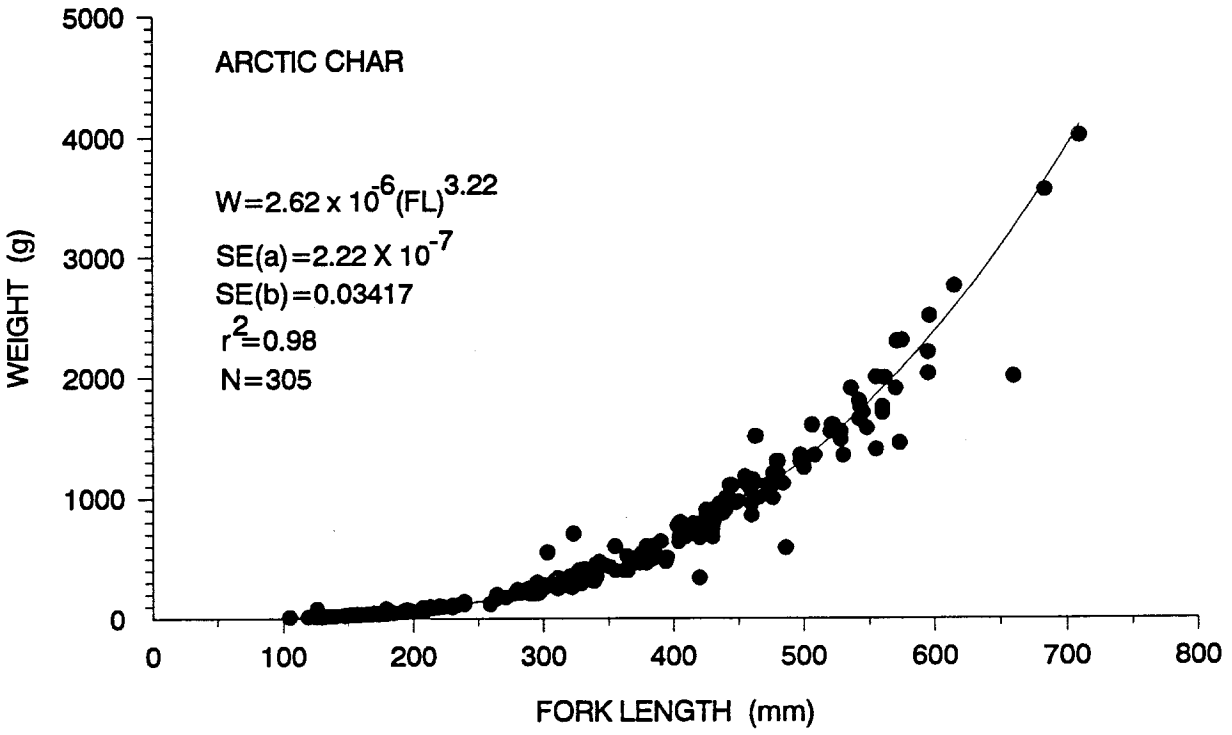


FIGURE 44.– Weight-length relationships of Arctic char captured by fyke nets in Arctic Refuge coastal waters.

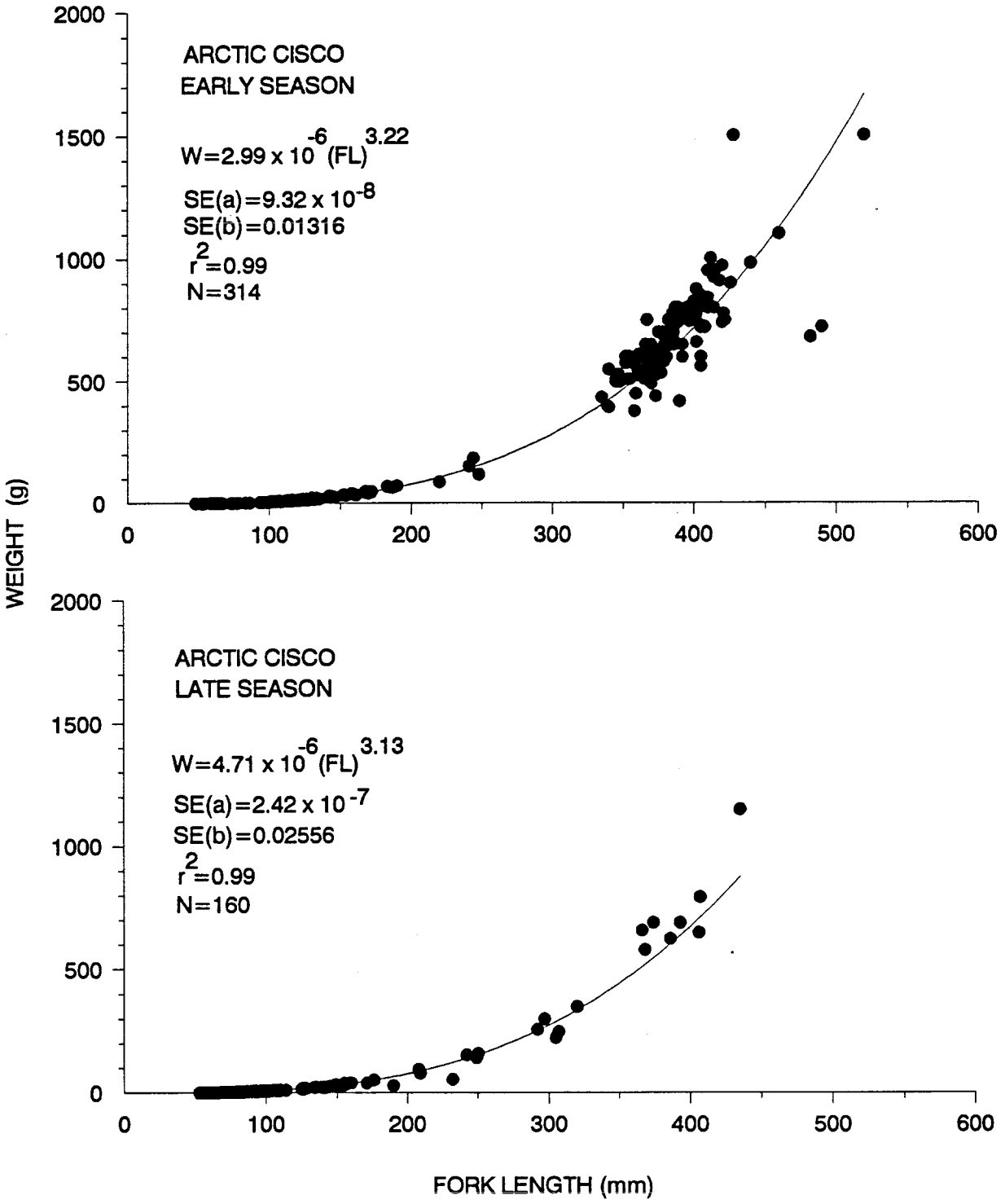


FIGURE 45.– Weight-length relationships of Arctic cisco captured by fyke nets in Arctic Refuge coastal waters.

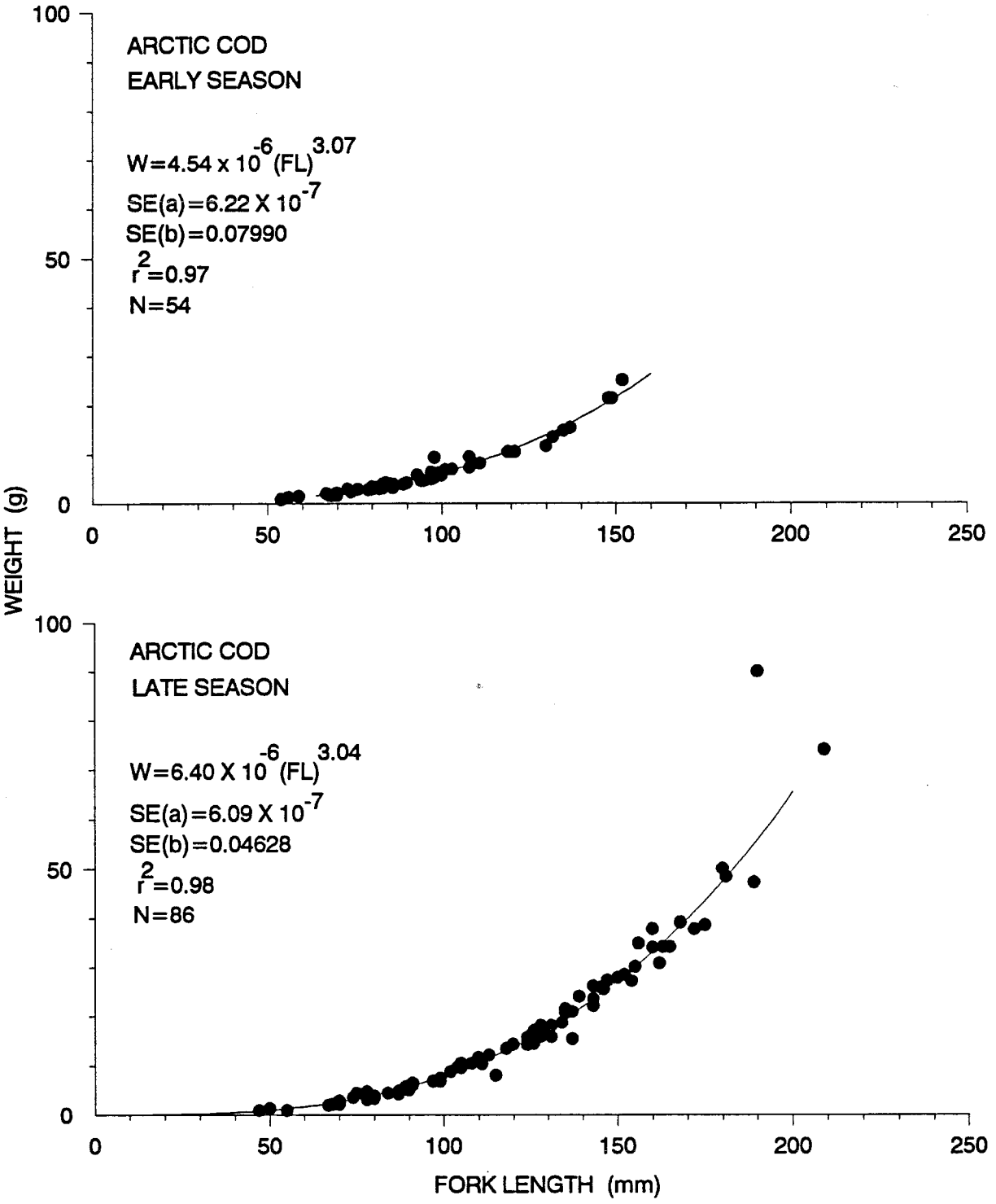


FIGURE 46.– Weight-length relationships of Arctic cod captured by fyke nets in Arctic Refuge coastal waters.

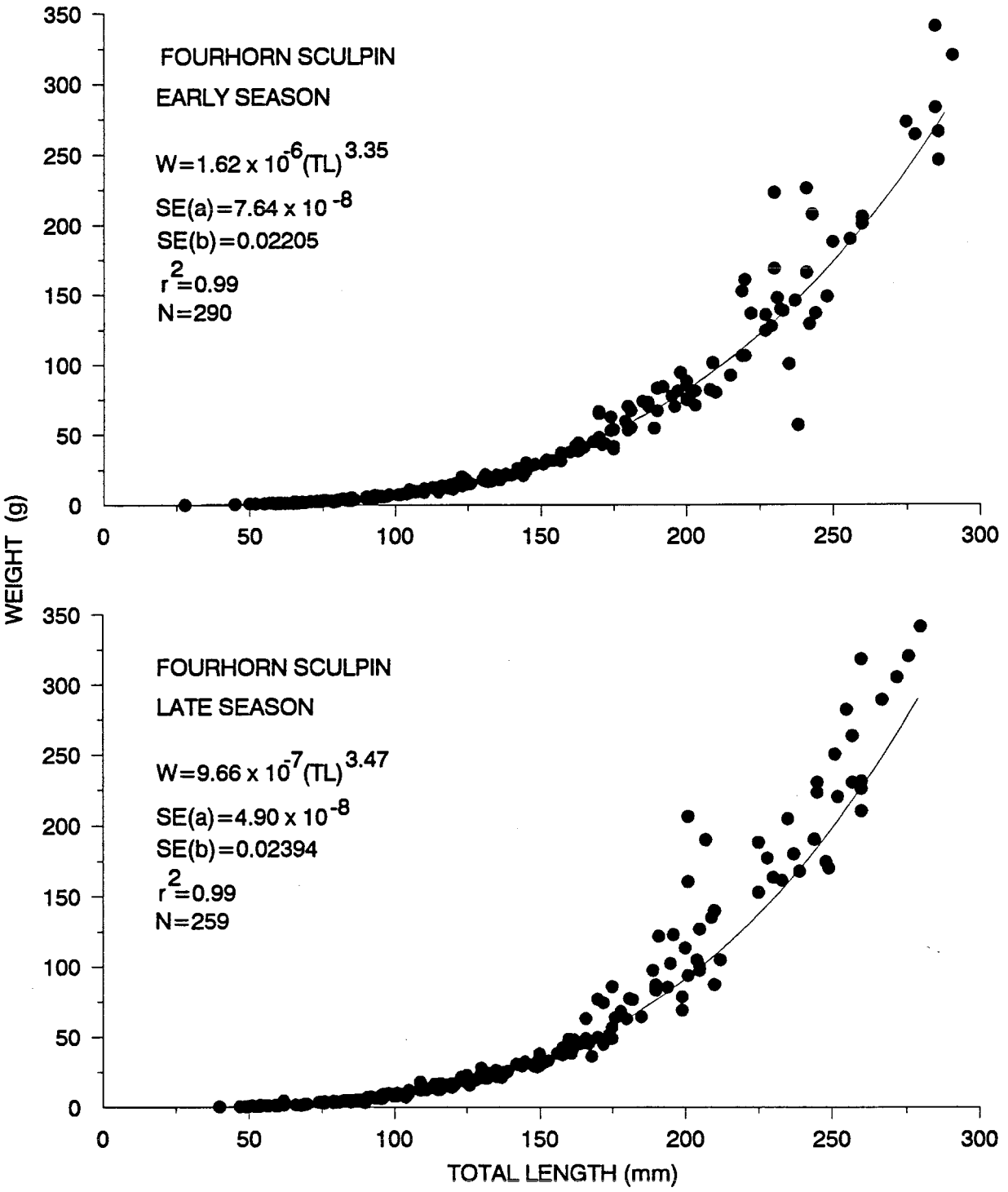


FIGURE 47.– Weight-length relationships of fourhorn sculpin captured by fyke nets in Arctic Refuge coastal waters.

