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Impact of scallop dredging: design and evaluation of dredge modifications to minimise contact between bag and sea-bed.

Final Report

By

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For

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Impact of Scallop Dredging: Final Report

Executive Summary

The bag of scallop dredges is normally dragged across the sea-bed causing a major part of the environmentally damage caused by commercial scallop dredging. The aim of the project was to design and test modifications to standard scallop dredges that would support the bag off the sea-bed on runners or a similar arrangement with a view to reducing the environmental impact and facilitating the sorting qualities of the bag. Modifications were to be compatible with existing scallop gear and as simple and practical as possible. During the first phase of the project a number of prototypes were developed and tested at sea on a commercial scalloper to evaluate compatibility with existing commercial gear, and additionally to qualitatively assess fishing and sorting (riddling) performance. The results of the trial were positive and other advantages, including reduced wear on the bellies and potential savings in fuel costs became apparent. Further quantitative trials were planned as the second phase.

The initial results informed some further design refinements and the second sea trials methodology was decided in collaboration with the School of Ocean Sciences, Menai Bridge (SOS) and carried out on board the R.V. Prince Madog. The plan was to compare quantitatively the performance of the two best prototypes with a standard dredge, and to record a series of data to form the basis of a scientific paper to be prepared by S.O.S.. These trials were carried out later than originally agreed and bad weather restricted the location and extent of the trials.

Nevertheless, the results were very encouraging, showing the modified designs to be at least as effective in catching scallops as standard dredges and at the same time catching less debris with reduced by-catches. However, due to the limited extent of the trials, the data was insufficient to confirm these results as statistically significant.
Observations also confirmed that the bellies of the modified dredges were totally supported above the sea-bed. The best prototype, Wings 2, took the form of two pairs of supporting skids attached by D-shackles at the middle and the rear of the belly of the bag.

The scientific paper from SOS will address the size spectra of scallops caught and the community composition of the benthos, damage scores of scallops and invertebrate

species, and analysis of load cell data to assess the probable reduction in towing force afforded by raising the bag on runners.

More sea trials are required to statistically establish the fishing qualities of the latest prototype and the evident improvements in performance regarding sorting and by-catch. Having established these qualities statistically, it would be useful to begin to investigate differences in actual impact on the benthos. Further work addressing durability and wear issues is required to produce a version of the prototype suitable for extensive testing in the commercial scallop fishery.

1. Introduction

Following the design and testing of the prototypes documented in the interim report (Cyclone Marine Ltd, September 2011), the project proceeded as planned. Initial results informed some further design refinements resulting in an additional prototype (Wings 2). The second sea trials methodology was decided and carried out in collaboration with the School of Ocean Sciences, Menai Bridge (SOS). In addition to the results outlined in this report, the data of the second sea trials will form the basis of a scientific paper to be prepared by SOS.

2. Prototype development prior to second sea trials

Design modifications have evolved through a series of prototypes with a view of securing the best performance along with ease of operation, simplicity of design and attachment, economy and practicality for commercial use.

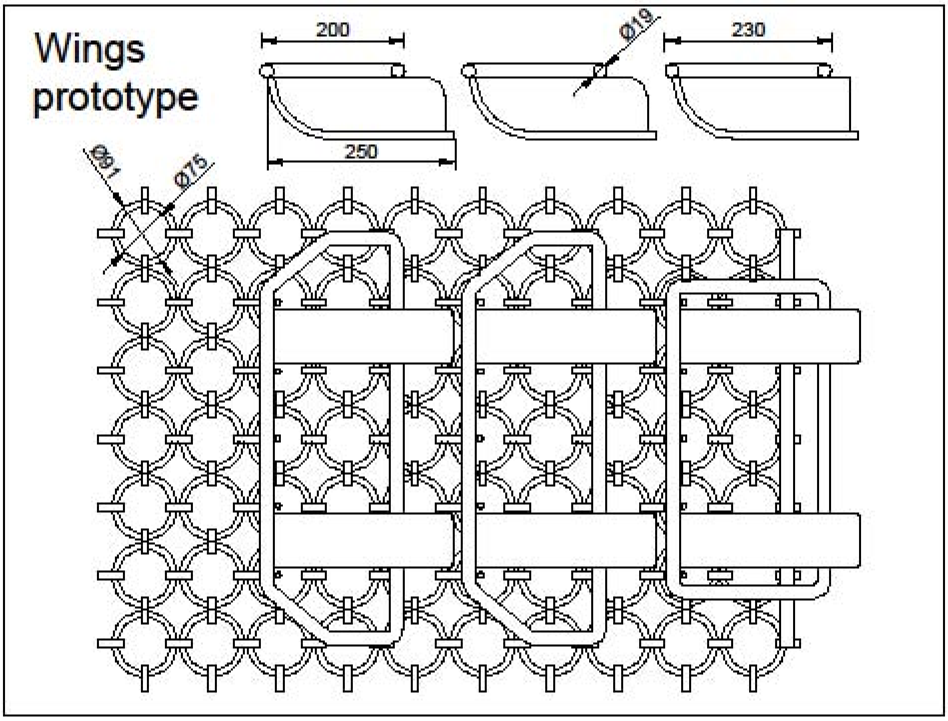
The first sea trials revealed a weakness in the performance of the first prototype (Armadillo) causing it to be excluded from further trials. While the catch performance of this model was very good, the skids occasionally became crossed and out of line. This results in unnecessarily increasing the effective track width and detracts from the aim of minimising impact on the benthos.

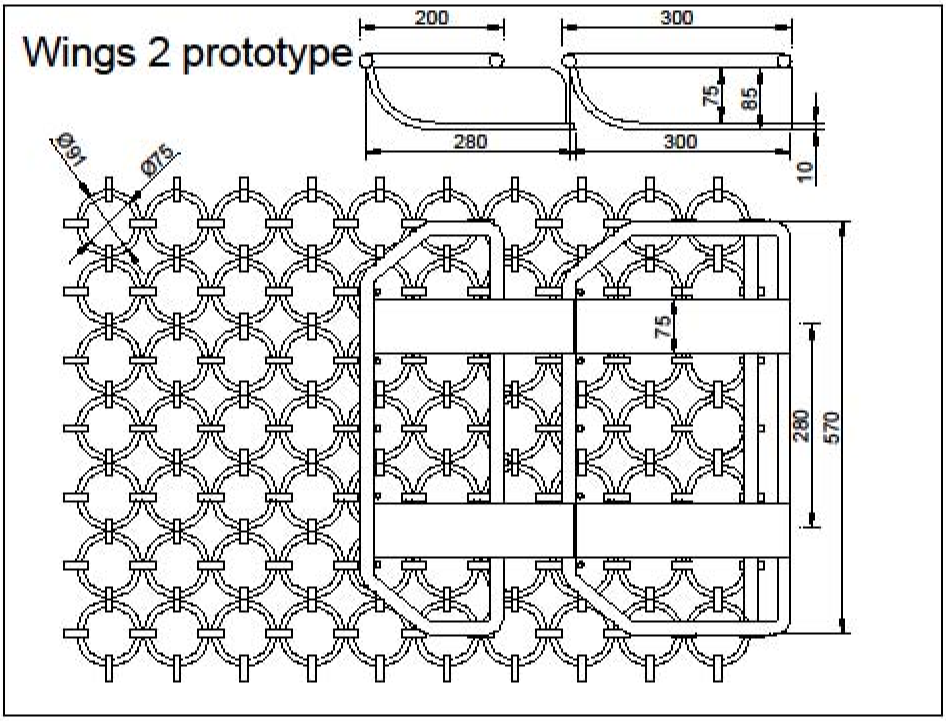
In addition, the Armadillo model was welded to the belly of the bag, unlike the 'Wings' prototype, which performed equally well but needs only D-shackles for attachment.

A major design criterion was the compatibility of the new designs with existing dredges and the ease with which adaptations could be made and adopted by commercial users. Obviously a dredge modification that can be simply shackled onto existing dredge bellies is preferable.