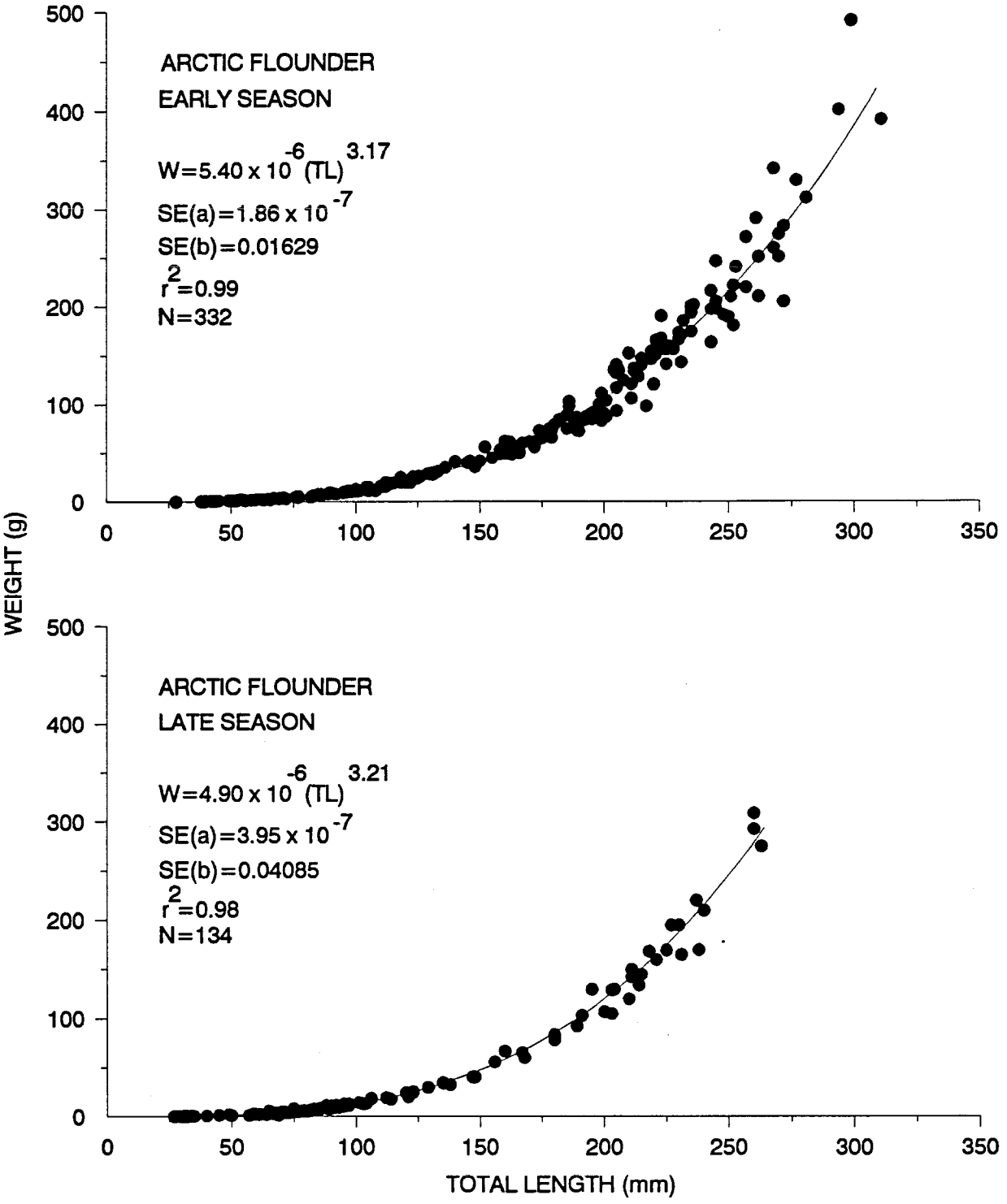


FIGURE 48.– Weight-length relationships of Arctic flounder captured by fyke nets in Arctic Refuge coastal waters.

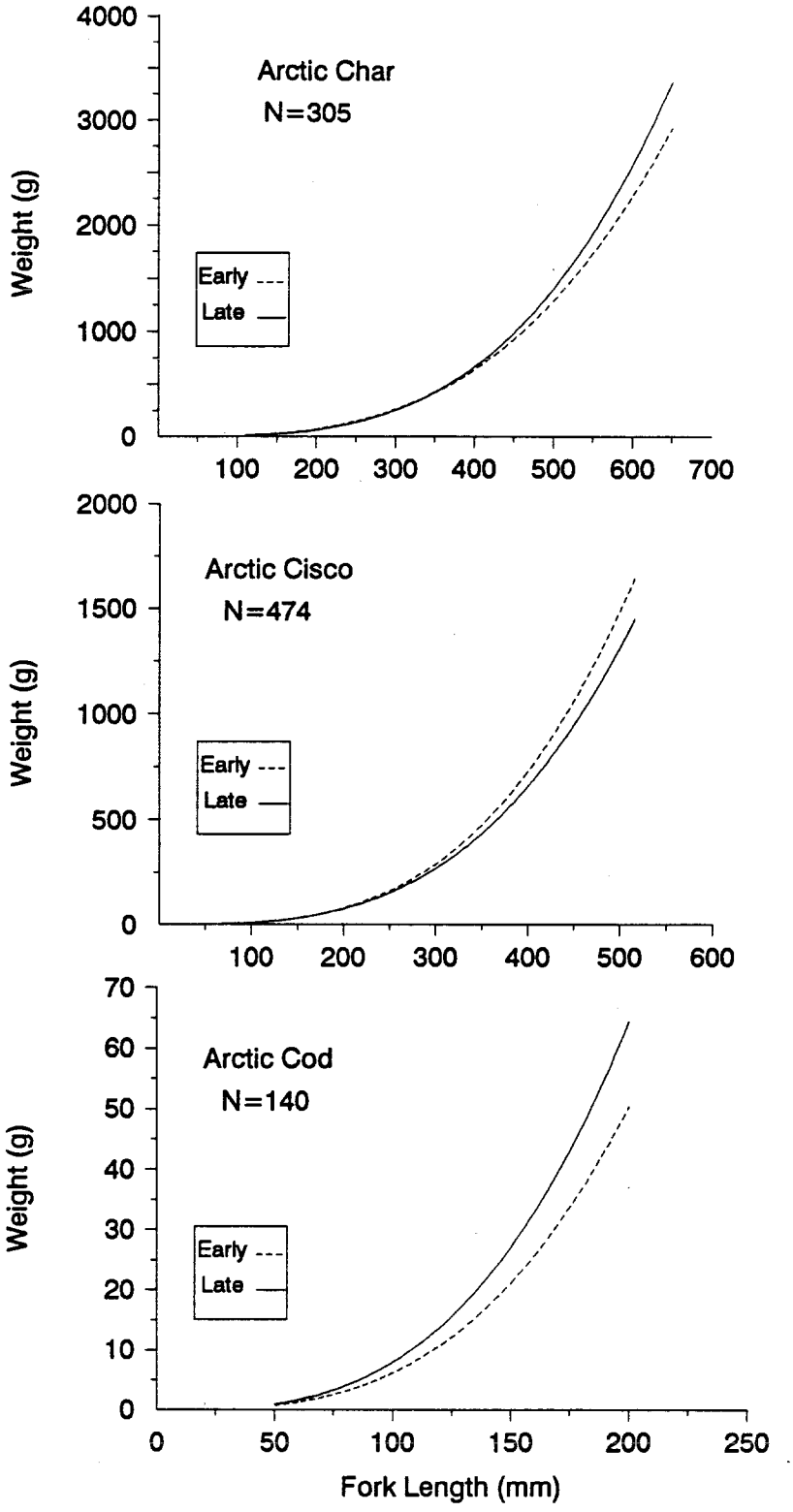
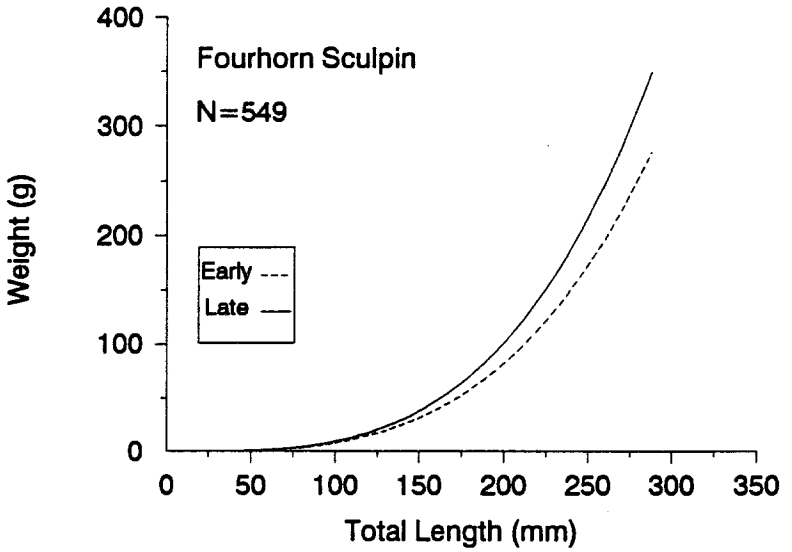


Figure 49.— Fish condition as modeled by weight-length relationship for Arctic char, Arctic cisco and Arctic cod.



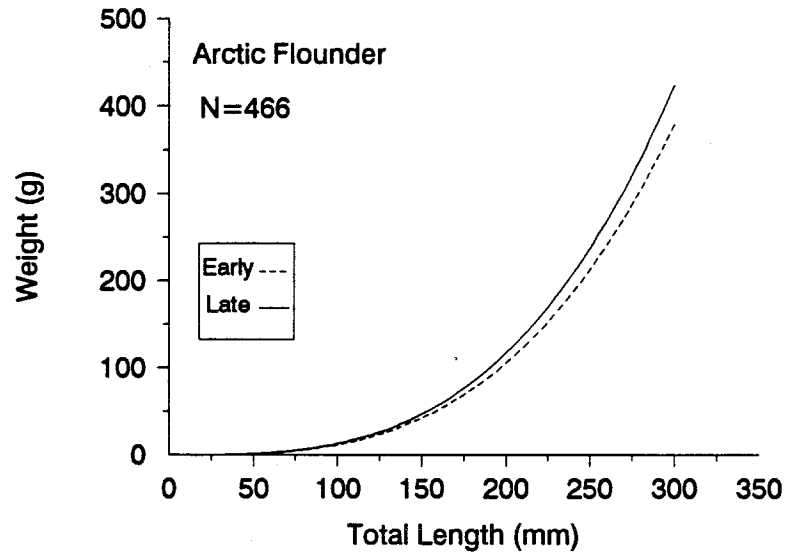


Figure 50.– Fish condition as modeled by weight-length relationship for fourhorn sculpin and Arctic flounder.

TABLE 10.– Mean fork length at age of Arctic cisco captured durin the early (July 10-24) and late (August 29-September 14) periods from Arctic Refuge coastal waters, 1990.

Age	N	Mean FL	SD	Range
		Early Season		
0	60	58	12.2	35-114
1	150	120	21.1	64-223
2	55	156	30.1	70-199
3	12	226	29.4	164-250
4	1	---	----	252
		Late Season		
0	122	77	15.1	52-114
1	27	141	24.01	82-296
2	6	191	33.0	141-233
3	3	209	56.5	145-251
4	1	----	----	249

TABLE 11.– Instantaneous growth rates (G) of Arctic cisco, ages 0-4. The change in time (Δt) is approximately 50 days. The other symbols are fork length (FL), initial mean weight (W_1), and final mean weight (W_2). Mean weights were calculated from the weight-length functional regression.

	Initial means			Final means			
Age	N_1	FL_1 (mm)	W_1 (g)	N_2	FL_2 (mm)	W_2 (g)	G
0	60	58	1.4	122	77	3.8	1.00
1	150	120	15.1	27	141	25.6	0.53
2	55	156	35.2	6	191	66.4	0.63
3	12	226	116.4	3	209	88.1	-0.28
4	1	252	165.4	1	249	150.0	-0.10

TABLE 12.– Number of fish dye-marked (N) and recaptured, by location, during the summer of 1990, Arctic Refuge coastal waters.

		Recapture Area		
Marking area	N	Camden Bay	Kaktovik and Jago lagoons	Beaufort Lagoon
		Arctic char		
Camden Bay	461	12	0	0
Kaktovik / Jago	658	0	27	0
Beaufort Lagoon	67	0	0	1
		Arctic cisco		
Camden Bay	282	0	0	0
Kaktovik / Jago	1400	1	2	0
Beaufort Lagoon	283	0	0	0

Anchor type tags were attached to 1,398 fish in Kaktovik and Jago lagoons, 807 fish in Camden Bay, and 378 fish in Beaufort Lagoon (Table 13). Recaptured fish from our 1990 field effort were recovered mostly from the original tagging area (Table 13). During 1990, recapture rates ranged from 0% for Arctic cisco to 2% for fourhorn sculpin and Arctic flounder. Tags were also recovered from two Arctic cisco and four least cisco originally tagged in the Prudhoe Bay area, and one Arctic char previously tagged in Oruktalik Lagoon (Table 14). Finally, one Arctic cisco tagged and released in 1988 from Arctic Refuge waters was reported to have been recaptured in Canada.

A total of 964 Arctic char were tagged and 12 were recaptured. Seven Arctic char were recaptured at their original tagging station and four at another station within the original sampling area (Table 13 and 14). One Arctic char was recaptured in a different sampling area (Table 14). This fish measured 392 mm FL when tagged in Jago Lagoon on July 19, 1990 and measured 411 mm at recapture in Camden Bay on August 17, 1990. Distance traveled was approximately 62 km (travel rate of 2.1 km/d).

We tagged 465 fourhorn sculpin and recaptured 11 during 1990. Seven fourhorn sculpin tagged in Kaktovik and Jago lagoons and Simpson Cove were recaptured at their original tagging station. Three were recaptured within their respective sampling areas. The first had moved from station KL05 to KL10 in Kaktovik Lagoon after 32 days at large. The second sculpin moved from station KL10 on August 30 to station KL05 after six days at large, and the third moved from station SC01 to station SC04 in Simpson Cove after 16 days at large. Another fourhorn sculpin tagged at station SC01 on July 27 was recaptured in Kaktovik Lagoon at station KL10 on September 9, approximately 57 km east of the station of tagging (travel rate of 1.2 km/d).

Of the 655 Arctic flounder tagged during the 1990 field season (Table 13), 13 were recaptured, all within their respective areas of tagging and six from the original tagging station. Four Arctic flounder moved east within Camden Bay from station SC04 to SC01, and one moved west from SC01 to SC04. Another Arctic flounder tagged on July 24 moved east from JL12 and was recaptured at JL14 on July 26, a distance of 4.0 km (a travel rate of 2.0 km/d). One Arctic flounder migrated 18.0 km between lagoons from station KL10 east to station JL14 in 23 days (a travel rate of 0.8 km/d).

Three Arctic char tagged in Arctic Refuge coastal lagoons in 1990 and previous years were recaptured in rivers of the Arctic Refuge. One was tagged at Kaktovik Lagoon on August 28 and recaptured 48 days later on the Hulahula River, a travel rate of 0.5 km/d. A second Arctic char, originally tagged at Camden Bay on August 18, 1987 was recaptured in the Kongakut River on August 30, 1990. Length at tagging was 493 mm FL, and after three years at large it was 535 mm FL. The third Arctic char, originally tagged at Oruktalik Lagoon on August 26, 1986 was recaptured four years later in Jago Lagoon on July 24, 1990.

Ten Arctic cisco were recaptured outside of Arctic Refuge coastal waters. One fish, tagged July 10, 1990 was recaptured 17 days later in an unidentified river in Canada. The other nine fish were recaptured in the Coville River

TABLE 13.– Number of fish Floy tagged (N) and recaptured, by location, during the summer of 1990, Arctic Refuge coastal waters.

		Recapture Area		
Tagging area	N	Camden Bay	Kaktovik and Jago lagoons	Beaufort Lagoon
Arctic char				
Camden Bay	321	1	0	0
Kaktovik / Jago	560	1	9	0
Beaufort Lagoon	83	0	0	1
Arctic cisco				
Camden Bay	179	0	0	0
Kaktovik / Jago	249	0	0	0
Beaufort Lagoon	69	0	0	0
Fourhorn sculpin				
Camden Bay	106	3	1	0
Kaktovik / Jago	254	0	7	0
Beaufort Lagoon	105	0	0	0
Arctic flounder				
Camden Bay	199	10	0	0
Kaktovik / Jago	335	0	2	0
Beaufort Lagoon	121	0	0	1

TABLE 14.– Summary of tagging and recapture data for fish species recaptured in Arctic Refuge coastal waters, summer, 1990.

Tagging location	Tagging date	Recapture location	Recapture date	Minimum distance traveled (km)	Length at tagging (mm)	Length at recapture (mm)	Tag number
			Arctic char				
JL14	07/19/90	SC01	08/17/90	62.0	392	411	FWS 09707
SC04	07/29/90	SC04	07/30/90	0.0	317	317	FWS 11394
BL02	08/05/90	BL02	09/03/90	0.0	345	347	FWS 12690
JL14	08/10/90	JL14	08/13/90	0.0	339	344	FWS 13578
JL14	08/03/90	JL14	08/08/90	0.0	312	318	FWS 13171
KL10	07/12/90	KL05	07/14/90	5.5	386	380	FWS 08863
KL05	07/14/90	KL05	07/16/90	0.0	323	333	FWS 09782
KL10	07/15/90	KL05	07/17/90	5.5	308	337	FWS 09754
KL10	07/15/90	KL05	07/26/90	5.5	308	327	FWS 09754
KL05	07/16/90	KL05	07/18/90	0.0	403	405	FWS 09584
JL14	08/03/90	KL10	08/11/90	5.5	278	376	FWS 13164
KL10	08/27/90	KL10	08/28/90	0.0	504	499	FWS 14937
[a]Oruk.	08/26/86	JL12	07/24/90	21.0	510	555	FWS 07468
			Arctic cisco				
[b]West Dock	07/22/90	SC01	08/13/90	150.0	261	271	LGL 2821
[b]Heald Point	07/16/88	JL14	07/10/90	202.0	364	444	LGL 8800299
			Fourhorn Sculpin				
JL14	07/23/90	JL14	08/04/90	0.0	232	230	FWS 09670
JL14	07/26/90	JL14	09/09/90	0.0	269	275	FWS 10985
KL05	09/11/90	KL05	09/12/90	0.0	265	262	FWS 14896
KL10	08/30/90	KL05	09/06/90	5.5	219	215	FWS 14092
SC01	07/28/90	SC04	08/14/90	5.0	218	224	FWS 11286
SC04	07/31/90	SC04	08/14/90	0.0	220	224	FWS 11088

[a]Oruktalik Lagoon
[b]Prudhoe Bay Area

TABLE 14.– Continued

Tagging location	Tagging date	Recapture location	Recapture date	Minimum distance traveled (km)	Length at tagging (mm)	Length at recapture (mm)	Tag number
			Fourhorn Sculpin				
SC04	07/28/90	SC04	08/14/90	0.0	208	210	FWS 11265
KL10	07/22/90	KL10	08/08/90	0.0	219	220	FWS 09658
KL10	07/27/90	KL10	09/01/90	0.0	239	239	FWS 14929
SC01	07/27/90	KL10	09/09/90	57.0	205	215	FWS 11182
KL05	08/09/90	KL10	09/11/90	5.5	232	240	FWS 13508
			Arctic Flounder				
JL12	07/24/90	JL14	07/26/90	4.0	218	220	FWS 10947
KL10	07/16/90	JL14	08/07/90	18.0	234	236	FWS 08909
BL02	07/16/90	BL02	08/03/90	0.0	211	212	FWS 12089
SC01	07/26/90	SC04	07/30/90	5.0	213	218	FWS 11183
SC04	07/27/90	SC04	08/02/90	0.0	223	224	FWS 11250
SC04	07/27/90	SC04	08/05/90	0.0	229	227	FWS 11239
SC01	07/30/90	SC01	07/31/90	0.0	217	211	FWS 11370
SC01	07/28/90	SC01	08/03/90	0.0	208	207	FWS 11280
SC01	07/26/90	SC01	08/05/90	0.0	226	232	FWS 11186
SC04	07/31/90	SC01	08/09/90	5.0	218	219	FWS 11084
SC04	07/29/90	SC01	08/15/90	5.0	225	224	FWS 11388
SC04	08/11/90	SC01	09/22/90	5.0	209	205	FWS 11922
SC04	08/12/90	SC01	09/02/90	5.0	214	211	FWS 11935
			Least cisco				
[b]Point Prower	07/25/85	SC01	07/29/90	125.0	323	340	ENV 20637
[b]Endicott	07/15/90	SC04	07/27/90	133.0	293	290	LGL 3423
[b]West Dock	07/17/88	SC01	07/27/90	150.0	341	347	LGL 00693
[b]Endicott	07/15/90	SC04	07/28/90	133.0	296	295	LGL 3507

[b]Prudhoe Bay Area

subsistence and commercial fisheries. Travel distances exceeded 210 km from the original tagging sites. Travel time was from 75 to 99 days (travel rate over 2 km/d).

Six fish tagged in the Prudhoe Bay area by other investigators were recaptured during the 1990 field season (Table 14). Two were Arctic cisco tagged by LGL, Alaska Research Associates, Inc (LGL). One, originally tagged on July 22 was recaptured in Camden Bay 22 days later on August 13 (a travel rate of 6.4 km/d). The other, originally tagged on July 16, 1988 was recaptured approximately 202 km east of Prudhoe Bay in Jago Lagoon on July 10, 1990. Four least cisco tagged by other investigators were recaptured 140 km east of Prudhoe Bay in Camden Bay. One least cisco tagged by Envirosphere company measured 323 mm FL on July 25, 1985 and 340 mm FL at recapture on July 29, 1990. Two least cisco tagged by LGL on July 15, 1990 were recaptured 12 and 13 days later at Camden Bay (travel rate of 11.6 and 10.8 km/day, respectively). A fourth least cisco originally tagged by LGL on July 17, 1988 measured 341 mm FL when tagged and was 347 mm FL two years later.

DISCUSSION

RELATIVE ABUNDANCE AND DISTRIBUTION

The most notable change during 1990 compared to previous years was the prevalence of small Arctic cisco (≤200 mm FL). The change was due to increased catches of young-of-the-year Arctic cisco except at Camden Bay. In contrast, low catch rates occurred at all sampling stations in 1988 and 1989. Total catches of Arctic cisco in 1988, 1989 and 1990 were 21,006, 7,626 and 117,316 representing 27%, 2% and 39% of the species composition, respectively (Fruge et al. 1989; Palmer and Dugan 1990).

Small Arctic cisco (≤ 200 mm FL) not only occurred in greater abundance during 1990, but the young-of-the-year appeared earlier. Catch rates of over 100 fish/d occurred by July 14 in Beaufort Lagoon, July 31 in Kaktovik and Jago lagoons, and August 5 in Camden Bay. The first occurrence of small Arctic cisco (≤ 200 mm FL) catch rates exceeding 100 fish/d did not appear until July 20 in 1988 (Fruge et al. 1989) and August 26 in 1989 (Palmer and Dugan, 1990).

The reason for the relatively early arrival of Arctic cisco may be strong winds from the east. Fechhelm and Griffiths (1990) stated that recruitment of young-of-the-year Arctic cisco was aided by wind driven ocean currents. In addition, they said that in years with steady east winds, Arctic cisco arrive in Alaskan waters earlier than in years when wind vectors are mixed. Complete analysis of meteorologic data may yield a more complete picture.

Relative abundance of Arctic char during the 1990 field season fluctuated both spatially and temporally. Apparent spatial variability, not suggested by 1988 and 1989 data, was evident by increasing seasonal catch rates from east to west (Table 4). However, this perceived pattern from east to west could be an artifact of net station placement. A temporal pattern is suggested for Arctic char by corresponding high catch rates for stations SC01, KL05 and BL02 in July (Figures 7-9). Only station SC01 appears to have similar high catch rates in previous field seasons. These changes in relative abundance could be a result of greater Arctic char abundance, increased movement along pathways between preferred summer and winter habitat, weather patterns, oceanographic conditions, movement of food resources and/or variability between stations.

Spatial and temporal trends of relative abundance of Arctic cisco >200 mm FL were evident. Variability was high. Catch rates appeared to differ by sampling area, with an apparently increasing trend from east to west (Table 4). Similar spatial variability was suggested in 1988 and 1989 (Fruge et al. 1989 and Palmer and Dugan 1990). Temporal variations were indicated by corresponding maximum catch rates in Camden Bay, Beaufort Lagoon and station KL05 in Kaktovik Lagoon occurring during late July to early August. These maximum rates appear to be consistent with observations from previous field seasons for stations SC01 and KL05. Catch rates also appeared to decrease in all sampling areas in September. As with Arctic char these

observed trends may be the product of variability between stations, or the effect of abiotic and biotic factors.

In 1988 and 1989 Arctic cod was the most abundant species, however, in 1990 Arctic cod numbers were less than those of Arctic cisco. Arctic cod made up 38%, 68% and 28% of the total catch in 1988, 1989 and 1990, respectively. The reduction as a percent of the catch in 1990 is due to the increased catches of Arctic cisco rather than a reduction in Arctic cod catches. In Camden Bay, where the bulk of Arctic cod are usually captured, catches were actually lower in 1988 than in 1990. Arctic cod total catch appears to be driven by a few days with extremely high catch rates in Camden Bay.

Relative abundance of fourhorn sculpin varied by location in 1990. Daily catch rates were highly variable and did not exhibit trends in temporal distribution. Camden Bay had the highest daily catch rates and relative abundance appeared to decrease from west to east. This suggests that sampling area variability is present, and that a possible relationship between environmental factors and fish movements might exist.

During 1990, Arctic flounder catch rates appeared to vary temporally. Inconsistent with information from previous field seasons (Fruge et al. 1989; Palmer and Dugan 1990), Arctic flounder catch rates decreased at most sampling stations after August 15, although stations BL02 and KL05 continued to have some high catch rates after this date. Maximum catch rates were higher in 1990 than in 1989 at all sampling areas. Similar to 1989, catch rates at station KL05 were highly variable throughout the field season.

Collection of gill net data during the 1990 field season was hampered by poor weather conditions, significantly reducing sample sizes. Although catch rates of Arctic char and Arctic cisco were highest nearshore, at the shallowest depths, these differences are not significant. Thorsteinson et al. (1991) found that Arctic char and Arctic cisco had a preference for nearshore waters during the 1990 open water season. This is similar to findings for Arctic cisco during the 1988 and 1989 field seasons (Fruge et al. 1989; Palmer and Dugan 1990). Results for Arctic char during previous field seasons may contrast with the findings of Thorsteinson et al. (1991) because there was no significance difference in catch between nearshore and offshore sites, although sample sizes were relatively small.

Experimental fyke nets did catch fish, but were difficult to maintain and generally had limited application. Although no analyses were done, the number of species caught in experimental fyke nets appear less than that of the standard fyke nets. Inside Beaufort Lagoon experimental nets caught small Arctic cisco ($\leq$ 200 mm FL) quite well, but did not catch them outside the barrier island. Large Arctic cisco (> 200 mm FL) were not caught in the nets. It was not possible to tell from the data if these differences stem from a lack of fish or net design and efficiency. More importantly, however, was the problem of net maintenance. Outside the barrier islands it was difficult to keep the net fishing. Floating ice and wave action

knocked down traps, leads, and wings. Downed traps and netting were often buried in sand requiring a substantial number of hours to retrieve them. Therefore, the experimental nets were unreliable and labor intensive when used as intended outside the barrier islands.

LENGTH FREQUENCY DISTRIBUTIONS

Length frequency distributions of Arctic char caught in 1990 have some similarities to distributions from previous years (Fruge et al. 1989; Palmer and Dugan 1990). In Camden Bay modal groups between 200 and 300 mm FL were present throughout the four time periods during 1989. In contrast, all size groups were poorly represented in September, 1990. In Kaktovik and Jago lagoons Arctic char less than 100 mm FL were present in 1989, but absent in 1990. In Beaufort Lagoon during 1989 and 1990, two modal groups were present with Arctic char of approximately 300 mm FL poorly represented. At the same time Arctic char of that size were well represented in Kaktovik and Jago lagoons and Camden Bay.

Length frequency distributions of Arctic cisco (<300 mm FL) showed that young-of-the-year appeared earlier in the year than in 1989 (Palmer and Dugan 1990). Although no sampling occurred in Beaufort Lagoon in 1988, young-of-the-year were present by July 31 in Pokok Bay (Fruge et al. 1989). Distributions for Arctic cisco (<300 mm FL) in 1990 were more similar to those in 1988 than 1989 (Fruge et al. 1989; Palmer and Dugan 1990).

Representation of large Arctic cisco (>300 mm FL) frequency distributions progressively decreased during the season. Large fish were poorly represented after August 16 at Camden Bay, September 1 at Kaktovik and Jago lagoons, and August 1 at Beaufort Lagoon. A similar change in the size structure occurred in 1988 and 1989 (Fruge et al. 1989; Palmer and Dugan 1990). Current hypotheses suggest this would occur as mature Arctic cisco migrate from the Prudhoe Bay area to the Mackenzie River for spawning.

The length frequency distributions of Arctic cod appeared to be somewhat different from those of 1989 (Palmer and Dugan 1990). In Beaufort Lagoon, a large modal group between 70 and 90 mm FL was present in 1989, but absent in 1990. Also, in Camden Bay and Kaktovik and Jago lagoons in 1989, the mode was greater than 100 mm FL while in 1990 it was less than 100 mm. More than one explanation for this discrepancy is possible. One explanation could be that growth may have been somewhat slower in 1990 and the mode shifted to the left. Another explanation could be that the dominant age class was >100 mm FL in 1989 and <100 mm FL in 1990. As in 1989, Arctic cod were not caught in Beaufort Lagoon until September.

Length frequency distributions of fourhorn sculpin were similar to those of 1989. There is some evidence that the modal group from 50 to 100 mm TL was proportionally larger in 1990 (Figures 38-40) as compared to 1989 (Palmer and Dugan 1990). This may indicate a stronger year class moving through the population.

Arctic flounder length frequency distributions changed substantially in 1990 compared to previous years (Fruge et al. 1989; Palmer and Dugan 1990). Larger fish (150 to 250 mm TL) that dominated the distribution in 1989 were still present, but reduced as a proportion of the catch. The large modal group (<50 mm TL) that appeared in September 1989 only at Kaktovik and Jago lagoons appeared again at all sampling areas in 1990.

WEIGHT-LENGTH RELATIONSHIPS

Weight-length regressions coefficients estimated during 1990 were similar to those in other years (Fruge et al. 1989 and Palmer and Dugan 1990). Strict statistical comparisons among years will be presented in the final project report, but reported coefficients are useful to estimate weight of individual given the length.

FISH CONDITION

Differences in early and late weight-length relationships as detected by analysis of covariance indicated a change in condition. Changes (except for Arctic cisco) reflected an increase in weight at a given length: fish became more robust between the early time period and the late time period. One would expect fish would develop fat reserves and gonadal tissue during the warm summer season.

In contrast, Arctic cisco appeared to lose weight at a given length during the 1990 summer. Several explanations are possible. One explanation would suggest that different populations were sampled in the two time periods. If so, our results would only reflect the differences between populations and not a change in condition of one population. Given the transient nature of Arctic cisco, separate populations are possible. A second explanation of reduced condition might be that Arctic cisco were stressed in September and lost weight. Stress might be caused by lower temperature or higher salinities. Third, it is possible that large Arctic cisco, which were poorly represented in the late time period, had a reduced effect on the regression calculation and so changed the relationship.

FISH MOVEMENTS

Less than one percent of the Arctic char marked during the 1990 field season were recaptured. Most recaptures occurred in the original sampling area where the fish were tagged. Arctic char start returning to the freshwater systems for overwintering as early as August and continue this migratory pattern into October (Craig 1984). Three Arctic char recaptured in freshwater rivers in 1990 were originally tagged at coastal sampling stations in the Arctic Refuge. Our data appear consistent with current migration theories for this species in Beaufort Sea coastal waters (Craig 1984).

Westward movement in refuge waters was documented for small Arctic cisco (<200 mm FL) during 1990 by the recapture in Camden Bay of a fish dye marked in Kaktovik Lagoon. Fechhelm and Fissel (1988) and Fechhelm and Griffiths (1990) indicate that wind driven longshore currents aid young-of-the-year Arctic cisco in their westward dispersal out of refuge waters from Canada, but little is known about the movement of older immature fish. Migrating young Arctic cisco (ages 0-1) from the Mackenzie River are believed to be moving westward through refuge waters to overwintering areas in the Colville and Sagavanirktok River deltas, and moving back toward the Mackenzie River upon maturity (Gallaway et al. 1983).

Although only two large Arctic cisco (>300 mm) were recaptured during the 1990 field season, their movements seem consistent with past findings. These two Arctic cisco, one recaptured in Camden Bay and the other in Jago Lagoon, had been originally tagged in the Prudhoe Bay area. These movements eastward of older, larger Arctic cisco are consistent with current migration theories for this species in Beaufort Sea coastal waters (Gallaway et al. 1983). Gallaway et al. (1983) believed that mature Arctic cisco (age 7-9; >350 mm FL) migrate east to the Mackenzie River to spawn.

Fechhelm et al. (1989) hypothesized that anadromous least cisco found in the Prudhoe Bay waters are members of the Colville River population which disperse along the coast during the brief summer and return to the Colville prior to freeze up. The recapture of four least cisco at Camden Bay during July appears to be consistent with this explanation.