A further significant observation from the first sea trials was that there was absence of wear (bright metal) on the belly of the standard dredge until beyond the forward third of the belly. This suggests that no support is required at this point.

As a result of these considerations, a fourth prototype was designed and constructed (Wings 2). This is similar to Wings (i.e skids on simple frames attached by D-shackles to the belly rings), but uses only two sets of shoes instead of three, in effect, leaving out the first (forward) set. (see Figure 1, below).


Wings
prototype
200
Ø19
230
250
Ø91
Ø75


Wings 2 prototype
200
300
75
85
280
300
10
Ø91
Ø75
75
280
570

Weights of Dredges

The weights of the dredges, standard and with modifications attached, are as follows:

Standard Dredge	104.5 kg (10mm belly rings 8mm back rings)
Wings	111.0 kg (8mm belly rings 6mm back rings)
Wings 2	104.5 kg (8mm belly rings 6mm back rings)

The Wings attachments weigh 22.5 kg, partially offset by the lighter scantlings of the belly and back. The added weight of the Wings 2 modification, 16 kg, is balanced by the lighter belly and back.

3. The Second Sea Trials

The second sea trials were carried out from 11 November – 13 November 2011 on board the R.V. Prince Madog on established scallop grounds in the Irish Sea. This was considerably later in the season later than originally arranged. Trials took place at two sites which provided a range of seabed types, scallop density and variation in the prevalence of stones and the variety and quantity of by-catch. However, owing to adverse weather conditions over the period of the ship's availability, the preferred more distant grounds were not attainable and the grounds used for the tests were of relatively low yield, and the number of tows restricted by the sea state. The log details of the tows are shown in Appendix A. The trials were conducted and performed with the assistance of a team of seven scientists from SOS Menai Bridge, resulting in the recording of a large variety and amount of data and observations which was later subjected to statistical analysis.

Experimental design

A standard scallop beam was modified to take three dredges rather than four, and three dredges were tested alongside each other – Wings, Wings 2 and an unmodified dredge.

(see photograph A)

The positions of the dredges on the beam were regularly rotated over the course of the trials so as to negate any bias by position that might affect performance. For example, it is known that there is a tendency for the outer dredges to perform slightly better than inner ones.

The precise time and position of the beginning and end of each tow was recorded. The following variables were measured and recorded from the catch for each dredge:

Weight of king scallops (*Pecten*)

Weight of queen scallops (*Aequipecten*)

Weight of remaining by-catch

Weight of stones

Weight of debris

The number of scallops (*Pecten*)

The size (diameter) of individual scallops (*Pecten*)

The condition (damage score) of individual scallops and by-catch

The age of individual scallops. (*Pecten*)

(see photograph B)

In addition to quantitatively measuring catches, arrangements were made to measure the relative drag (towing effort) for each dredge. This was to quantify the expected reduction in friction between the bag and the sea-bed and the required towing effort that skids might offer, resulting in an additional potential advantage of reduced fuel consumption. To this effect, an electronic load cell and recording device (data logger) were installed between the beam and the dredge at the central position. A continuous series of measurements of tension were recorded for each dredge in rotation.

(see photograph C)

4. Summary of results

4.1 Catches

During the trials the modified dredges caught:

- More king scallops (*Pecten*) than the standard dredge
- Fewer queen scallops (*Aequipecten*) than the standard dredge.
- Less by-catch and debris

Although the modified dredges caught slightly more king scallops, preliminary analysis (see Appendix B) showed that there were no statistically significant differences in king scallop catches between the three different gear types. Catches of queen scallops and invertebrate by-catches, as well as debris were lower in the modified dredges, but again, none of these trends could be shown to be statistically significant. However, the observed general trends were consistent with the expected difference between the three dredge types with regards to their sorting performance (riddling). Raising the bag off the ground was expected to improve the sorting performance of the belly leading to lower catches of by-catch, debris, queen scallops and immature king scallops. However, because of the bad weather over the period of the trials, the sampling effort (15 individual 30-40 minute tows) proved to be insufficient to confirm these trends as statistically significant. The lack of significance is related to a lack of statistical power. The inherent high variability in the distribution of benthic organisms and the relatively small differences in dredge performance require more data, in the form of more tows, to produce a significant statistical result.