Movement patterns of fourhorn sculpin and Arctic flounder during the 1990 field season were localized. Our findings are generally consistent with studies by Craig (1984) and Palmer and Dugan (1989) who reported localized movement patterns for both these species in Arctic coastal waters.

ACKNOWLEDGMENTS

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APPENDIX A: Length Frequency Distributions of Arctic char and Arctic cod in 5 mm increments.

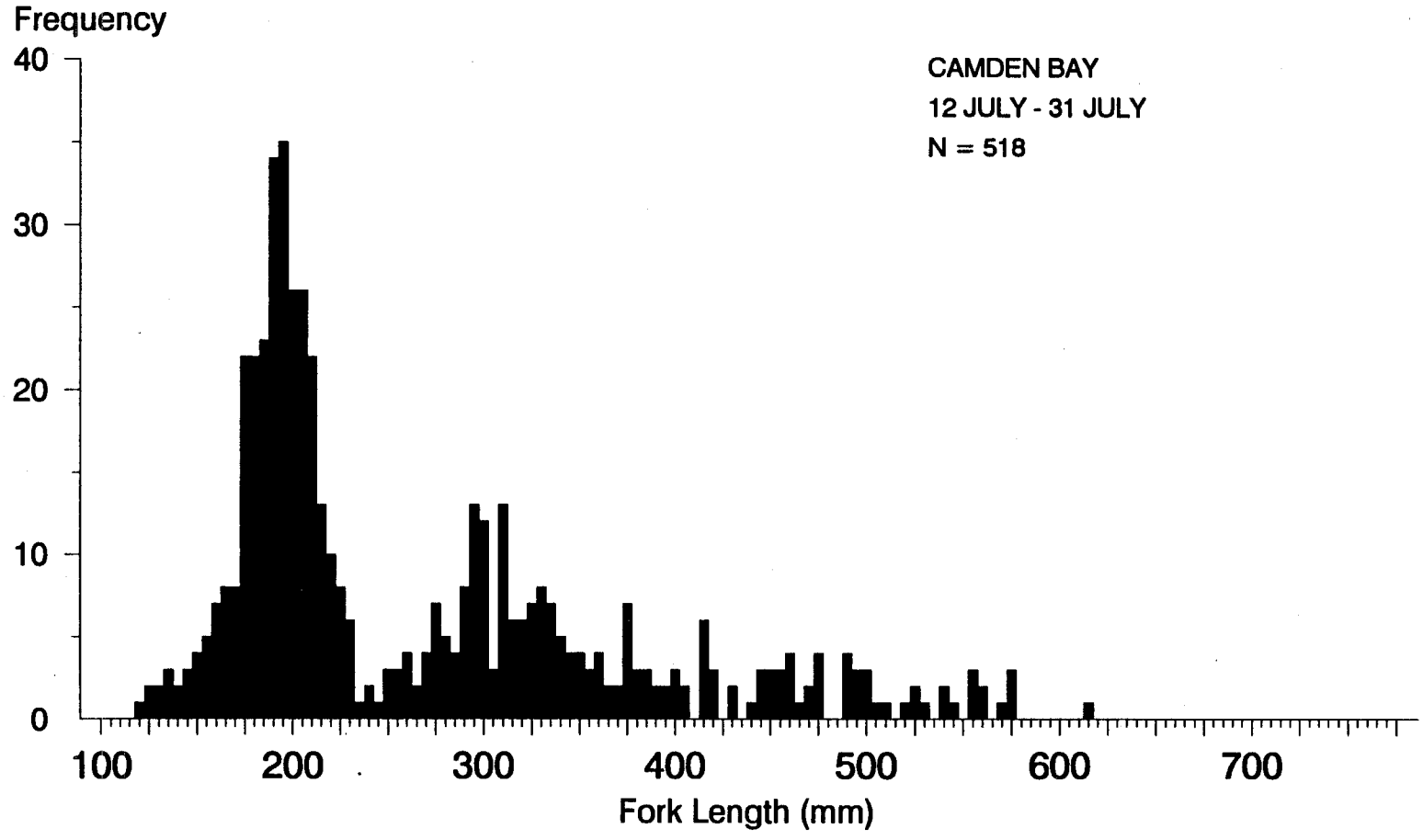

FIGURE A.1.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Camden Bay, 12 July - 31 July, 1990.

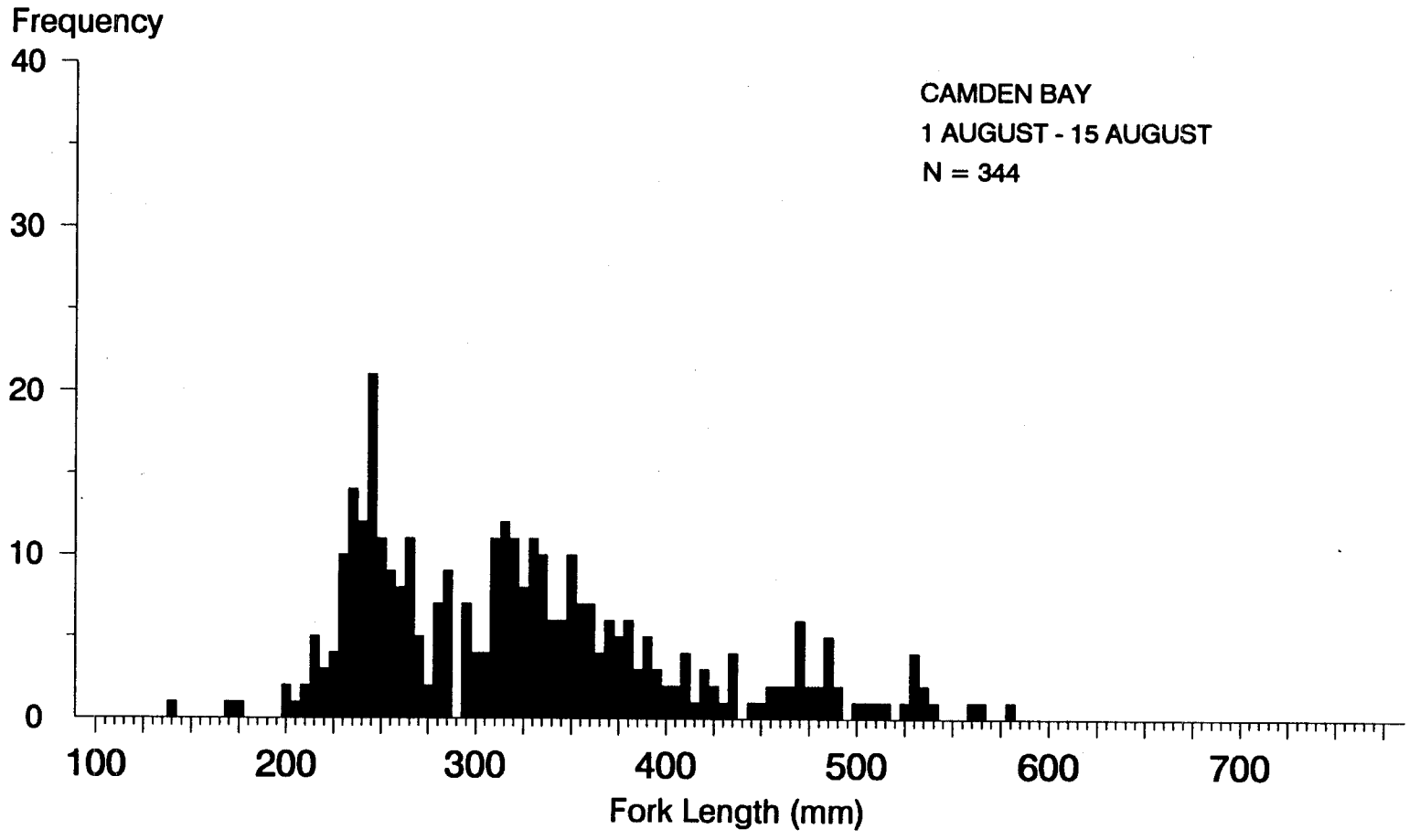

FIGURE A.2.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Camden Bay, 1 August - 15 August, 1990.

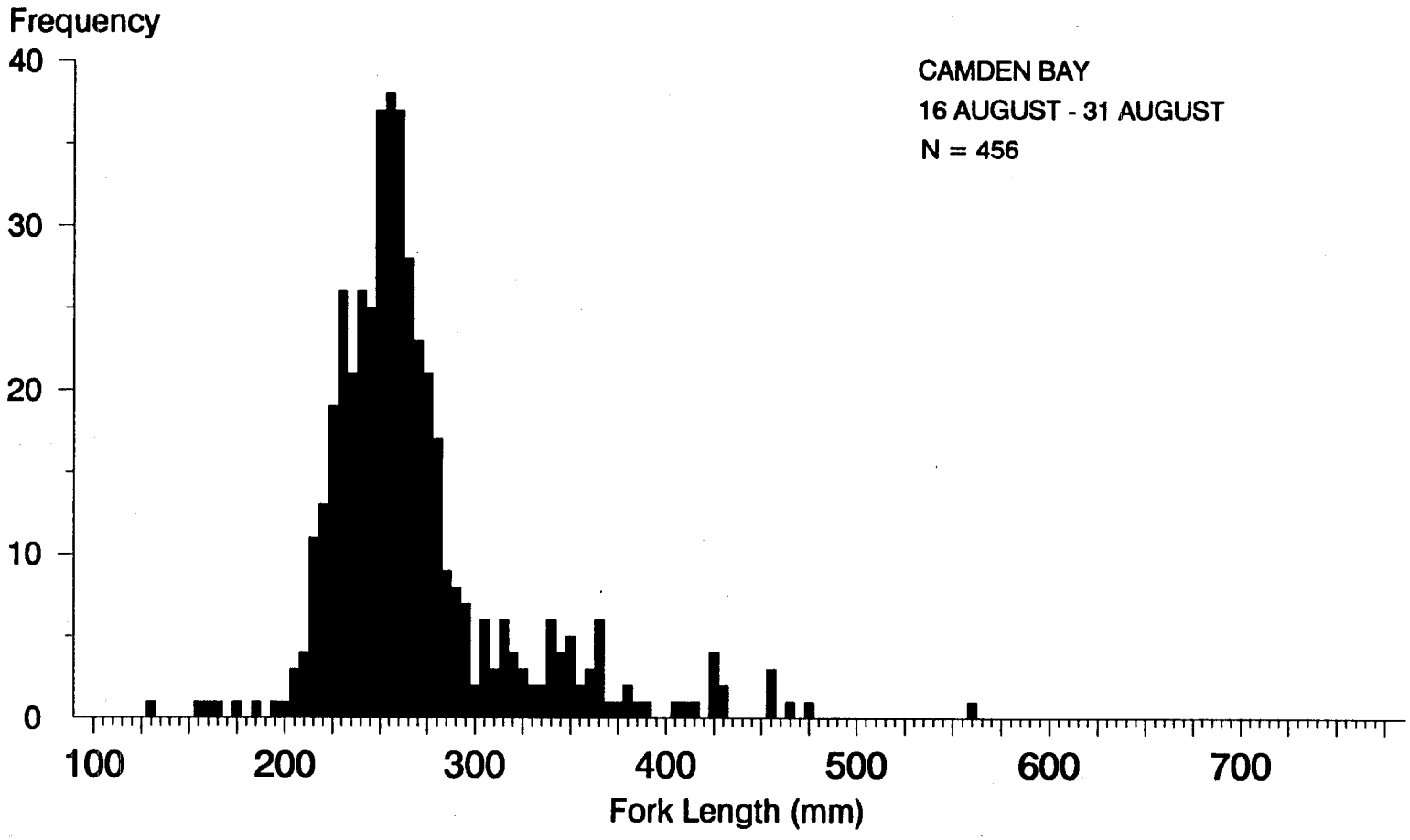

FIGURE A.3.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Camden Bay, 16 August - 31 August, 1990.

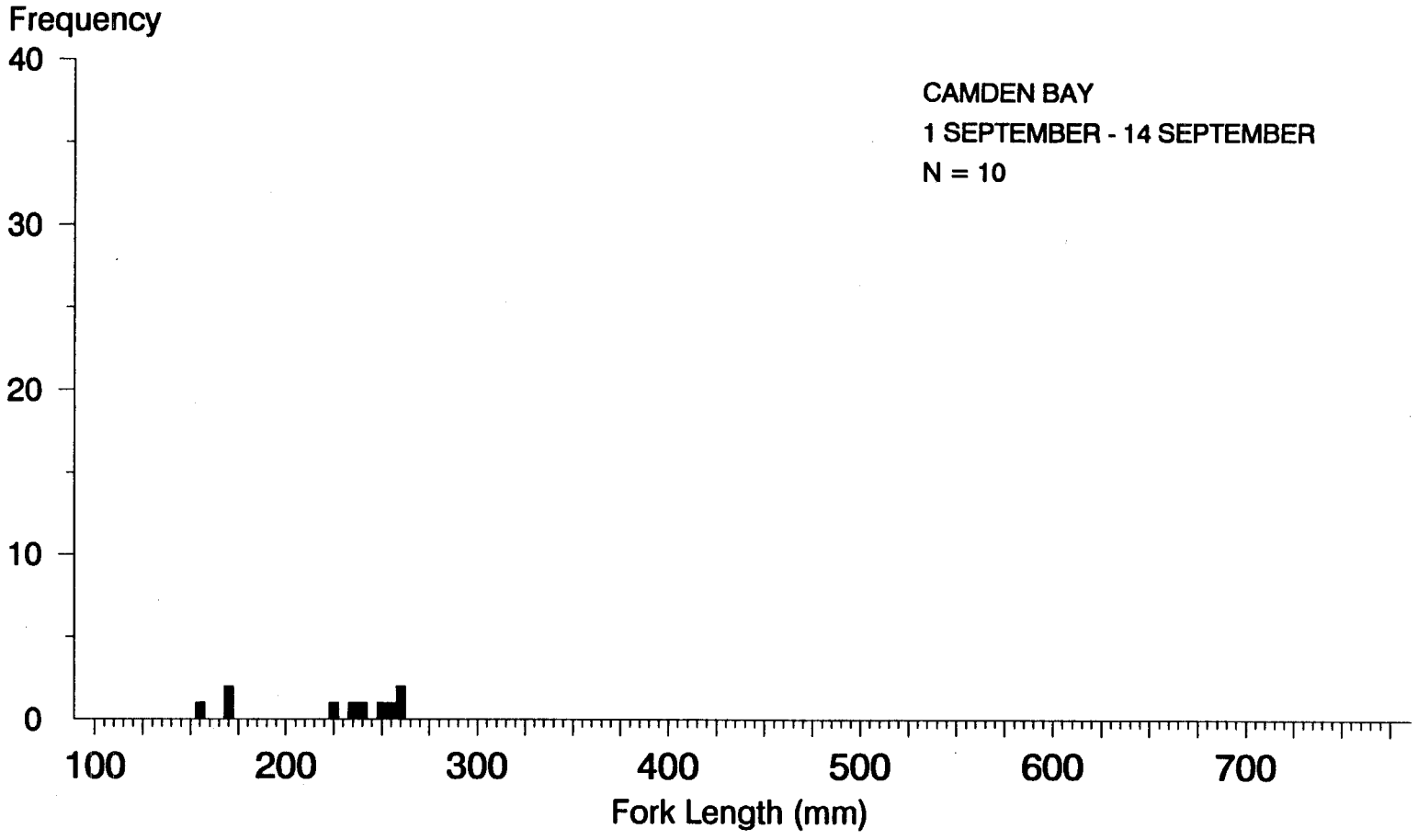

FIGURE A.4.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Camden Bay, 1 September - 14 September, 1990.

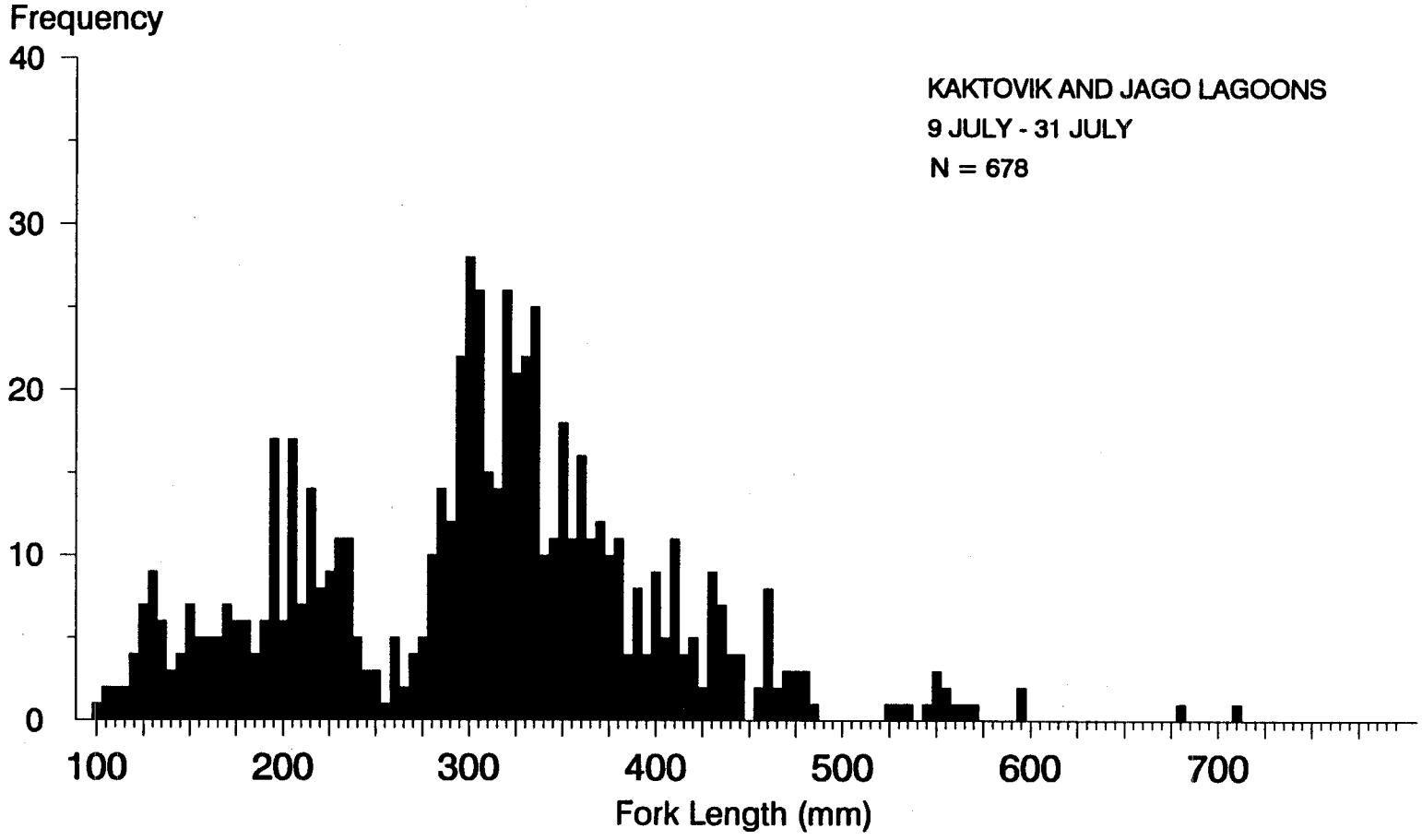

FIGURE A.5.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Kaktovik and Jago lagoons, 9 July - 31 July, 1990.

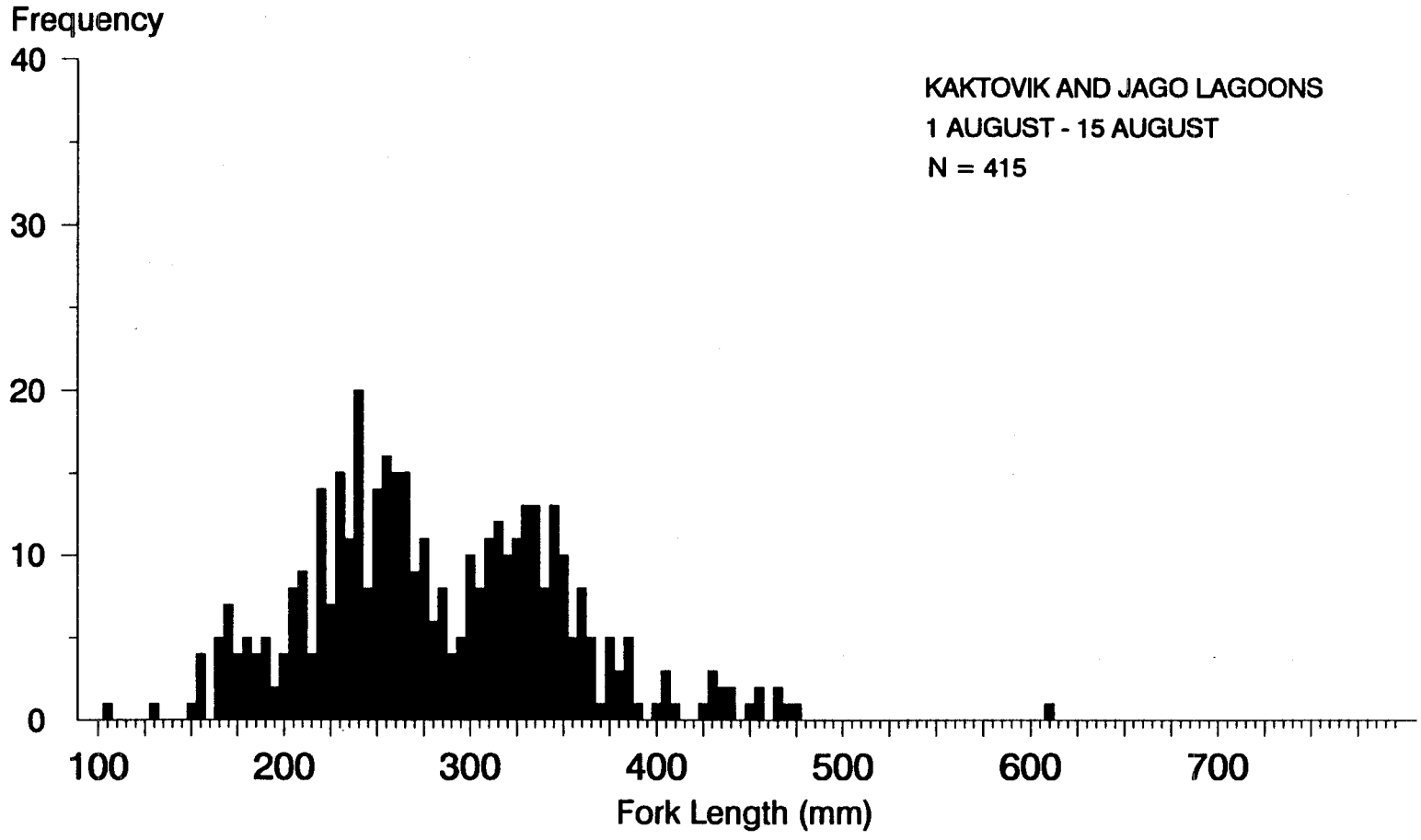

FIGURE A.6.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Kaktovik and Jago lagoons, 1 August - 15 August, 1990.

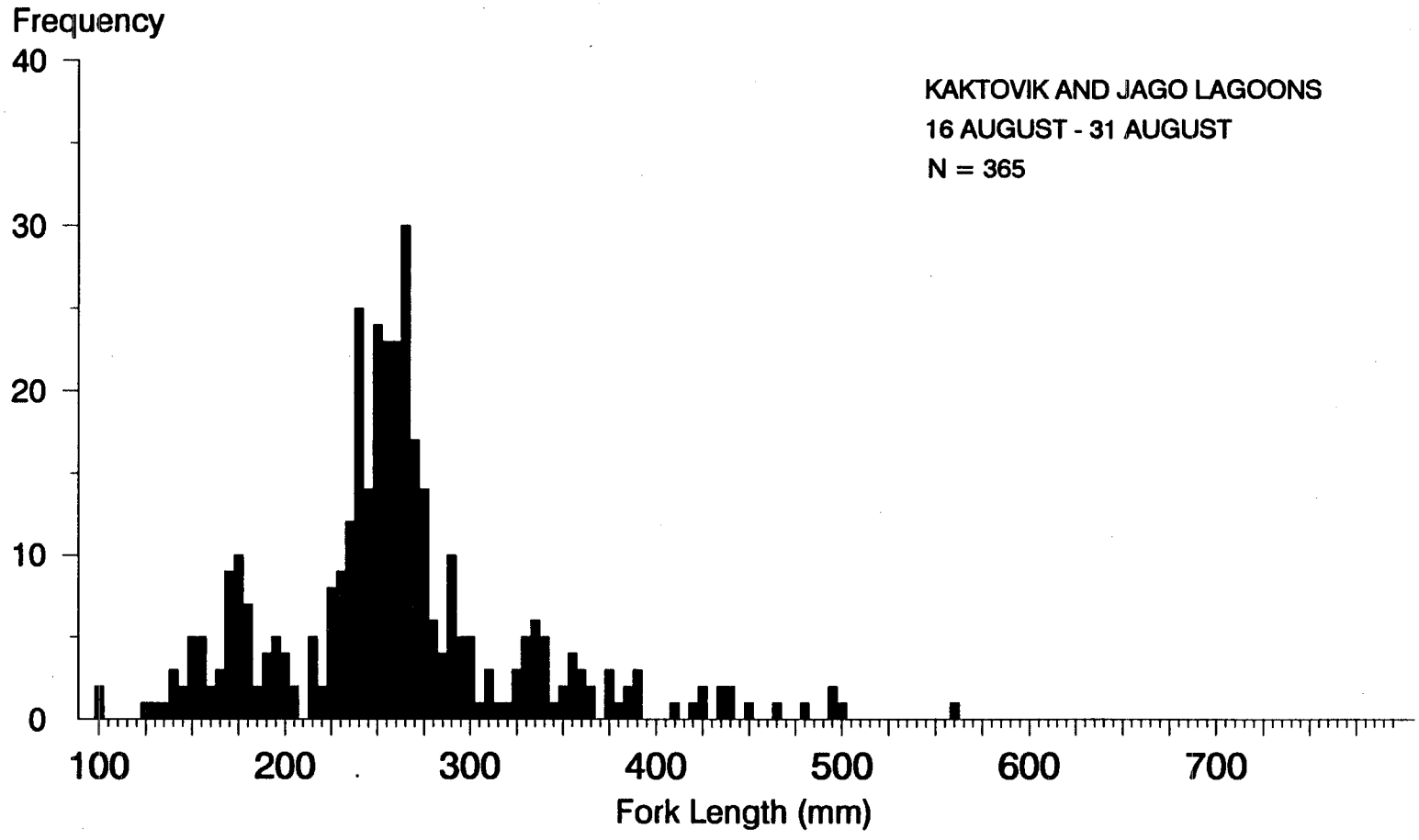

FIGURE A.7.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Kaktovik and Jago lagoons, 16 August -31 August, 1990.

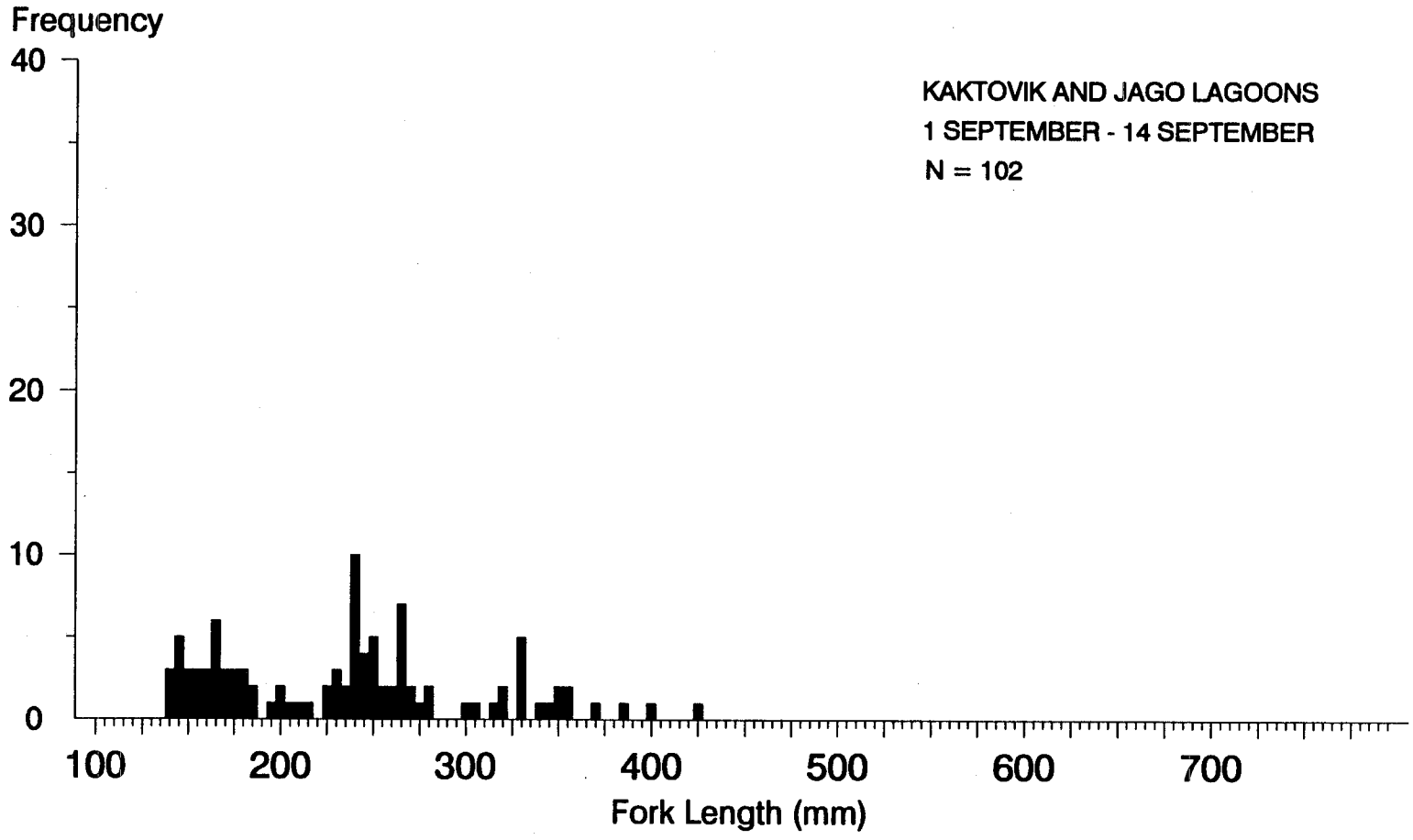

FIGURE A.8.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Kaktovik and Jago lagoons, 1 September - 14 September, 1990.