Nevertheless, the results are very positive in that they show the modifications to cause no reduction in catching performance and strongly suggest that by raising the bag the sorting (riddling) qualities of the modified dredges are enhanced, resulting in fewer undersized and queen scallops, less by-catch and less debris. The scientific paper currently in preparation by the School of Ocean Sciences, Menai Bridge will include further analysis looking at size spectra of scallops caught and the community composition of the benthos. In addition, damage scores of scallops and invertebrate species will be analyzed. Statistical analysis of the results is shown in Appendix B

4.2 Towing Effort

The data from the load cell proved to require detailed analysis before any conclusions could be drawn. The results of this part of the trial will be included in the planned scientific paper currently in preparation by SOS. However, from an initial look at the data, it seems likely that a different approach would provide clearer results, using, for example, a set of three or four identical modified dredges on the same beam (compared with unmodified dredges) with the warp tension measured on deck.

5. Overall Conclusions

The results very strongly suggest the modifications in raising the bag off the sea-floor do not compromise fishing performance or ease of handling yet improve sorting qualities resulting in a lower by-catch. To prove these points statistically, however, it will be necessary to perform more trials.

6. Performance of individual prototypes.

As was the case during the first sea trials, absence of wear on the bellies of the modified dredges (areas of shiny steel) shows that the bags were kept off the seabed by the attachments.

Wings 2 (2 pairs of skids) performed as well, and possibly better, than Wings 1 (three pairs of skids) and therefore represents an improvement in design by being simpler and offering less obstruction to sorting by the belly. Examination of the bags during the trials showed some slight wear on the shackles just forward of the leading skids of Wings2. This suggests that attaching these one ring further forward might be appropriate.

(see photograph D)

7. Suggested Further Work

More sea trials are required to achieve statistical significance regarding the fishing performance of the prototypes and the evident improvements in performance regarding sorting and by-catch. It would be advisable to now test several dredges of the Wings 2 design (i.e. the dredge showing the most promising trends) on the same beam and compare these to an equal number of standard dredges. By testing several dredges of the same design the variability of catches can be addressed better and this should help to increase statistical power. Having established these qualities, it would be useful to begin to investigate differences in actual impact on the benthos between modified and unmodified dredges by intensive ecological investigations.

Further development of the prototype skids is also required to design and a produce a model that is fully compatible with commercial use. In particular, considerations of wear and durability and economic aspects of mass production need to be further addressed. For example, easily replaceable skids of wear-resistant steel such as ‘Hardox’ are likely to be needed in order to extend the life of the wearing parts to a practical level. The mild steel prototype skids were expected from the onset to show unacceptable rates of wear and were only used to prove the concept and allow for easy modifications. Trials by commercial scallopers are currently being considered to fully test these aspects.

8. Scallop dredge regulations

Attachments to scallop dredges other than those with the sole purpose of operator safety are currently prohibited by the English Scallop Order 2004, now under review, and it is hoped that an additional exemption can be made for attachments with the sole purpose of reducing environmental damage and reducing by-catch. We are contact with the relevant authorities regarding this issue.