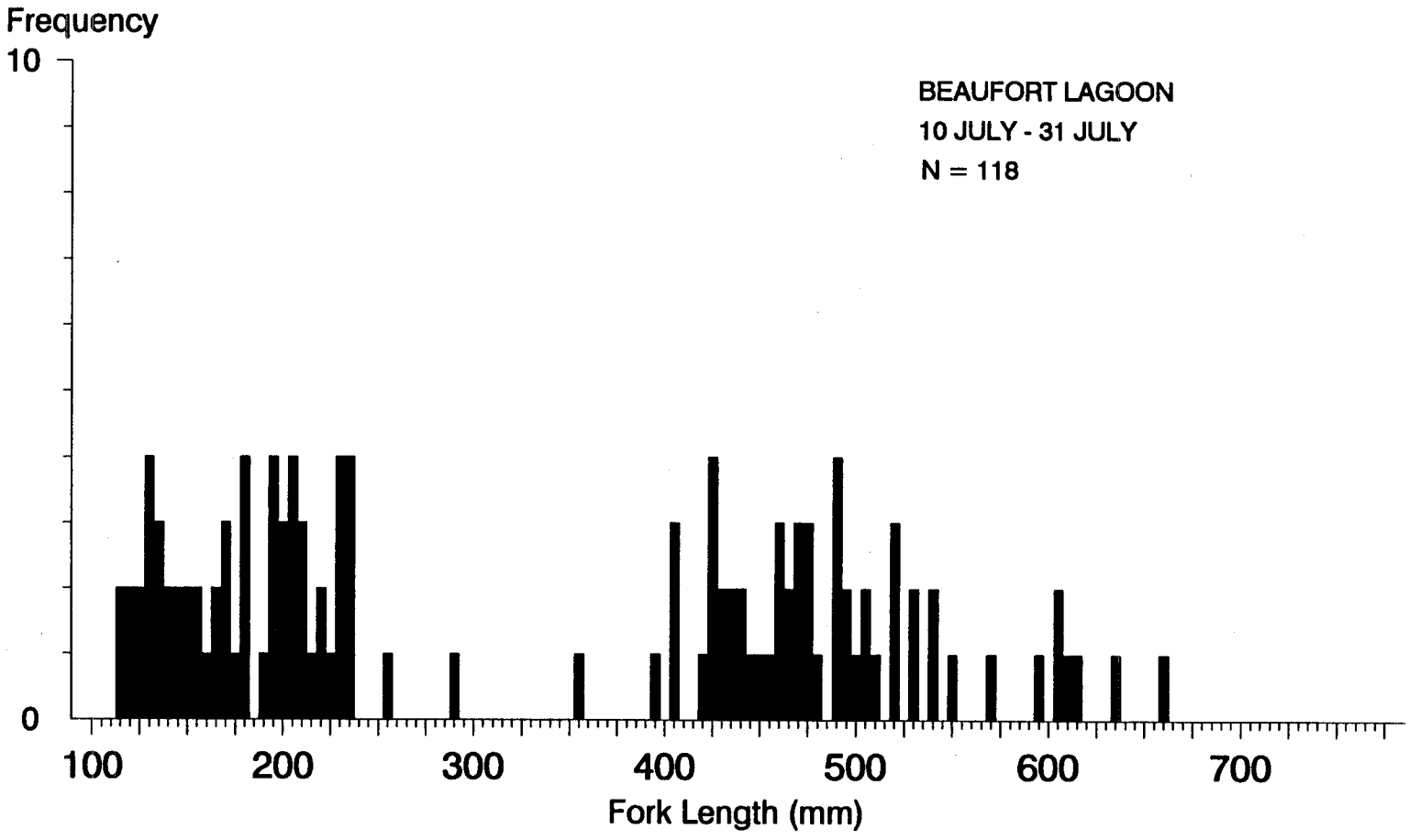

FIGURE A.9.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Beaufort Lagoon, 10 July - 31 July, 1990.

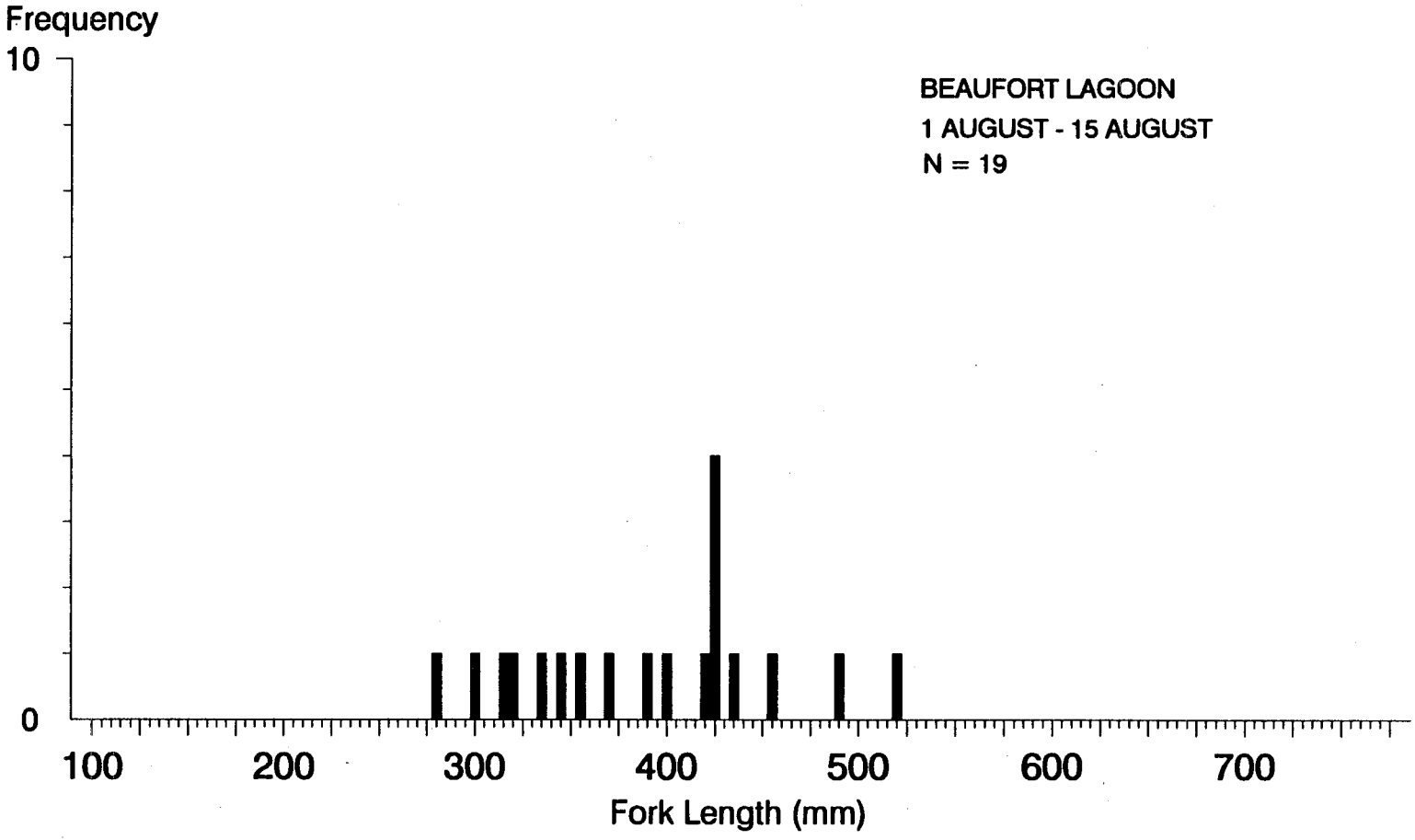

FIGURE A.10.- Length frequency (5 mm increment) of Arctic char captured by fyke nets in Beaufort Lagoon, 1 August - 15 August, 1990.

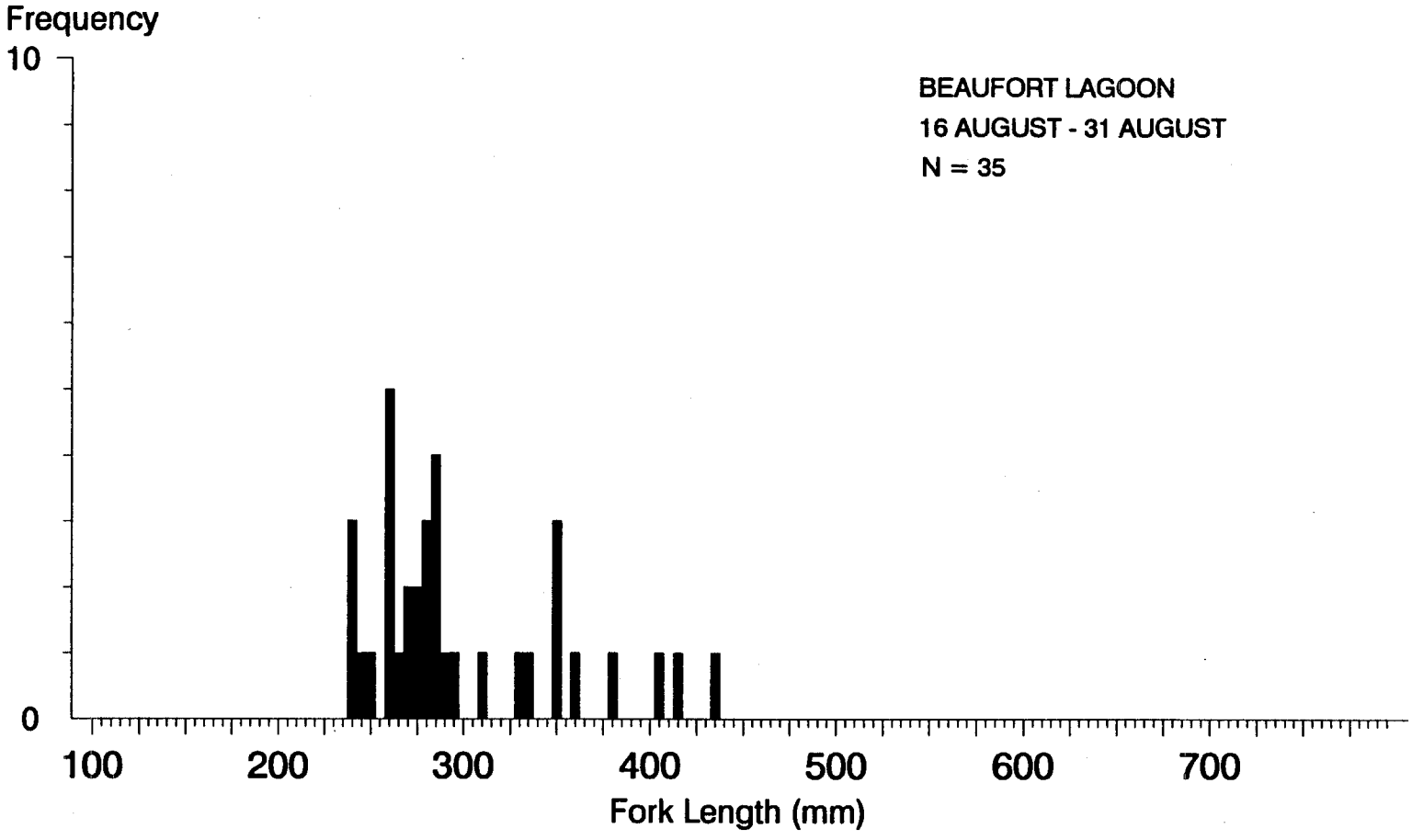

FIGURE A.11.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Beaufort Lagoon, 16 August - 31 August, 1990.

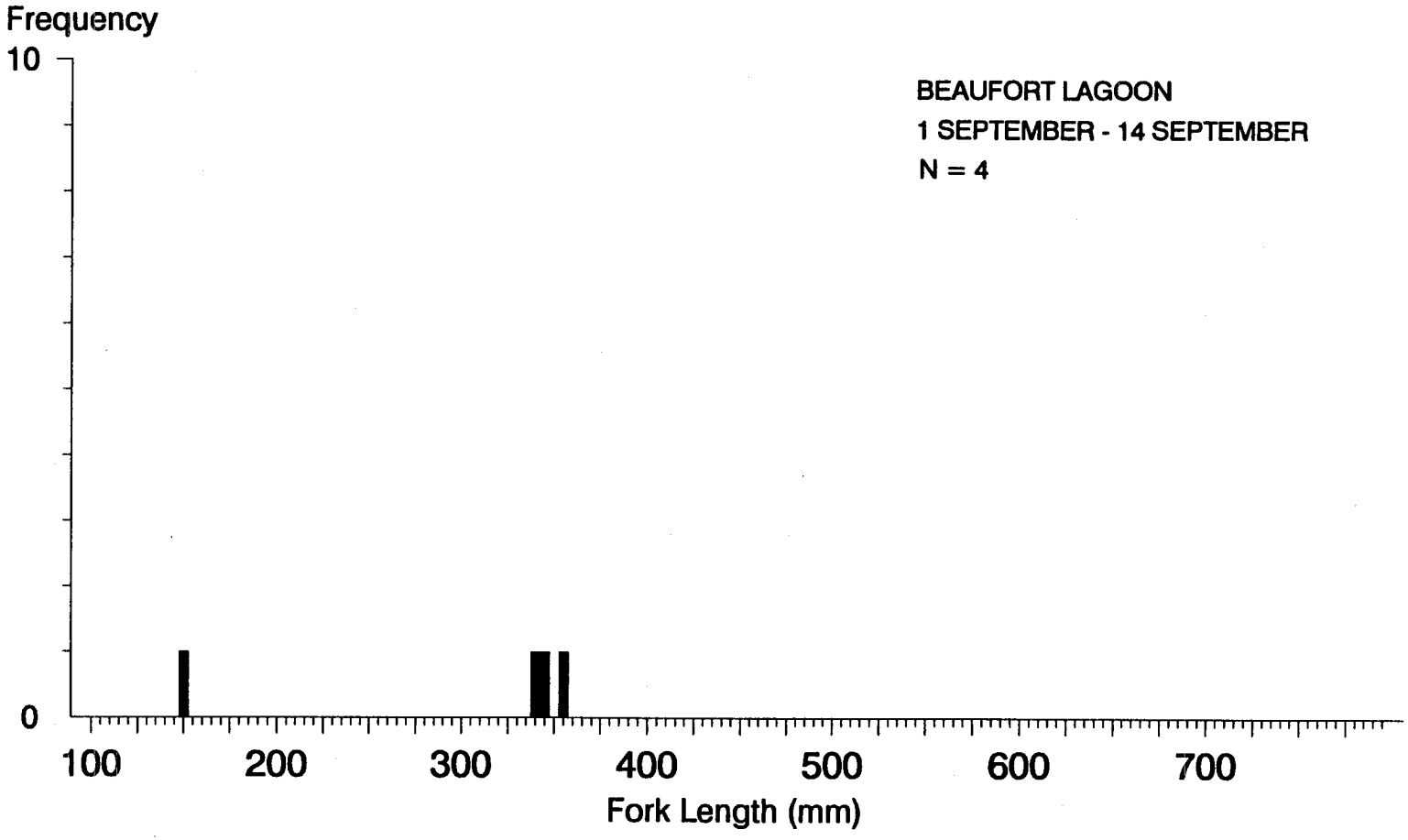

FIGURE A.12.– Length frequency (5 mm increment) of Arctic char captured by fyke nets in Beaufort Lagoon, 1 September - 14 September, 1990.

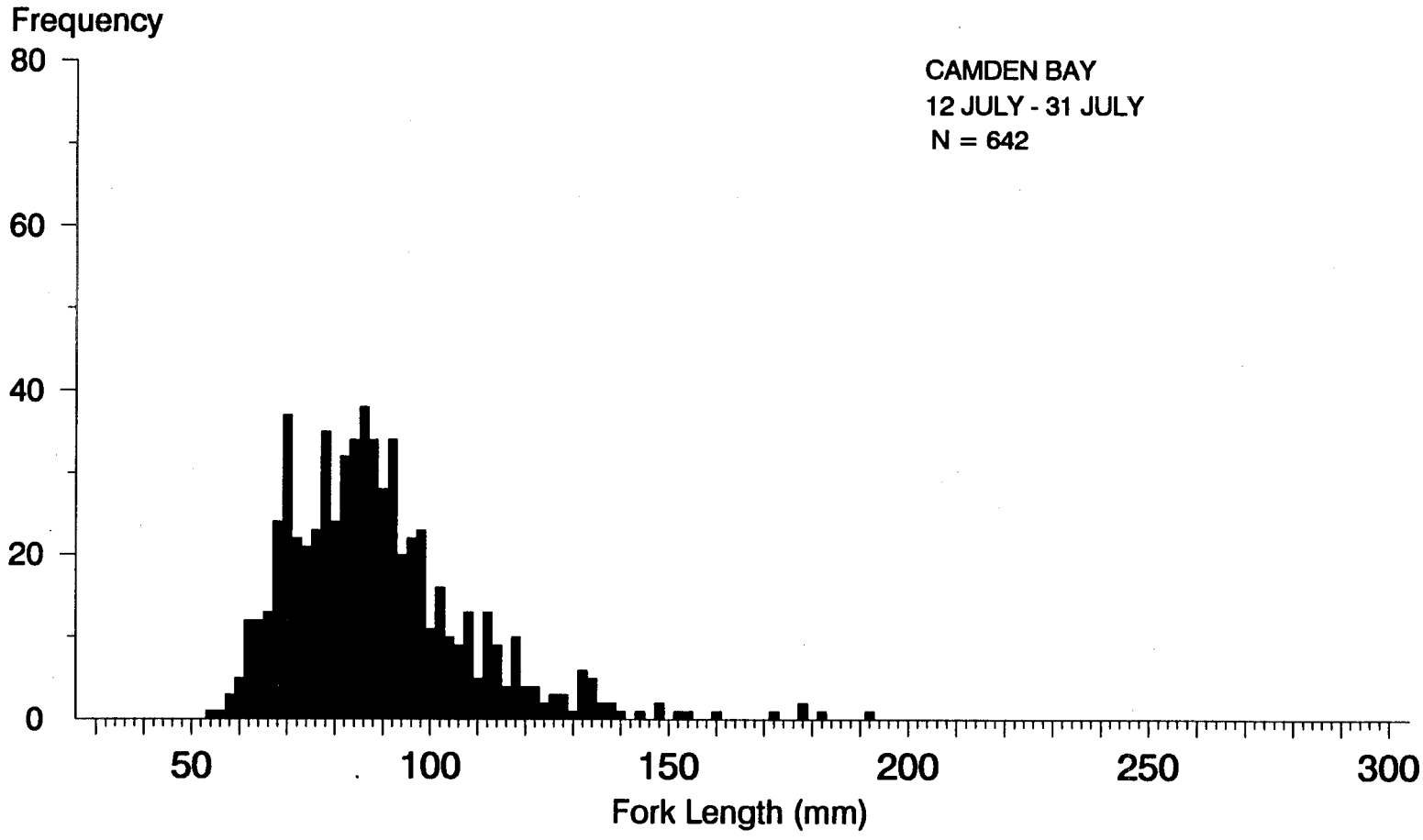

FIGURE A.13.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Camden Bay, 12 July - 31 July, 1990.