http://www.defra.gov.uk/consult/files/110826-scallops-condoc.pdf

Appendix A

FES 254 Scallop dredge 2nd sea trials

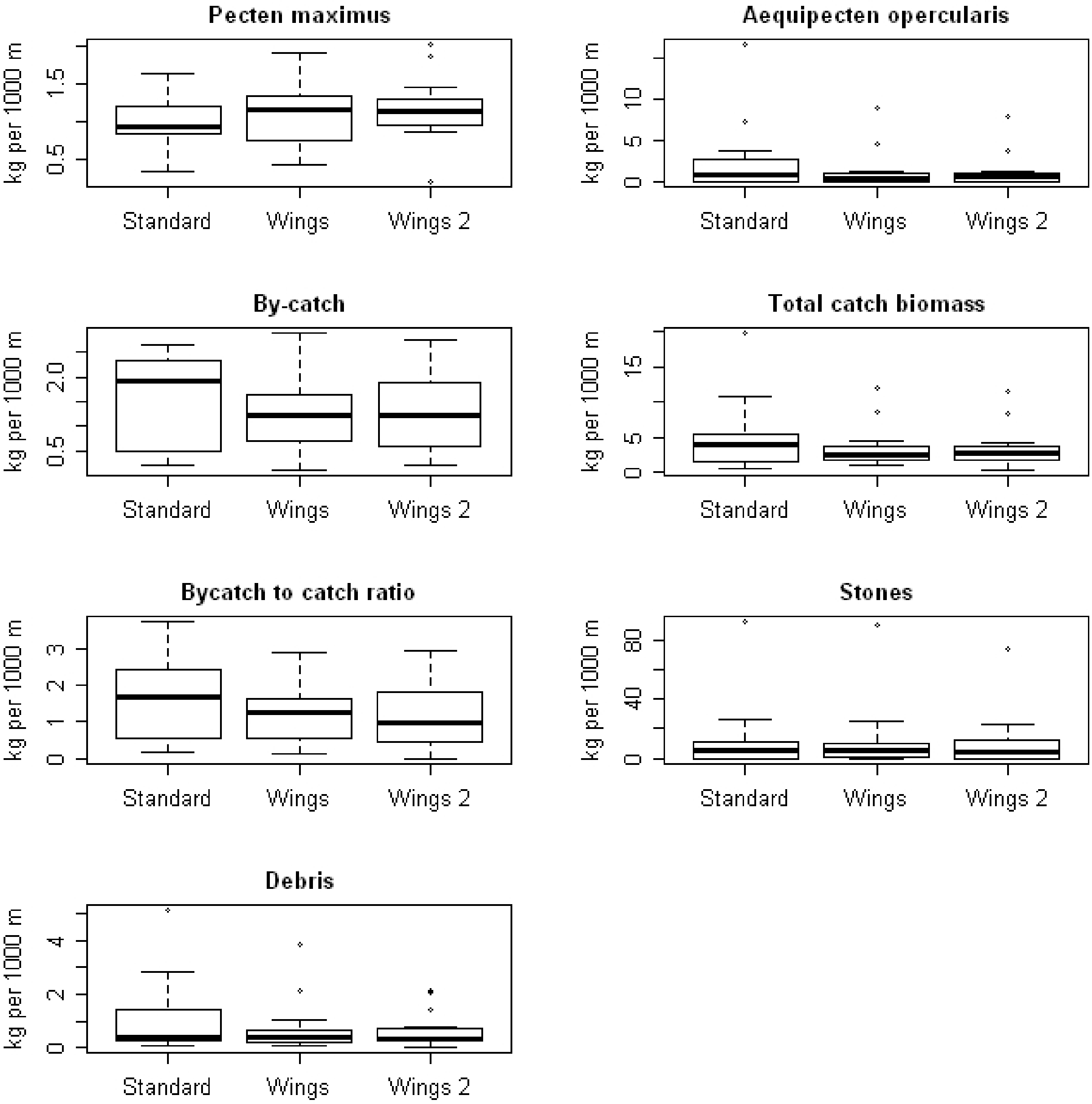
Nov-12		wind force 3 SS3			
Day 1	Arrive first site Depth 40-42m	Lat	Long		
Tow1					sw2sw1p
8.27	Dredge away	53.634	3.937		
830	winch stop	53 38.04	3 56.22		
915	start haul	53 39.36	4 00.03		
920	on deck				
Tow 2					
930	away	53 39.29	3 59.34		
1010	on deck	53 38.82	3 56.67		
Tow 3	dredge swap				ssw2w1
1027	winch stop	53 38.66	3 53.87		
1058	start haul	53 38.66	3 59.49		
1101	on deck				
Tow 4					
1111	away	53 39.78	3 59.55		
1114	winch stop				
1142	start haul	53 39.69	3 57.12		
1145	on deck				
Tow 5	dredge swap				syrbp
1232	away	53 39.69	3 58(.00?)		
1235	winch stop				
1303	start haul	53 39.83	4 01.09		
Tow 6					
1312	away				
1315	winch stop	53 39.91	4 01.22		
1345	start haul	53 40.25	3 58.75		
1348	on deck				
Tow 7	no dredge swap				syrbp
1344	away	53 39.89	3 59 (.00?)		
1347	winch stop				
1416	start haul	53 39.45	4 1.77		
1419	on deck				
Tow 8	Dredge swap				swbrp
1433	away	53 29.33	4 00.96		
1436	winch stop				
1503	start haul	53 39.07	3 58.46		
Tow 9	Dredge swap				sbyrp
1522	away	53 38.64	3 59.19		
1524	winch stop				
1552	start haul	53 58.53	4 01.93		
1555	on deck				
1600	heading for Red Wharf anchorage				
Nov-13					
Day 2	Depth range 25-35m	wind 3-7(increasing)	seastate 3-6		
Tow 1	dredge swap (outsides reversed)				srybp
704	away	53 24.58	4 02.54		
707	winch stop				
749	start haul	53 24.52	4 05.62		