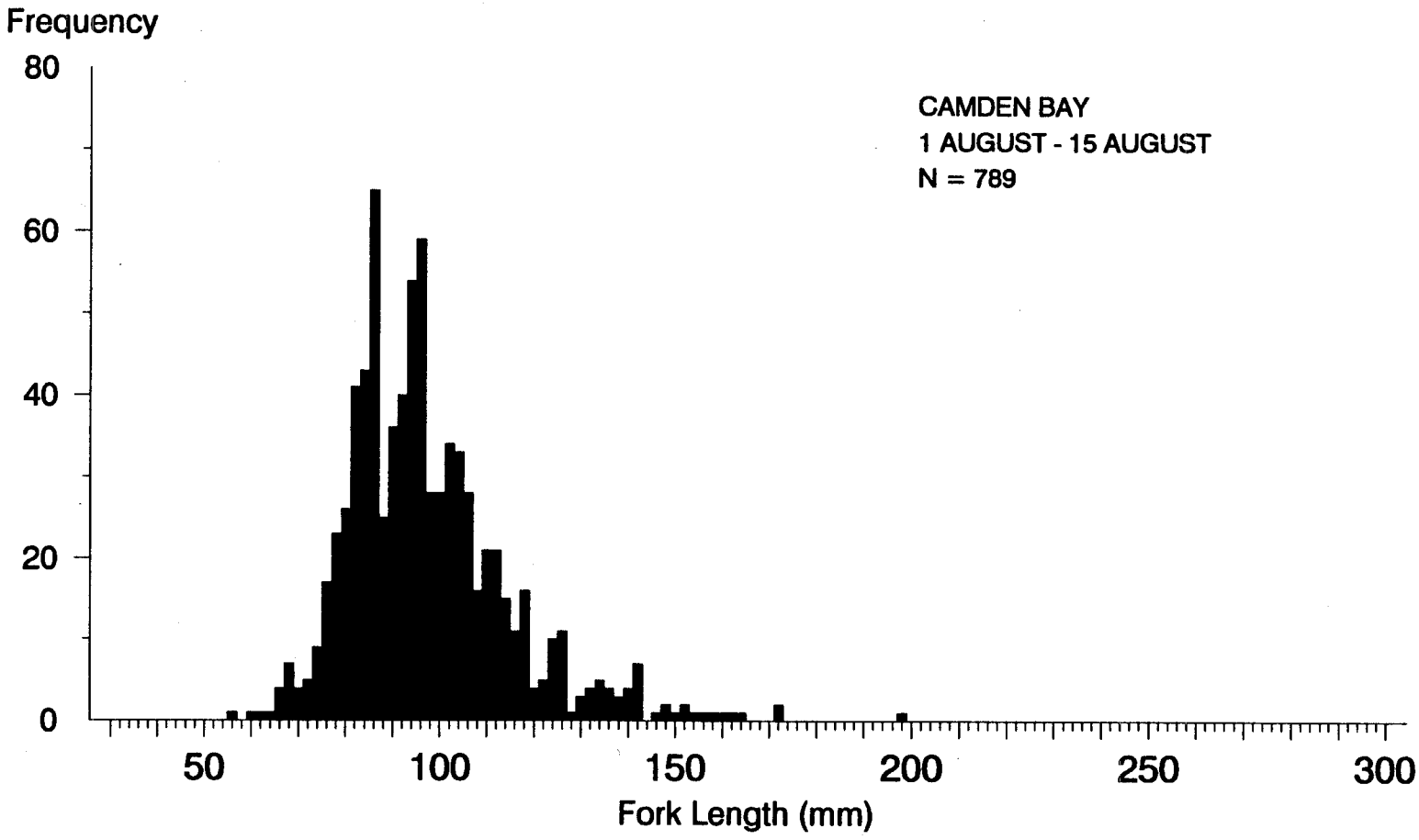

FIGURE A.14.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Camden Bay, 1 August - 15 August, 1990.

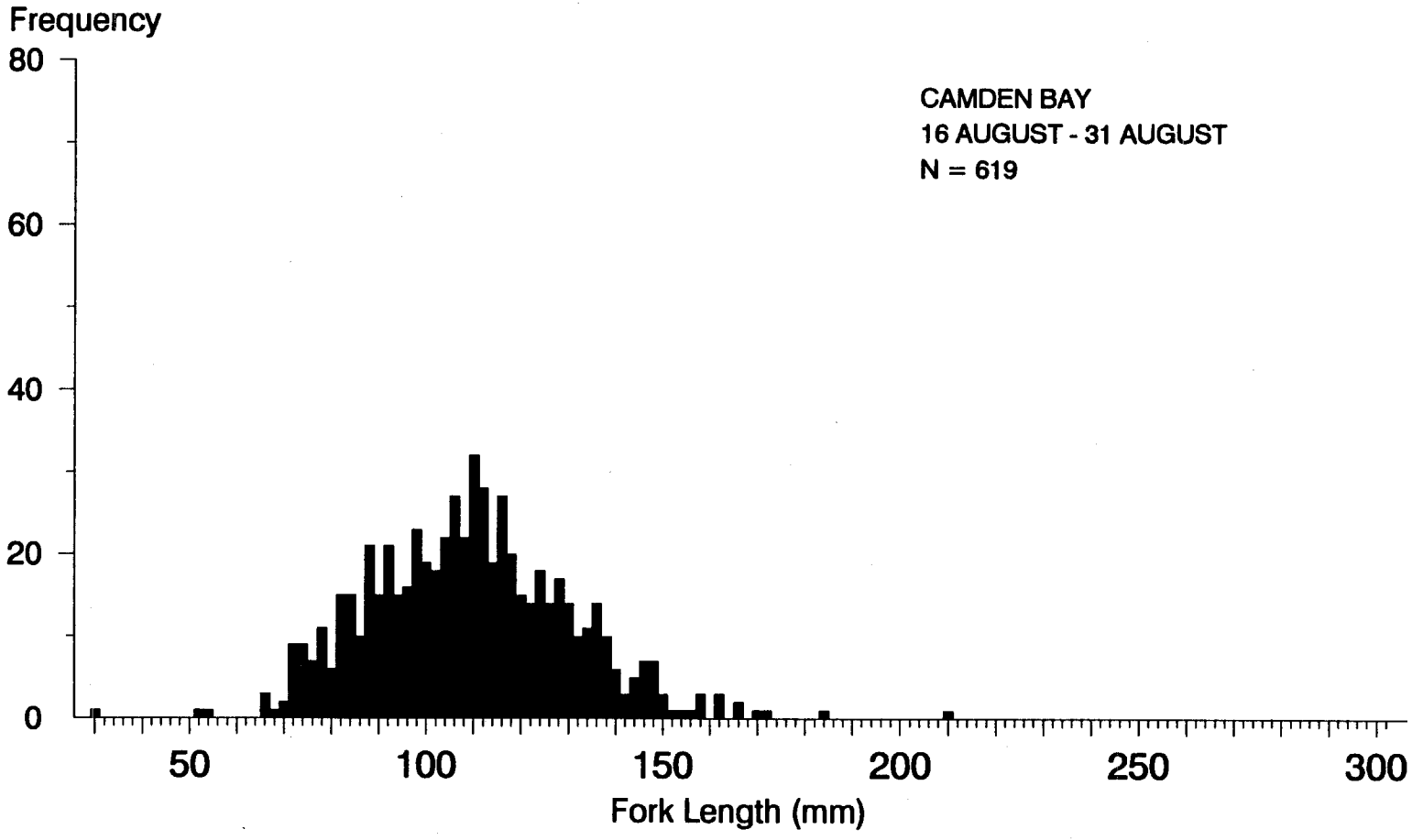

FIGURE A.15.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Camden Bay, 16 August - 31 August, 1990.

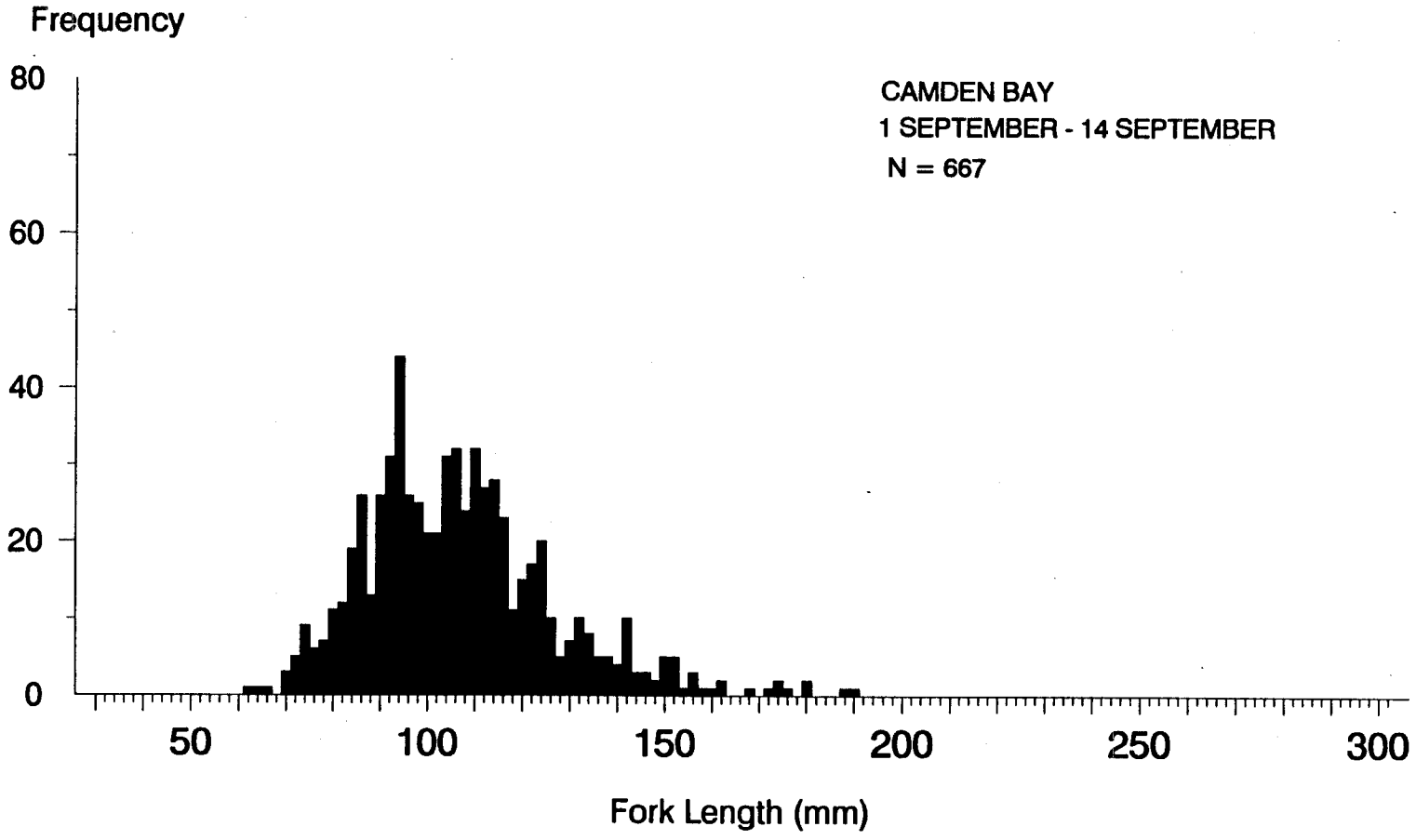

FIGURE A.16.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Camden Bay, 1 September - 14 September, 1990.

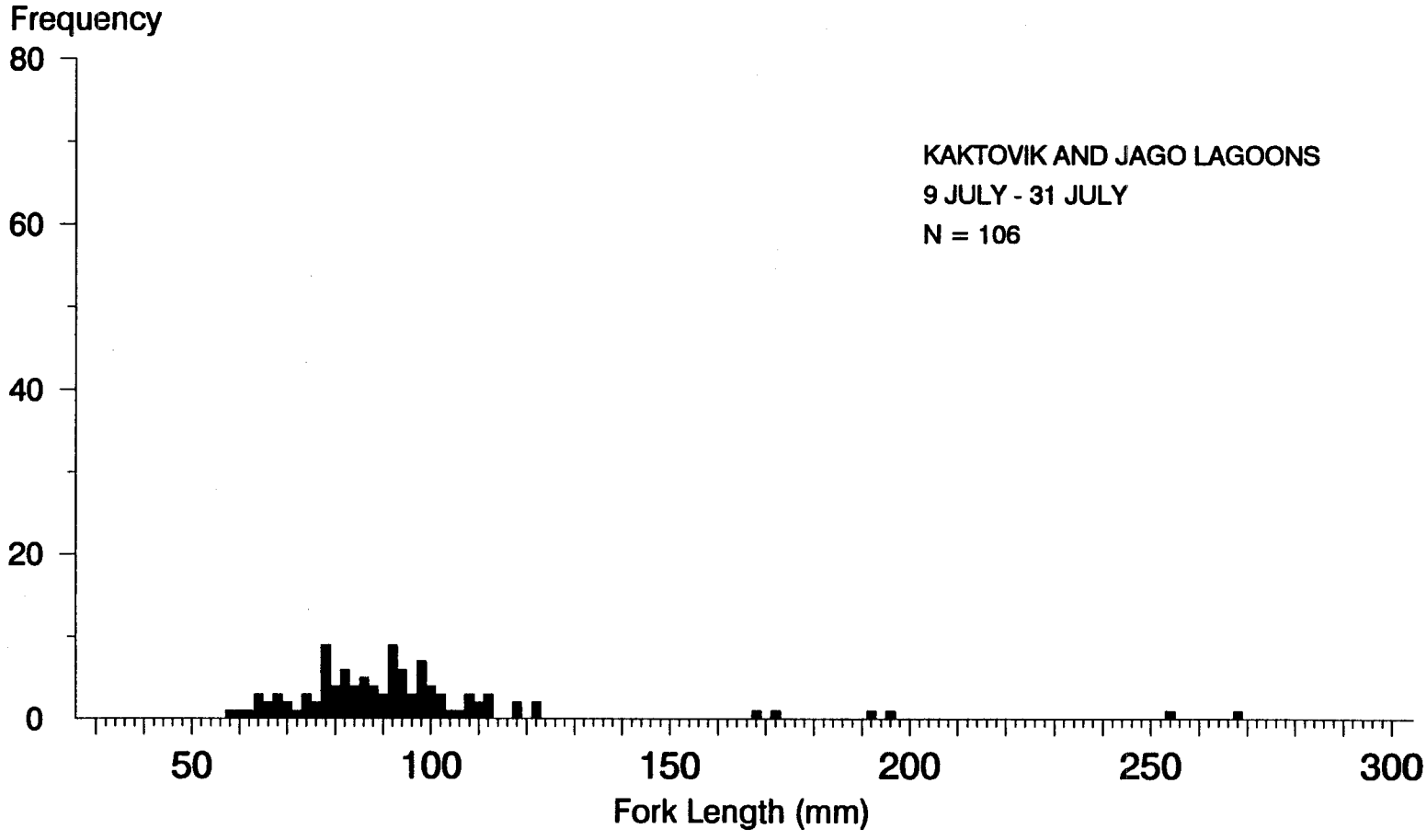

FIGURE A.17.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Kaktovik and Jago lagoons, 9 July - 31 July, 1990.

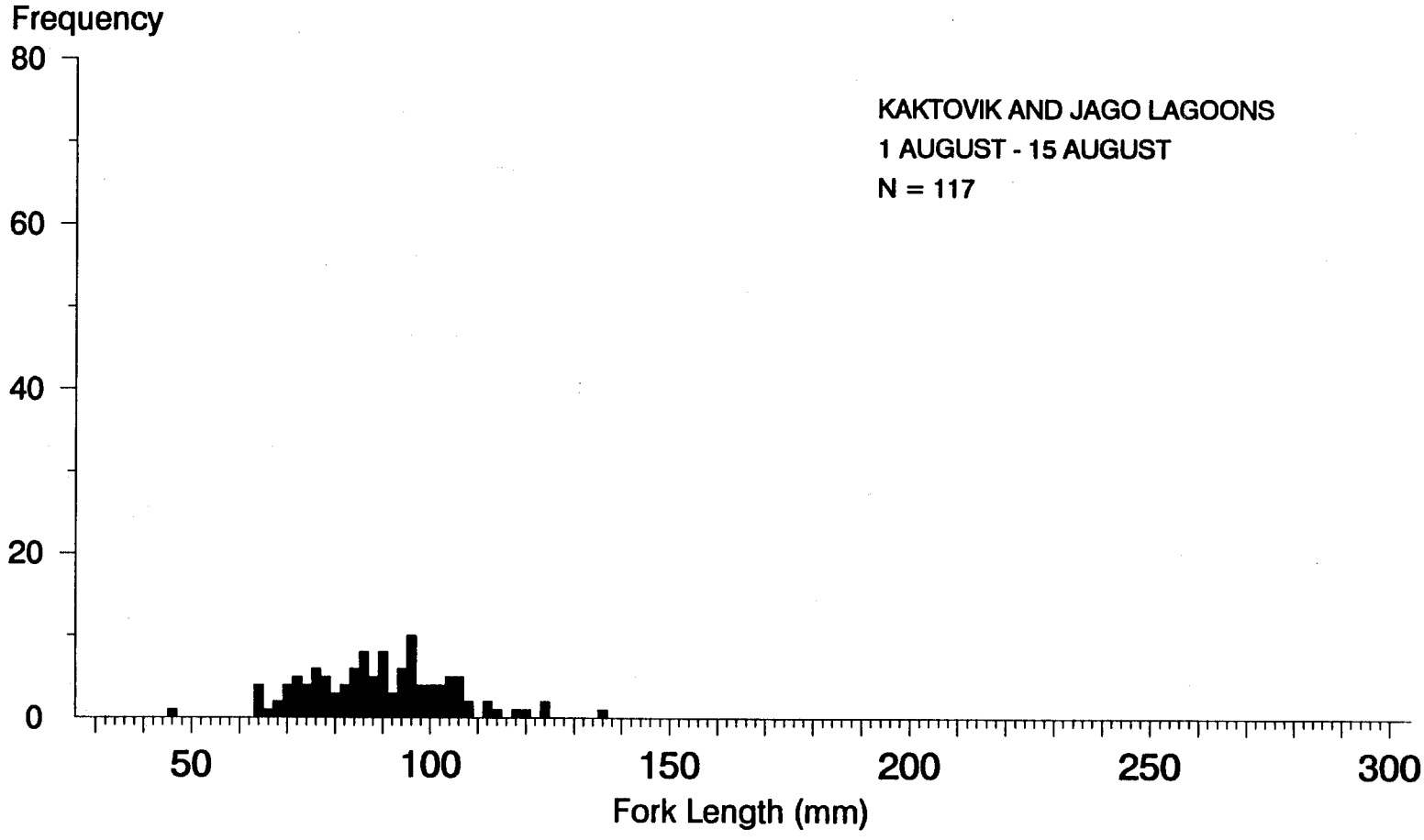

FIGURE A.18.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Kaktovik and Jago lagoons, 1 August - 15 August, 1990.

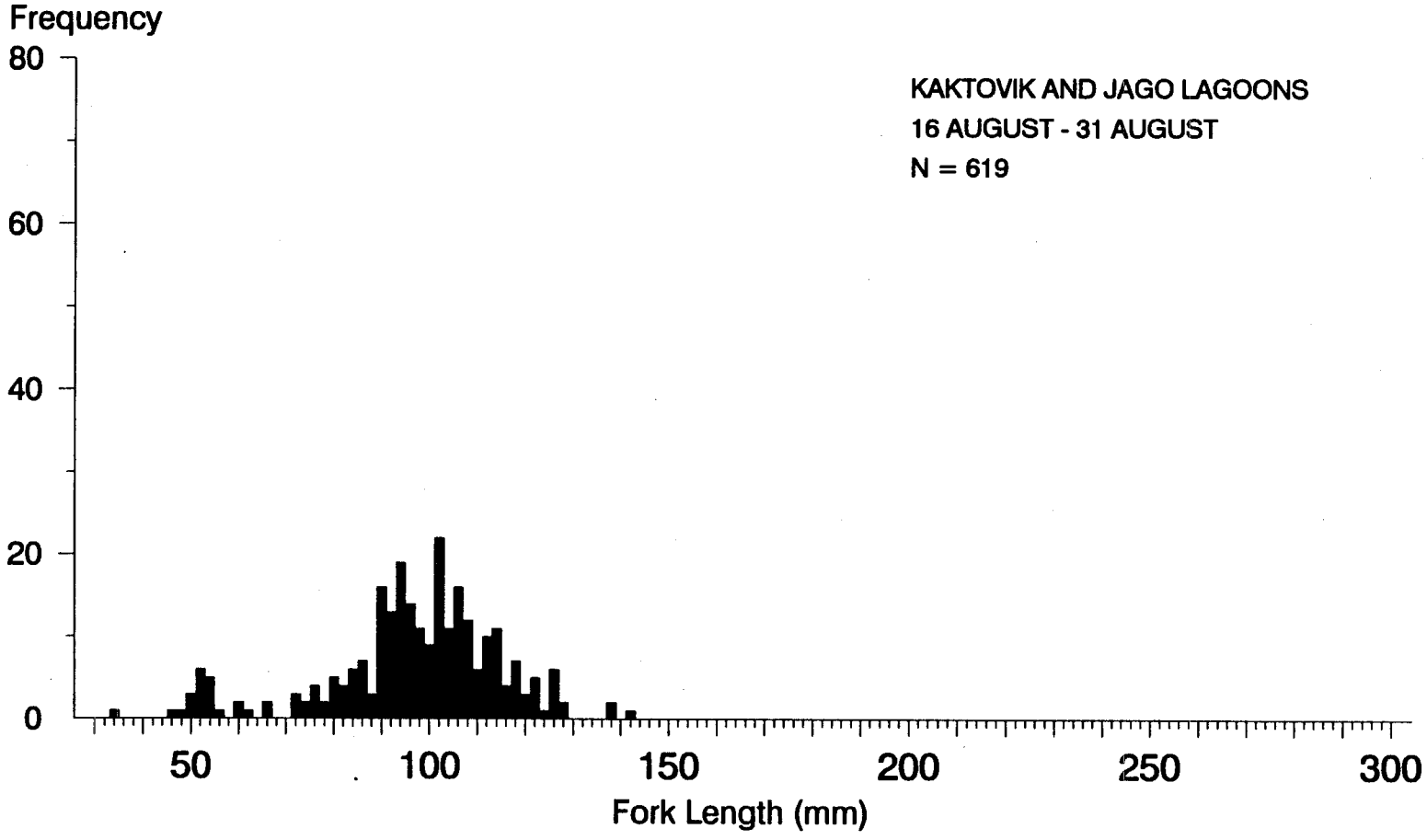

FIGURE A.19.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Kaktovik and Jago lagoons, 16 August - 31 August, 1990.

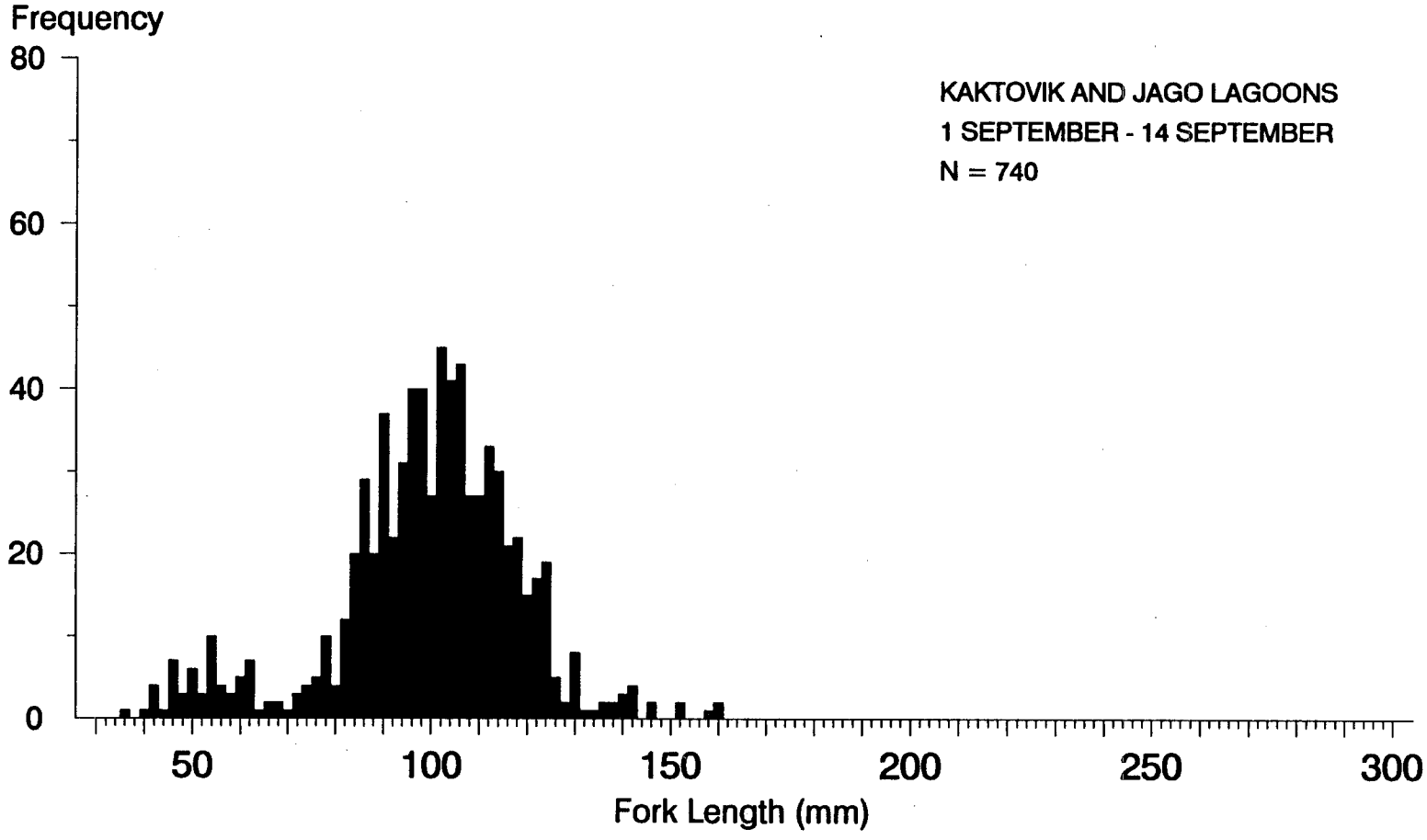

FIGURE A.20.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Kaktovik and Jago lagoons, 1 September - 14 September, 1990.

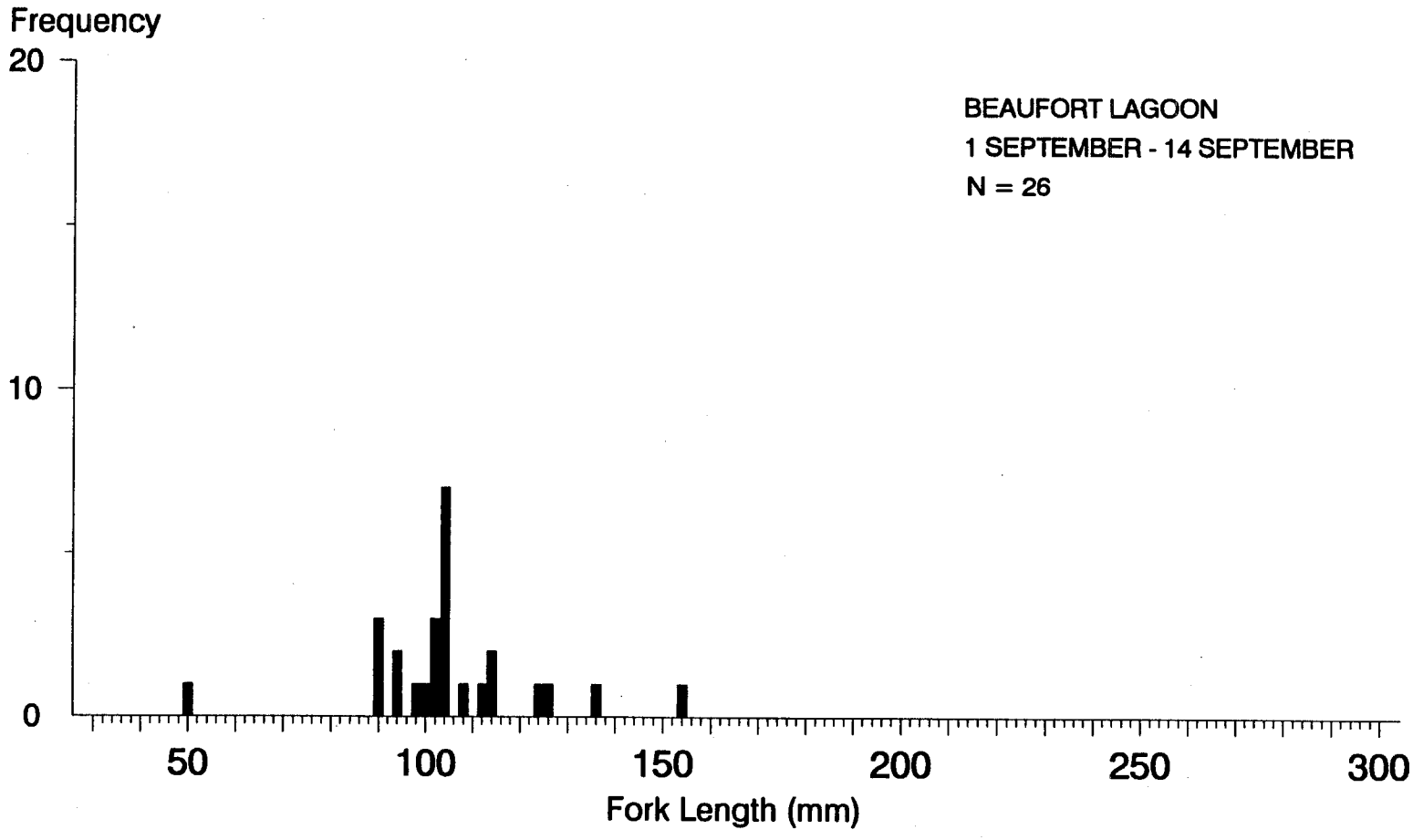

FIGURE A.21.– Length frequency (2 mm increment) of Arctic cod captured by fyke nets in Beaufort Lagoons, 1 September - 14 September, 1990.