Tow 2				
756	away	53 24.52	4 06.00	
840	start haul	53 24 77	4 02.46	
Tow 3	Tightened tines change dredge			srbyp
858	away			
900	winch stop	53 24.90	4 02.82	
945	start haul	53 25.22	4 05.45	
Tow 4				
952	away	53 25.11	4 05.65	
955	winch stop			
1040	start haul	53 24.81	4 04.36	
1043	on deck			
Tow 5	change dredge			sbryp
1056	away	53 24.51	4 02.028	
1139	start haul	53 24.96	4 05.62	
Tow 6				
1148	away	53 24.95	4 05.55	
1233	start haul	53 25.10	4 02.29	

Appendix B

FCF Scallop dredge 2nd sea trials

Results of Statistical Analysis



The following linear models were run:
Response variable = Dredge type (fixed factor)* Position (fixed factor) + Station (Sta, random factor). If position proved non significant it was removed from the analysis leaving dredge type (fixed factor) and Station (random factor).

Results

Pecten maximus

```
Error: Sta
          Df  Sum Sq Mean Sq F value Pr(>F)
Residuals  1 0.25957 0.25957

Error: Within
          Df Sum Sq Mean Sq F value Pr(>F)
Dred       2 0.3291 0.16455   1.064 0.3544
Residuals 41 6.3406 0.15465
>
```

Aequipecten opercularis

```
Error: Sta
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals  1 74.288  74.288

Error: Within
           Df  Sum Sq Mean Sq F value  Pr(>F)
Dred        2  14.861  7.4307  1.0295 0.36692
Posi2       1   3.972  3.9720  0.5503 0.46274
Dred:Posi2  2  57.384 28.6919  3.9753 0.02706 *
Residuals  38 274.264  7.2175
```

Bycatch

```
Error: Sta
     Df Sum Sq Mean Sq
Dred  1 20.872  20.872

Error: Within
          Df Sum Sq Mean Sq F value Pr(>F)
Dred       2 0.5427 0.27133  1.0901 0.3459
Residuals 40 9.9559 0.24890
```

Debris

```
Error: Sta
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals  1 11.367  11.367

Error: Within
          Df Sum Sq Mean Sq F value Pr(>F)
Dred       2  1.745 0.87263  0.9325 0.4018
Residuals 41 38.368 0.93581
```

Stones

```
Error: Sta
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals  1 4010.8  4010.8

Error: Within
          Df  Sum Sq Mean Sq F value Pr(>F)
Dred       2    41.5   20.74   0.053 0.9485
Residuals 41 16056.6  391.63
```

Bycatch to catch ratio

```
Error: Sta
          Df Sum Sq Mean Sq F value Pr(>F)
Residuals  1 13.953  13.953

Error: Within
          Df  Sum Sq Mean Sq F value Pr(>F)
Dred       2  2.3604 1.18021  2.3895 0.1043
Residuals 41 20.2509 0.49392
```